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Evaluation of the LVNL 2022 safety measures in converging runway operations at Schiphol Airport

Thesis

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Management summary

This research investigates the effectiveness of the 2022 safety measures implemented at Amsterdam Schiphol Airport for dependent converging runway operations during the Uniform Daylight Period (UDP) under good visibility conditions, specifically with a Cloud Base (CB) higher than 2000 feet (ft) and visibility of 5 kilometer (km) or more. Schiphol's unique runway layout, designed to accommodate varying wind directions, includes dependent converging runways that are often used simultaneously for arrivals and departures. While this configuration enhances operational capacity, it also introduces significant safety risks, particularly in the event of a missed approach, where the missed approach can conflict with the simultaneous departure. A notable incident in 2018, where two aircraft came dangerously close during such an operation. After thorough investigation, the Netherlands Air Traffic Control (LVNL) introduced safety measures in July 2022 for these type of operations, including enhanced training for Runway Controllers (RC), who are responsible for managing dependent converging runway operations, 10 second guideline where pilots have 10 seconds after take-off clearance to roll initiation, and the information to pilots have been updated, where the 10 second rule has been described in the Aeronautical Information Publications (AIP) and in the Standard Instrument Departure (SID) cards for pilots.

The main objective of this research is to evaluate *how these 2022 safety measures are applied in daily operations and to what extent they reduce operational risks during dependent converging runway operations under good visibility conditions*. The study mainly focuses on two key aspects: the position of arriving aircraft at the moment a departing aircraft begins its take-off roll to evaluate the impact of RC training, and the time interval between take-off clearance and roll initiation to assess pilot compliance with the 10-second guideline inside the UDP with good visibility of 5 kilometers or more and a CB higher than 2000 ft.

A mixed-methods approach was used, combining quantitative analysis of over 395,000 runway operations from 2015 to 2025 with qualitative data from RC interviews, pilot surveys, and live observations from the Schiphol control tower. The analysis focused on the two most critical and frequently used runway combinations at Schiphol Airport: L06/S09 and L18C/24.

The findings show that the safety measures have led to a significant shift in aircraft positioning away from high-risk areas and more toward safer areas, indicating improved controller awareness and decision-making. Runway controllers reported that the training, particularly the use of color-coded risk charts from the risk analysis, which was conducted by LVNL per dependent converging runway combination, has made them more cautious and consistent in issuing take-off clearances. However, the average time between takeoff clearance and roll initiation has changed only slightly, from 19,8 seconds before the safety measures to 19,6 seconds after. This remains well above the 10-second guideline as described in the AIP and SID cards. The delay is influenced by several factors, including aircraft type, airline-specific behavior, and cockpit procedures. Home carriers operating at Schiphol Airport, tend to take longer to initiate the roll, and runway controllers often adjust their timing accordingly. Pilot surveys revealed inconsistent awareness of the 10-second rule, and standard cockpit protocols, such as the "cleared–checked" confirmation following readback, often delay roll initiation. Furthermore, live observations showed that aircraft typically begin rolling sooner than radar data suggests. While live data showed an average of 17,5 seconds, radar data showed an average of around 20 seconds. This discrepancy highlights limitations in radar accuracy, especially when multiple aircraft are present.

Although the number of reported incidents has not decreased, rising slightly from an average of 1,2 to 1,25 incidents per year, the RC interventions have changed. All recent incidents were resolved through take-off abortions, unlike the situation before the safety measures were introduced. This indicates that these aircraft have stayed on the ground and were not far in their roll for RC to abort the take-off, which suggests earlier and more decisive action by controllers. This shift reflects increased operational risk awareness, even if the overall incident rate has not reduced.

The study concludes that the 2022 safety measures have positively influenced controller behavior and aircraft positioning. However, further improvements are needed in pilot compliance, communication, and training. The findings underscore the importance of continuous collaboration between Air Traffic Control (ATC) and flight crews to ensure mutual understanding and effective risk management in dependent converging runway operations.

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List of Abbreviations

Abbreviation	**Definition**
AIP	Aeronautical Information Publications
ALARP	As Low As Reasonably Practicable
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
BZO	Limited Visibility Conditions
CB	Cloud Base
CTR	Control Zone
EHAM	Amsterdam Schiphol Airport
FAA	Federal Aviation Administration
FT	Feet
GARDS	Go-around Detection System
EFHK	Helsinki Airport
IandW	Infrastructure and Water management
ICAO	International Civil Aviation Organization
ILT	Leefomgeving en Transport
ISMS	Internal Safety Management System
KM	Kilometer
LVNL	Netherlands Air Traffic Control
MHz	Megahertz
NLR	Netherlands Aerospace Center
NM	Nautical Miles
OM	Operations Manual
OVV	Onderzoek voor Veiligheid
RC	Runway Controller
R/T	Radio Telephony
SID	Standard Instrument Departure
SM	Safety Measures
TCAS	Traffic Collision Avoidance System
TOPSAG	Top Safety Action Group
UDP	Uniform Daylight Period
UTC	Coordinated Universal Time
VEMMIS	Safety Efficiency Environment Management Information System
VIS	Visibility
WTC	Wake Turbulence Category

1 Introduction

Schiphol Airport has several runways positioned in different directions. This design helps aircraft take off and land safely, as planes ideally fly into the wind rather than dealing with strong crosswinds. These strong crosswinds can make the landing and take-off difficult and perhaps dangerous. By having runways in multiple directions, Schiphol Airport ensures that specific runways can be used that aligns with the wind direction. However, this system has some disadvantages. Some of the runways cross each other, either on the ground or in the air. Where runways cross each other in the air is called "dependent converging runway operations". This can lead to potential risks in the operation. Especially in situations where an approach needs to be aborted at the last moment and the aircraft has to do a go-around. When a pilot decides to cancel the landing and climbs back up in the air is called a missed approach or a go-around.

The runway layout at Schiphol Airport inherently increases the risk of dependencies between runways. To manage the high traffic demand, three runways are often used simultaneously, with arrival and departure operations typically occurring on converging runways. This configuration heightens the likelihood of potential conflicts between arriving and departing aircraft. For example, on March 29, 2018, two aircraft came very close to each other in the air. One plane had to abort its approach and climb back into the air while the other plane was taking off. Because their flight paths crossed in the air, they got uncomfortably close to each other. The minimum separation between the two aircraft was approximately 960 meters (0,5 Nautical Miles) horizontally and 300 feet (ft) vertically.

To improve safety for crossing runways in the air, also known as dependent converging runway operations, the Netherlands Air Traffic Control (LVNL) introduced new safety measures in July 2022. These measures aim to reduce risks, especially during times when visibility is good, during daytime, and when there is a lot of air traffic at Schiphol airport. One important measure involves carefully timing the take-offs and landings to ensure planes maintain a safe distance from each other. Timing is crucial for safety. However, pilots often take different amounts of time to start their take-off roll after getting clearance to take-off. Previously, it took about 20 seconds for pilots to begin their take-off roll. The new "10-second rule" aims to reduce this time to 10 seconds to enhance safety. The risk analysis, conducted by LVNL provides a probability distribution for each converging runway combination of simultaneous crossing of the intersection, without intervention by the Runway Controller (RC) and without pilot response. In other words, an aircraft in the red area of the risk analysis increases the likelihood that, in the event of a go-around and unsuccessful intervention, a time-critical situation will arise with a departing aircraft in certain circumstances.

However, it is important to evaluate how well these measures work in daily operations, due to the complexity of these operations. Factors like pilot behavior, decisions made by Air Traffic Control (ATC), weather conditions, and runway conditions can affect how these measures are implemented. This study aims to see how well these safety measures are being applied in daily operations and whether they are effective in reducing operational risks at Schiphol Airport. These operational risks include the possibility that the arriving aircraft can conflict with the simultaneous departure, as well as other factors that may impact safety during dependent converging runway operations.

1.1 Problem background

The Dutch Safety Board (OVV) is an independent organization that investigates accidents and dangerous situations to identify what went wrong. The goal of these investigations is to learn from past mistakes and make improvements to prevent similar incidents in the future. By identifying risks and making safety recommendations, the OVV helps improve safety in the Netherlands (*Over de Onderzoeksraad - OVV*, 2025).

Following the 2018 incident at Schiphol Airport, the OVV conducted an investigation to determine the cause. The investigation revealed that one of the main reasons for the incident was the way ATC procedures were written in the Operations Manual (OM) used by LVNL. The OM contains the procedures and working methods that ATC needs to perform their tasks efficiently and safely ("Operations Manual", 2025). It allowed two aircraft to use converging runways simultaneously, one for landing and the other for take-off. Normally, a departing aircraft should only receive clearance for take-off once ATC has confirmed that the landing aircraft has safely touched down. However, the OM included an exception that allowed ATC to give take-off clearance before the arriving aircraft had fully completed its landing under certain conditions. This procedure, known as "Reduced Separation Between Departing and Landing Traffic," posed risks if the landing aircraft had to abort its landing (a go-around), potentially bringing the two aircraft dangerously close to each other. This situation had already occurred twice before, in 2007 and 2015 at Schiphol Airport (*OVV*, 2023). Following the investigation, the OVV issued a report with recommendations to prevent similar incidents in the future. Two key recommendations were directed at LVNL and the Minister of Infrastructure and Water Management (IandW):

1. *Recommendation to LVNL:* The OVV advised LVNL to remove the "Reduced Separation Between Departing and Arriving Traffic" procedure from the OM. Although this procedure had been implemented to enhance Schiphol's capacity, it introduced risks under certain conditions. Given the history of multiple incidents, the OVV recommended eliminating this procedure to improve safety ("Verminderde Separatie Na Doorstart", 2020).

2. *Recommendation to the Minister of IandW:* The OVV advised the minister to arrange a formal review of whether LVNL's procedures regarding dependent runway operations complied with existing laws and regulations. Since the procedure had been established without requiring approval from the Inspectie Leefomgeving en Transport (ILT), it was unclear whether all OM procedures concerning dependent runway usage met regulatory standards ("Verminderde Separatie Na Doorstart", 2020).

In response to these recommendations, the Minister of IandW issued a letter stating that the ILT had been tasked with reviewing and assessing all procedures related to dependent converging runway operations to ensure compliance with legal requirements ("Luchtvaartbeleid", 2020). Furthermore, the minister confirmed in another letter that ILT had completed its investigation into LVNL's OM procedures concerning dependent runway usage ("Luchtvaartbeleid", 2020a). The ILT concluded that these procedures fully complied with all safety standards from International Civil Aviation Organization (ICAO) regulations ("Kruisend Luchtverkeer op Schiphol", 2021). The ICAO rules cover standard runway operations, including parallel runways, but do not specifically address converging runway use. Additionally, there are no national laws or regulations addressing this matter. ILT's findings were independently reviewed by two expert organizations, both of which confirmed the conclusions of the ILT. The minister's second letter to the OVV further stated that the changes made by LVNL went beyond the recommendations in the OVV report and would improve safety even further. LVNL also responded in a letter to the OVV and the Minister of IandW, explaining that it had chosen to implement additional safety measures to further reduce risks during operations involving converging runways. LVNL worked closely with the U.S. Federal Aviation Administration (FAA) and the Netherlands Aerospace Centre (NLR) to study the issue. Based on their findings, LVNL introduced a new, safer procedure, which was officially implemented on July 14, 2022. This new procedure applies when using converging runways for departing and landing operations during the daytime and in good weather conditions.

The change was initiated by the Internal Safety Management System (ISMS), which consists of airline, airport, and ATC organizations operating at Schiphol Airport. To enhance collaboration among the various parties responsible for safety, the ISMS was established. This system complements the existing safety management frameworks of individual organizations, with a specific focus on risks arising from interactions between these parties, known as interface risks. Through ISMS, incidents are investigated collaboratively, and proactive safety checks are carried out (*Safety in The Dutch Aviation Sector — Integral Safety Schiphol*, 2025).

The findings of the ISMS indicate that current regulations and ATC procedures provide sufficient flexibility to ensure safe separation between aircraft. However, LVNL and the ISMS partners have explored potential ways to further enhance safety, particularly concerning dependent runway use for take-off and landing. By adjusting the existing procedure for ATC and implementing comprehensive training, along with improvements in pilot information and flight procedures, the findings of the ISMS investigation have been addressed ("Converging Approach And Take-off Operation", 2020). As a result, the underlying risk identified in the OVV recommendation has been further reduced. These measures contribute to enhancing the safety of air traffic at Schiphol Airport. The Safety Risk Management within the ISMS is well-developed and works effectively. The process of identifying safety concerns, assessing risks, and finding ways to reduce them is fully in place and running smoothly. The Risk Assessment Workshop is a useful and creative way to evaluate risks, bringing together experts and using data from the NLR. This helps identify potential issues between partners and provides important information to the Top Safety Action

Group (TOPSAG), which is responsible for ensuring that these risks are managed and reduced to an acceptable level. On September 4, 2018, TOPSAG decided to form an ad hoc taskforce to develop a risk reduction action plan addressing the risks associated with converging approach and take-off operations during the UDP and with good visibility. Following this, TOPSAG made the decision to:

1. *Optimize the use of converging runways:* Ensure longitudinal separation between departing aircraft and those potentially executing go-arounds by adjusting procedures to maintain safe distances between aircraft, thereby minimizing the risk of collisions during critical phases of flight.

2. Reduce the time between take-off clearance and the actual start of the take-off roll.

3. *Enhance ATC instructions*: Raise pilot awareness and provide comprehensive training for both pilots and air traffic controllers.

The task force focused on the risk of a collision between an arriving flight performing a go-around and a departing flight during converging approach and take-off operations. This risk was specifically analyzed under conditions of good visibility and within the UDP, when air traffic is generally higher. The main goal of the risk reduction plan was not to eliminate the risk entirely or achieve a specific safety target but rather to ensure that the risk remains as low as reasonably practicable (ALARP). To achieve this, the task force followed a structured approach, starting with an inventory of potential risk reduction measures through a workshop with operational experts (ATC and pilots), work sessions within the taskforce, and a working visit to the FAA ("Converging Approach And Take-off Operation", 2020).

Once they had identified a range of potential risk reduction measures, the task force analyzed them in more detail. They assessed how effective each measure might be in reducing risk and how feasible it would be to implement. During this phase, the NLR developed a special analysis tool to study how timing practices could be adjusted to create a safe distance between aircraft, providing valuable insights into what factors contribute to risks, how different measures could reduce these risks, and what impact they might have on overall airport capacity. Next, the task force brought together operational experts once again for a workshop to evaluate the potential solutions. Each measure was carefully reviewed based on its expected effectiveness in reducing risk and its practicality. After this evaluation, the most viable risk reduction measures were selected and formally recommended to the TOPSAG.

As a final step, the task force created the Risk Reduction Action Plan. This document outlined all the measures that had been considered, along with assessments of their effectiveness and feasibility. The workshops with operational experts played a crucial role throughout this process, ensuring that the best possible risk reduction measures were identified and evaluated. Lastly, a risk analysis has been carried out that provides detailed insights into each runway combination, highlighting the potential risks of a rolling take-off when an aircraft is on final approach (*VEM Effect Report (VEMER) Converging Departure And Arrival Runway Operations Inside UDP And Good Visibility*, 2022). The risk analysis offers a general indication of the likelihood of aircraft intersecting at the intersection point with color-coded risk charts, with the arriving aircraft potentially performing a go-around while the departing aircraft begins its roll on the simultaneous runway. The transition of color goes from red to orange, then yellow, and finally green, and the other way around, reflecting varying risk levels in different scenarios.

Although these safety measures were introduced in 2022, three years have now passed. According to the ILT, LVNL is required to evaluate the safety of its procedures within five years. This means that an evaluation must be conducted to determine how effective the 2022 safety measures for converging runway operations have been in daily practice and to what extent they have successfully reduced operational risks.

1.2 Problem statement

The operation has not yet been evaluated to determine to what extent the designed procedures and methods are being followed in practice.

1.3 Research objectives

The main objective of this research is to evaluate the effectiveness of the 2022 safety measures implemented for dependent converging runway operations at Amsterdam Schiphol Airport. The study aims to assess how well these measures are applied in daily operations and to what extent they reduce operational risks during the Uniform Daylight Period (UDP) under good visibility conditions. To achieve this, the research focuses on the following specific objectives:

- Assess the position of arriving aircraft at distance X from the runway threshold at the moment a departing aircraft begins its take-off roll, in order to evaluate the impact of controller training on operational behavior.
- To analyze the time interval between take-off clearance and roll initiation of departing aircraft and assess compliance with the 10-second rule introduced as part of the safety measures.
- To conduct interviews with runway controllers to understand how they manage dependent converging runway operations and to evaluate whether their training remains effective over time.
- To conduct pilot surveys to gain insight into cockpit procedures, determine pilot awareness of dependent converging runway operations, and assess their understanding and application of the 10-second rule.
- To evaluate the overall impact of the safety measures on reducing operational risks, including the risk of aircraft coming too close during simultaneous arrival and departure operations, as well as identifying any remaining challenges related to human factors, timing, and communication.

1.4 Research Questions

In order to ensure the completion of this report, it is essential to have a clearly stated main question that outlines the scope of the assignment. Before answering the main question effectively, it is necessary to answer and address all sub-questions.
The main question is formulated as follows:

'How are the 2022 safety measures applied in daily operations for converging runway combinations at Schiphol Airport, and to what extent do they reduce operational risks under good visibility conditions in the uniform daylight period?'

In the following section, an overview is given of the compiled sub-questions:

- What are the safety measures for converging runway operations at Schiphol Airport?
- How well do the new safety measures introduced in 2022 work in daily operations?
- How do the safety measures affect the decision-making process of air traffic controllers and pilots during converging runway operations?
- To what extent do the safety measures reduce operational risks under good visibility conditions during the uniform daylight period?

1.5 Research scope

This research focuses on evaluating the effectiveness of the 2022 safety measures implemented for arrival and departure operations on dependent converging runways at Amsterdam Schiphol Airport. The study aims to determine how well these measures are applied in daily operations and their impact on reducing operational risks, particularly in the UDP when visibility (VIS) is good and is more than 5 kilometers with a Cloud Base (CB) higher than 2000ft.

1.6 General assumptions, Limitations, and Delimitations

Variability in how pilots and air traffic controllers behave and make decisions can influence the effectiveness of the safety measures. Furthermore, the research is limited to operations conducted during the UDP with good visibility conditions. This includes a visibility of 5 kilometer (km) or more and a cloud base higher than 2000 feet (ft). This focus excludes nighttime operations and periods with poor visibility, which may present different challenges and risks. Moreover, nighttime operations follow separate procedures. Additionally, the research emphasizes dependent converging runway combinations involving both take-off and landing operations. Consequently, it excludes scenarios where only landing operations occur on the dependent runways.

1.7 Thesis structure

Chapter two includes a review of the literature, providing relevant background and context for the study. Chapter three offers a detailed overview of the methods used to evaluate how the measures taken are applied in daily practice and their effectiveness in operational risk reduction. Chapter four presents the results of the study, while Chapter five discusses these findings. Chapter six gives an overview of the key findings of the research and finally, chapter seven provides recommendations based on the results and concludes the thesis.

2 Review of the Literature

This literature review explores the operational and safety aspects of dependent converging runway operations at Amsterdam Schiphol Airport.

2.1 Dependent runway combinations

This research focuses on operations where the extended centerlines of runways intersect, known as converging runway operations. Converging runways are designed with angles typically ranging from 15 to 100 degrees. This means that although the runways start separately, their paths eventually converge or intersect as they extend. The intersection point of these runways is known as the "common point" (see figure 1, the red dot which shows the common point of the converging runway combination) (FAA, 2017). This configuration is commonly used to optimize traffic flow, especially at airports like Schiphol, where both inbound and outbound traffic peaks occur regularly. These operations are considered dependent because the missed approach procedure for a landing aircraft can conflict with the departure path of a take-off runway. Dependent converging runways stem from the historical design of Schiphol airport, enabling runway operations in different wind directions.

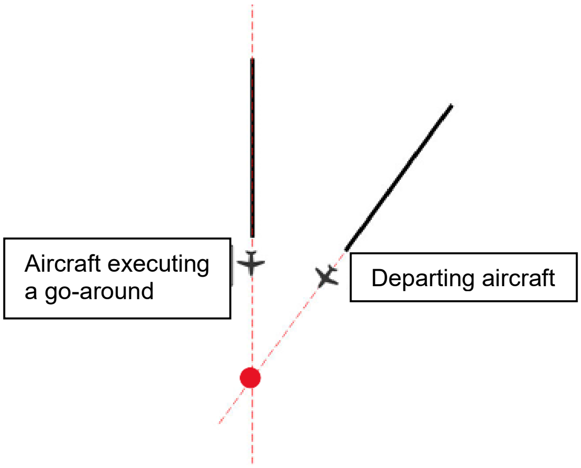

Figure 1 Common point

While dependent converging runways help increase the efficiency of an airport by allowing more planes to take off and land at the same time, they also come with some challenges. Since the flight paths cross, it is very important to ensure that aircraft maintain enough distance from each other. Proper coordination is required, especially when planes are taking off, landing, or performing a go-around. If not managed carefully, these two aircraft will meet each other at the common point. To address these challenges, safety measures are put in place, for operations inside the UDP with a good VIS of 5km or more and a CB higher than 2000ft, to make sure everything operates smoothly with the use of dependent converging runway combinations.

The UDP is determined based on the times of sunrise and sunset. Specifically, the daylight period is calculated from fifteen minutes before sunrise until fifteen minutes after sunset, which are provided at UTC (Coordinated Universal Time) (GEN 2.7 Sunrise/Sunset, 2024) (see appendix II for an example of the UDP in 2024). Since the safety measures for dependent converging runway operations apply only during the UDP under good visibility conditions, it is essential to have a clear understanding of all the dependent converging runway combinations used at Schiphol Airport. According to the OM for the ATC, Schiphol Airport has a total of fifteen dependent converging runway combinations (see table 1, figure 2 and to see every runway combination individually, see Appendix III) ("Operations Manual", 2025).

Table 1 fifteen dependent converging runway combinations at Schiphol Airport

Converging runway combinations Schiphol Airport	
Landing	**Departure**
↓ 04	↑ 06
↓ 04	↑ 09
↓ 06	↑ 04
↓ 06	↑ 09
↓ 06	↑ 18L
↓ 09	↑ 04
↓ 09	↑ 06
↓ 18C	↑ 22
↓ 18C	↑ 24
↓ 22	↑ 18C
↓ 22	↑ 18L
↓ 27	↑ 18C
↓ 27	↑ 36C
↓ 36R	↑ 09
↓ 36R	↑ 27

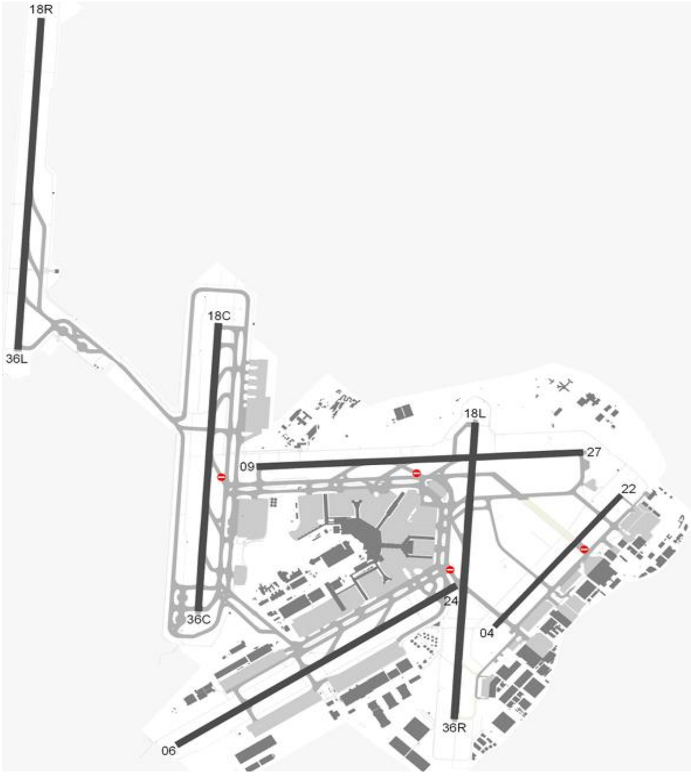

Figure 2 Schiphol Airport layout

In dependent converging runway operations, missed approaches present a key safety challenge. Since flight paths may intersect, a go-around must be carefully managed to avoid the two aircraft passing the common point at the same time. The next section explores the risks of late go-arounds, the role and limitations of TCAS at low altitudes, and the procedures used at Schiphol Airport to detect and manage these situations effectively.

2.2 Missed approach

A conflict between a late missed approach and an aircraft already rolling for take-off is undesirable. When a pilot decides to cancel the landing and climbs back up in the air is called a missed approach or a go-around. There are three ways to intervene: pilot intervention, ATC intervention and Traffic Collision Avoidance System (TCAS) intervention. Modern passenger aircraft are equipped with TCAS. TCAS continuously interrogates with the transponders of surrounding aircraft, processes their responses, and predicts their flight paths to identify potential conflicts (ICAO, z.d.). However, TCAS has its limitations, particularly at low altitudes. Its accuracy relies heavily on the precise altitude data reported by the aircraft involved. TCAS becomes less sensitive and less effective the closer the aircraft are to the ground ("Converging Approach And Take-off Operation", 2020). This significantly limits the effectiveness of TCAS in the very situations, such as a late missed approach versus a rolling take-off, where a quick response would be most critical.

Approximately one out of every 700 approaches at Schiphol result in a go-around ("Converging Approach And Take-off Operation", 2020). A go-around can be triggered by various factors such as poor weather, an unstable approach, the runway being out of sight, an occupied runway, or a failure to receive landing clearance, and more. During this phase of high workload, pilots prioritize establishing a safe climb (aviate), followed by navigation, and finally communication. Meanwhile, the air traffic controller closely monitors the situation.

A go-around is a standard procedure. It involves aborting the landing and following the lateral and vertical paths outlined in the missed approach procedure, as specified in the Aeronautical Information Publications (AIP) for pilots (*GEN 2.7 SUNRISE/SUNSET*, 2025). The missed approach procedure is designed to ensure safe separation from ground obstacles and other air traffic operating in the vicinity of the airfield. Once the decision to go around is made, the pilots must promptly inform ATC, usually within 10-20 seconds.

It is important to know that a go-around is not an emergency. It is a normal part of flying that pilots practice regularly. However, it can be used in emergency situations if needed. The most critical time for a go-around is when the plane is very close to the ground ((NTSB), 2013). Recognizing the need to go around early makes the maneuver safer. A go-around can be directed by ATC or initiated by the pilot. The flight crew does not need permission from ATC to perform a go-around, they can decide to do it whenever they think it is necessary for safety ((FAA), 2021). There are various methods to detect a go-around at Schiphol Airport within UDP ("Converging Approach And Take-off Operation", 2020):

- Direct visual observation by RC through the window.
- Monitoring the aircraft's altitude profile on the radar display in the tower.
- Receiving a go-around report from the pilots via radio communication (R/T).
- Utilizing the Go-Around Detection System (GARDS), which provides automatic visual and audio warnings when a go-around is detected.
- Receiving a warning from the arrival controller, who can observe the go-around on the radar display within the approach unit.

While go-arounds are standard procedures, they require precise coordination, especially in dependent converging runway operations where timing and visibility are critical ("VEMER", 2022). The ability to detect and respond to a missed approach in time is essential to maintain safe separation between aircraft. The next section outlines how these operations are structured, detailing the responsibilities of the RC, the procedures followed during different visibility conditions, and the safety protocols that support the use of dependent converging runways.

2.3 Description of dependent converging runway operations

Generally, one Runway Controller (RC) is responsible for both dependent converging runways when they are being used simultaneously for take-off and landing, so that in case the landing aircraft makes a go-around, the RC could intervene. A runway controller is a specialized Air Traffic Control (ATC) role, responsible for the direct management of aircraft movements on or near the runway. Within the UDP with good visibility of 5km or more and a cloud base higher than 2000ft, the RC applies visual separation between inbound and outbound traffic on the dependent runways, taking into account a possible missed approach of the inbound traffic when issuing the take-off clearance. The following conditions apply when issuing the take-off clearance ("Operations Manual", 2025):

- The approach is established on the final approach track
- The RC provides landing traffic with essential local traffic information about the departing traffic
- The RC monitors the landing to recognize a missed approach in time.

Numerous variables influence the decision to give take-off clearance. The Operations Manual (OM) states ("Operations Manual", 2025):

"RC monitors the landing of the arriving aircraft to recognize a missed approach in time."

Outside the UDP, the OM specifies ("Operations Manual", 2025):

"The RC gives the take-off clearance at such a time that the aircraft begins its take-off roll before the next landing aircraft on the dependent runway is 2NM from the runway threshold. If the take-off roll does not start in time, the RC cancels the take-off."

The rules outside the UDP are stricter compared to those inside the UDP. The RC applies visual separation and can give take-off clearance at their judgement, considering the possibility of a missed approach by the arriving aircraft. It is more effective to confirm an aircraft has landed within the UDP than outside the UDP. If the arriving aircraft performs a go-around, the RC can intervene by ("Operations Manual", 2025):

- Instructing the aircrew to turn or level off at a certain altitude
- Directing the aircrew taking off to abort the take-off or turn if already airborne or unable to abort.
- Providing traffic information to the involved air crews.

Before issuing take-off clearance to the departing aircraft, the RC provides the pilot with essential information. This includes the current wind conditions for the assigned runway, detailing direction, speed, and gusts of 5 knots or more, particularly if there is a significant deviation from the wind information broadcast via the Automatic Terminal Information Service (ATIS), which continuously provides pilots with updated weather, runway, and operational information at an airport. The RC also communicates wind details if the wind speed reaches 20 knots or higher ("Operations Manual", 2025). To further ensure a smooth departure, the RC informs the pilot of any significant weather changes that could impact the flight and delivers any additional departure instructions as necessary, ensuring that the pilot has all the crucial information needed for a safe take-off.

Approaching flights receive essential local traffic information about converging departure operations at Schiphol, if applicable. This did not change with the procedure update. Essential local traffic information is provided when a landing flight is within 2NM of the runway threshold and a departing aircraft begins its take-off roll on a runway that converges with the landing runway, due to the safety risk in the event of a missed approach and a simultaneously departing aircraft from a dependent converging runway. A departing flight within UDP with good visibility does not receive essential local traffic information about an approaching flight, because an approaching aircraft can see a departing aircraft, but a departing aircraft generally cannot see the approaching aircraft. Therefore, information about a departing flight on the simultaneous dependent runway is essential traffic information for the approaching flight, but information about the approaching flight is not essential traffic information for the departing flight ("Operations Manual", 2025).

Once all relevant information has been provided, and it is safe to proceed, the take-off clearance is issued. Pilots then apply power to the engines of the aircraft, initiating the aircraft's acceleration and take-off roll. In addition to issuing take-off clearances, the RC is also responsible for applying separation minima between departing aircraft ("Operations Manual", 2025). In particular, time-based separation is used when multiple aircraft are departing from the same runway. This type of separation ensures that adequate spacing is maintained based on the departing aircraft types involved, accounting for differences in wake turbulence generation and climb performance ("ICAO Wake Turbulence Groups (WTG)", 2023). The separation minima are defined in terms of elapsed time between departures and vary depending on the Wake Turbulence Categories (WTC) of the aircraft in front and behind (see table 2).

Table 2 WTC time-based separation minima in NM

WTC (Time-based separation minima in minutes)							
		Behind					
		A	**B**	**C**	**D**	**E**	**F**
In front	**A**	-	1:40	2:00	2:20	2:40	3:00
	B	-	-	1:20	1:40	2:00	2:20
	C	-	-	-	1:20	1:40	2:00
	D	-	-	-	-	-	2:00
	E	-	-	-	-	-	1:40
	F	-	-	-	-	-	1:20

Figure 3 shows examples of different types of aircraft, with each type grouped under its corresponding WTC to help better understand how they are classified.

Figure 3 WTC category with corresponding aircraft types (example)

Procedures differ inside and outside the UDP, but both aim to minimize the risk of aircraft converging at the common point. The next section examines a real-world example that highlights the importance of these procedures: a reference operation at Schiphol Airport where a go-around and a departure occurred simultaneously, illustrating the potential risks involved.

2.4 Reference operation

On March 29, 2018, an arriving aircraft performed a go-around from runway 18C while departures from runway 24 were occurring simultaneously. The incident happened within UDP, with good VIS of 5km and more and a CB higher than 2000ft. According to the OVV investigation, the departing aircraft took approximately 30 seconds to initiate its roll after receiving take-off clearance. At the moment the departing aircraft began its roll, the arriving aircraft was positioned 0.05NM beyond the runway threshold. According to the FAA: “The runway threshold is the designated beginning of a runway that is available for landing or take-off, marked with specific stripes (see figure 4 within the red rectangle)” (*Airport Marking Aids And Signs*, z.d.).

Figure 4 Runway threshold

The arriving aircraft was positioned in the red area of the risk analysis, as illustrated in figure 5 and appendix IV figure 24, which indicates that when the arriving aircraft conducts a go-around there is a high risk that the aircraft conducting a go-around and a departing aircraft will meet each other on the common point. The probability for each dependent runway combination is represented by using color codes (red, orange, yellow, and green) to indicate the probability of aircraft pairs crossing the intersection point simultaneously (*VEMER*, 2022) (Refer to Appendix IV for the risk analysis per runway combination).0 represents the runway threshold, with distance X being either positive or negative. A negative value indicates the aircraft is beyond the runway threshold, while a positive value indicates it is before the threshold. In this case, the arriving aircraft was at X=-0,05NM beyond the runway threshold, placing it in the red area of the risk analysis, while the departing aircraft was starting to roll and continued to take-off. This situation resulted in both aircraft flying too close to each other at the common point (“Verminderde Separatie Na Doorstart,” 2020).

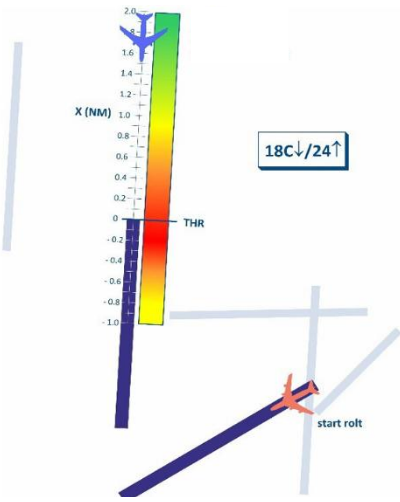

Figure 5 Risk analysis 18C/24

Similar incidents occurred in the United States (US), as the US has multiple dependent converging runway combinations. In the US, the FAA uses a so-called Arrival Departure Window (ADW) as a mitigating measure for converging approach and take-off operations. In short, an ADW is a pre-defined region along the approach path that must be free of arriving aircraft before air traffic controllers can release a departure. If the ADW is applied by the RC, it increases the likelihood that arriving and departing aircraft will remain at a safe distance from one another in case the arriving aircraft conducts a go-around. The essence of ADW regarding risk reduction is thereby comparable with timing procedures. The ADW acts like a “safety buffer” and is carefully calculated using simulations that consider factors like aircraft speed, runway layout, weather, and local procedures. The FAA then adds these windows to the controllers' displays so they can quickly and easily determine when, during an arrival's approach, it is safe to release a departure (Federal Aviation Administration, 2023). If the design principles are applied for the Schiphol specific context for the configuration L18C/S24, the window will have the size from -0,5NM to 1,8NM from the threshold of 18C (refer to figure 6).

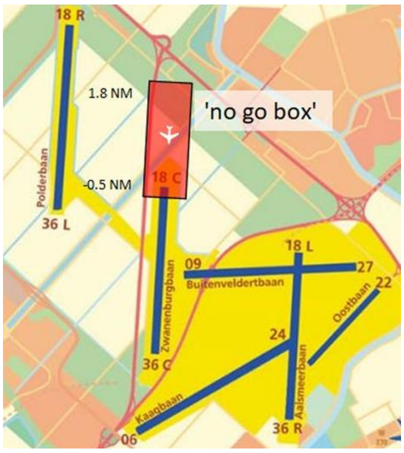

Figure 6 Impression of ADW Schiphol ((“Converging Approach And Take-off Operation”, 2020)

As the use of ADW is highly effective in the US, the feasibility of the ADW for Schiphol operation is low, as it has a negative effect on runway capacity due to the increased spacing between approaching aircraft to meet the constrains of the ADW on both sides of the window (“Converging Approach And Take-off Operation”, 2020). However, to mitigate the risks associated with dependent converging runway operations at Schiphol Airport, specific safety measures for operations at Schiphol Airport, were introduced by LVNL in 2022 for operations inside the UDP with good visibility conditions. The following section outlines the safety measures developed in response to such incidents at Schiphol Airport, focusing on procedural improvements, RC training, and operational adjustments designed to reduce the likelihood of similar incidents in the future inside UDP with good weather conditions.

2.5 Safety measures

Based on the incident of 2018, after thorough investigation, safety measures have been implemented into the operation inside UDP with a good VIS of 5km and more and a CB higher than 2000ft. The modeled safety risks in converging departure and arrival operations generally show a balance between the risks associated with two scenarios involving a rolling departure. These scenarios are: one where an aircraft on a missed approach is mistakenly assumed to have landed, and another where the missed approach involves the next arriving aircraft. The risk contributions of both scenarios vary depending on the specific runway combinations (“Training Convergerend Landen/Starten”, 2022).

Within UDP with good visibility (VIS ≥ 5km and/or CB > 2000ft), the reduced separation procedure applies. The term 'reduced separation' refers to the application of visual separation, as the RC determines the minimum separation within UDP with good visibility, based on their judgment. This procedure is different from the procedure “Reduced Separation Between Departing and Landing Traffic” that was removed from the OM as part of the safety measures, as this procedure allowed an exception that allowed ATC to give take-off clearance before the landing aircraft had fully completed its landing under certain conditions. With the current procedure, the RC considers the possibility of a missed approach when issuing take-off clearance. The RC gives take-off clearance at a point when the departing aircraft can begin its take-off roll before the next arriving aircraft reaches a defined distance (X in NM) from the runway threshold ("VEMER", 2022). Monitoring the landing to promptly identify a missed approach is standard practice for the RC. Therefore, within the UDP and under good visibility, it is not strictly required to wait for the landing to be confirmed before clearing a departure. However, during training, it is emphasized that for converging runway operations, it is safer to issue take-off clearance only after the landing has been confirmed ("Aanbeveling 990 ISMS: Convergerende Approach en Take-off Operaties", 2022). This visual separation procedure aligns with ICAO standards. Monitoring the landing to promptly identify a missed approach is standard practice for the RC.

Furthermore, before the safety measures were introduced, LVNL noticed that there were big differences in the time it took for aircraft to start rolling after receiving take-off clearance. This increased the risk of departing aircraft coming too close to aircraft performing a go-around, as what happened in 2018. According to the risk analysis, the interval between receiving take-off clearance and the time of the roll initiation had an average of 20 seconds (*VEMER*, 2022). When a departure is slow to start rolling, controllers may feel pressured to issue take-off clearance before a landing has fully completed, even as the next inbound aircraft is close to the runway threshold. To find a solution, LVNL analyzed how the size and weight category of an aircraft (light, medium, heavy or super) affects the time it takes to start rolling. Heavier aircraft generally require more time to initiate take-off, while smaller planes can begin moving more quickly. Additionally, LVNL looked at how other airports handle this. They noticed that Helsinki Airport (EFHK) has a clear rule regarding the timeframe between the take-off clearance and the start of the take-off roll:

"Air traffic control assumes, and bases the traffic planning, on the fact that the aircraft will start their take-off roll within 10 seconds of issuing the take-off permission. If the pilot is unable to comply with these regulations, they must inform air traffic control before taxiing to the runway (eAIP Finland, 2024)*."*

Based on this example, LVNL introduced the "10-second" guideline in 2022 as part of the safety measures. To address this issue at Schiphol Airport and improve overall timing and safety, adjustments have been made to the published flight procedures. To make pilots aware of this procedure, the information provided to pilots has been updated. This information emphasizes the importance of starting to roll as soon as the clearance is given, specifically within 10 seconds. The AIP states the following to pilots (*GEN 2.7 SUNRISE/SUNSET*, 2025):

"1.3.3.3 Minimum runway occupancy time
Converging departure and approach procedures may be in progress. To avoid conflicts with possible missed approaches:

- *Complete all cockpit checks before line-up.*
- *Expedite line-up and start the take-off roll within 10 seconds after receiving the take-off clearance.*

When unable to comply with the above, inform ATC as soon as possible. The take-off clearance may be revoked."

Furthermore, the AIP states the following in the Standard Instrument Departure (SID) documents:

"*Execute take-off immediately after receiving the clearance due to converging approach and departure procedures"* (see appendix V as stated in the red square, for an example of the SID of runway 24).

Furthermore, during the design phase of the safety measures, it was determined that the occasional use of the dependent runway combination for landings on runway 06 with 36R with departures from runway 09 is due to the number of dependencies involved not permitted anymore ("Aanbeveling 990 ISMS: Convergerende Approach en Take-off Operaties", 2022).

Finally, during the design process, it also became clear that additional training regarding procedures for approach and departure operations on converging runways at EHAM (Amsterdam Schiphol Airport) with good VIS conditions and inside the UDP, could further reduce risks. For this reason, LVNL has internally set requirements for the implementation of the procedural change.

2.5.1 RC Training

The training program comprised a series of presentations and simulator (SIM) sessions. The presentations included color-coded risk charts derived from the risk analysis, designed to raise controller awareness of the hazards associated with dependent converging runway operations. In contrast, the SIM sessions concentrated on practicing go-around procedures involving various combinations of converging runways (“Timing For Converging Approach And Take-off Operations Inside UDP And Good Visibility Project 2592”, 2022). The training covered several key areas (*Aanbeveling 990 ISMS*, 2022):

- Creating awareness: The RC monitors a landing to detect a missed approach in time.
- Essential traffic info: The RC provides essential local traffic information about departing traffic to landing aircraft at their discretion.
- Splitting responsibilities: Clarifying which RC is responsible for what and the communication flows used.
- R/T (Radiotelephony): Focusing on the R/T for aborting a take-off.

Additionally, the training highlights the importance of considering the following when issuing take-off clearance to departing aircraft (*Aanbeveling 990 ISMS*, 2022):

- The traffic situation in the Control Zone (CTR)
- The runway combination
- The type of aircraft (e.g., take-off weight)
- Weather conditions (e.g., wind direction)
- Final approach speed
- Operators

A landing is considered complete when a missed approach is no longer possible. In the aircraft, this occurs when the thrust reverse is activated. While wheel brakes are the primary method for stopping an aircraft, reverse thrust, when available, helps to slow it down. Some thrust reverser systems are designed to redirect the exhaust gases in the opposite direction (“Airplane Flying Handbook”, 2021). However, the thrust reverse is not always visible to the RC, making it difficult to determine if the landing is complete. The RC can conclude that the landing is completed in the following ways (“Operations Manual”, 2025):

- Using the track vector.
- Visual observation.
- On a wet runway within UDP, possibly by observing the water spray caused by the thrust reverse.
- A significant reduction in speed.
- The aircraft has turned off the runway.

There are two conflict scenarios associated with dependent converging runway operations, as outlined in the training PowerPoint for the RC (“Training Convergerend Landen/Starten”, 2022):

1. RC assumes that the arriving aircraft has landed or is about to land

In this scenario, the air traffic controller believes that the inbound aircraft has either already landed or is about to touch down (see figure 7 for a visualization of conflict scenario one). However, instead of completing the landing, the pilot unexpectedly initiates a missed approach while still flying above or close to the runway, this is known as a late missed approach. At the same time, a second aircraft, which has been cleared for departure, starts its take-off roll on a dependent runway.

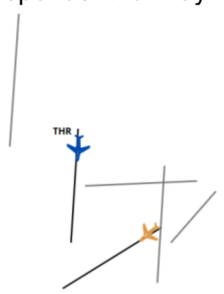

Figure 7 Conflict scenario 1

2. Arriving aircraft has landed, at the same time an approaching aircraft (number two) initiates a missed approach

In this situation, the arriving aircraft has safely landed and exited or is exiting the runway. The next approaching aircraft, which is following in the arrival sequence, is still some distance away, which is called distance X, but for one reason or another, the pilots decide to initiate a missed approach (see figure 8 for a visualization of conflict scenario one. At the same time, the departing aircraft has just started its take-off roll.

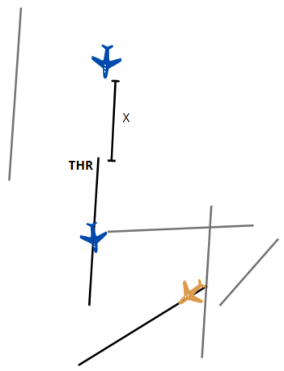

Figure 8 Conflict scenario 2

The SIM training consisted of a set number of exercises, where each lasted approximately forty minutes per person. This training allowed the RC to simulate real-world situations and familiarize themselves with procedures in a safe testing environment. The general scenarios covered during these training days included:

- Different runway combinations
- Various aircraft type combinations
- Different wind strengths and directions
- Final approach speed
- Splitting
- Essential traffic information
- Monitoring the landing

In conclusion, this training ensures that the runway controllers are well prepared to safely manage converging runway operations and respond effectively to missed approaches. This training must be repeated every two years in the Tower SIM.

3 Methodology

This chapter outlines the methodology used to evaluate the 2022 safety measures for dependent converging runway operations at Schiphol Airport. The research combines quantitative and qualitative approaches. The sections follow a structured process, covering data collection, cleaning, analysis, and visualization to assess the three sub-objectives. This mixed-methods approach ensures a comprehensive understanding of how the measures are applied and their impact on operational safety. The quantitative component focuses on analyzing aircraft positioning and timing during simultaneous arrival and departure operations. Specifically, it examines:

1. The position of an arriving aircraft relative to the runway threshold (distance X) at the moment a departing aircraft begins its take-off roll.
2. The time interval between the issuance of take-off clearance and the initiation of the take-off roll.
3. Reported occurrences before and after the implementation of the safety measures.

The qualitative component includes a complementary analysis in the Schiphol Tower, interviews and surveys with runway controllers and pilots to explore operational practices, training effectiveness, and awareness of the safety measures. As shown in figure 9, the evaluation combines various analyses and sources of information. This comprehensive approach enhances the robustness and validity of the findings.

Figure 9 Analysis and sources of information for the evaluation of the safety measures applied in daily practice

3.1 Quantitative research

The following sections examine the distance from the runway threshold to where the first arriving aircraft is located at the moment a departing aircraft begins its take-off roll. In addition, it analyzes the time interval between the issuance of take-off clearance and the initiation of the take-off roll, as well as the number of reported occurrences before and after the implementation of safety measures.

3.1.1 Distance from runway threshold at departure initiation

This research investigates the location (distance X) of the approaching aircraft from the runway threshold, when a simultaneously departing aircraft from a dependent converging runway starts to roll to evaluate the impact of the controller training on operational behavior (refer to figure 10 as an example of dependent runway combination L18C/S24 with the arriving aircraft located at distance X from the threshold, at roll initiation).

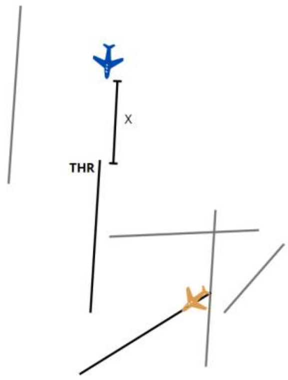

Figure 10 Distance X

Data collection

The departing aircraft starts to roll after it is cleared for take-off. At that moment, an aircraft on final approach is located at distance X from, at or beyond the runway threshold. Distance X is an important indication in what areas, of the risk analysis the approaching aircraft is located from the runway threshold, at the time a simultaneously departing aircraft is starting to roll. In order to conduct this research, access to data is essential to determine distance X of the approaching aircraft. For this purpose, a data sample has been extracted from the LVNL VEMMIS (Safety Efficiency Environment Management Information System) database and was delivered in Microsoft Excel. This data sample spans from January 2015 to March 2025, including the period before the safety measures were introduced (January 2015 to July 2022) and the period after the safety measures were introduced (August 2022 to March 2025).

The data sample contains 395.165 rows, each representing different dependent runway operations where the distance X varies for each scenario, as the take-off clearance is given at different moments when the arriving aircraft is at a certain distance from the runway threshold. Appendix VI represents the dataset that was acquired. The table below (table 3) describes the key variables included in the dataset that are needed for the analysis of distance X at the time a departing aircraft starts to roll.

Table 3 Most relevant variables included in the Excel dataset

Variables	Definition
ARR_DIST (distance X)	Distance, measured in Nautical Miles, from the runway threshold of the arriving aircraft at the time the departing aircraft starts to roll.
UDP	Whether the operation is inside or outside UDP
Sight	Categorized as good, BZO, or marginal
VIS	Measured in kilometers
CB	Measured in feet
RWY_COMB	Identifies the specific runways involved in the simultaneous departure and arrival of aircraft

The risk analysis of the fifteen dependent converging runway combinations was also provided in both Excel and in a separate document (refer to appendix IV). The aim was to analyze the number of aircraft flying in the more critical areas of the risk analysis after the safety measures were introduced, compared to the time before the safety measures were introduced. While the risk analysis includes transitions from one color to another, the analysis did not focus on the transition. These transitions are applied in the risk analysis because aircraft passing the intersection point at the same time, are dependent on multiple variables. The degree to which these numbers of aircraft flying in critical areas is an indication of the effectiveness of dependent converging runway operations.

Data Cleaning

To analyze the distance of arriving aircraft at the moment a departing aircraft begins its take-off roll from a dependent converging runway combination, a structured data cleaning and selecting process was applied in Microsoft Excel. A dynamic data summarization method was chosen in Excel for its ability to efficiently filter, organize, and summarize large volumes of information. This method allows for quickly selecting relevant data segments and supporting clear visual analysis. By cleaning and preparing the data, the most relevant and reliable information was used. This step helped make sure that the results would be accurate and meaningful. The cleaning process involved several steps to filter out irrelevant or incomplete data and to organize the rest in a way that made it easier to compare operations before and after the safety measures were introduced.

3.1.1.1.1 Selecting the dataset according to the defined criteria

The first step involved selecting the dataset according to the defined criteria. The dataset included various sight conditions, such as “Good” visibility, “Marginal,” and several “Limited Visibility Conditions (BZO)” categorized as BZO-A, BZO-B, BZO-C, and BZO-D. To align with the scope of the analysis, the dataset was selected to retain only instances that met the following criteria: “Good” visibility within the UDP, VIS of 5km or more, and a CB above 2000ft. Additionally, instances where no CB was reported were treated as having a CB above 2000ft, under the assumption that the absence of a CB indicates clear skies.

To facilitate a comparative analysis of operations before and after the implementation of the 2022 safety measures, the dataset was segmented into two distinct time periods. The first period, referred to as the situation before the safety measures, spans from January 2015 to 14^{th} of July 2022. The second period, after the safety measures, covers 15^{th} of July 2022 to March 2025. To enable this segmentation, a new variable, labeled “Before-After,” was created by extracting the year and month from the timestamp associated with each operation. This new variable clearly distinguishes between the two phases where “Before” includes the situation before the safety measures ranging from January 2015 to the 14^{th} of July of 2022 and “After” includes the situation after the safety measures ranging from the 15^{th} of July 2022 to March 2025. This allowed for efficient filtering and grouping of data by time period. This variable would be used in the analysis to compare aircraft behavior across the two periods.

3.1.1.1.2 Ensuring the presence of arriving aircraft located at distance X

A key variable in the analysis is the position of arriving aircraft from the runway threshold, referred to as distance X, when a departing aircraft initiates its roll. However, some rows in the dataset documented a departing aircraft initiating its take-off roll while no arriving aircraft was present at the relevant distance X (refer to appendix VI, the first row and the last row of the data set do not include an aircraft at distance X at roll initiation). When there is no aircraft located at distance X, it will look like as shown in the figure below (see figure 11). These cases were excluded from the analysis. This is done by adding an extra column to the dataset. This new variable identifies whether an arriving aircraft was located at distance X at the moment the departure started. A value of “True” indicates that an arriving aircraft was present at distance X from the runway threshold at the time when a departing aircraft is starting to roll, while “False” indicates that no such aircraft was present at distance X. Only rows with a “True” value were retained for further analysis. This step was crucial to ensure that the dataset exclusively reflected valid instances of dependent converging runway operations, where both arrival and departure events were occurring simultaneously.

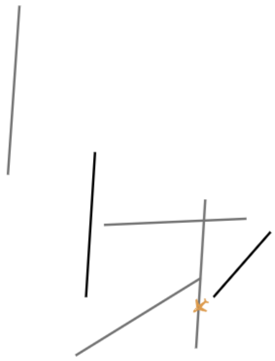

Figure 11 Operations involving only departing aircraft with no arriving aircraft located at distance X

Following the data cleaning process, a total of 140,951 valid operations were identified for the period before the implementation of the safety measures, and 45,499 for the period after. These filtered datasets formed the basis for data analysis and visualization.

Data analysis and visualization

Not all fifteen dependent converging runway combinations of Schiphol Airport are utilized in the period between January 2015 to March 2025. The dataset includes the following dependent runway combinations that are utilized within the period from January 2015 to March 2025:

- L06/S09
- L06/S18L
- L18C/S24
- L22-S18L
- L27/S18C
- L27/S36C
- L36R/S09

The dependent runway combinations L06/S18L, L22/S18L, L27-S18C, and L27/S36C are hardly ever utilized, resulting in insufficient data for thorough analysis. Additionally, the risk analysis indicates that the accident probability for the combinations L06/S18L, L27/S18C, and L27/S36C is negligible or moderate (refer to appendix IV for a visualization) ("VEMER", 2022). Due to the lack of proper data, a detailed analysis as for the other runway combinations is therefore not feasible and the analysis only focusses on the runway combinations L06/S09 and L18C/S24. These combinations are used regularly, and the risk analysis shows that their accident probabilities are relatively moderate and high, respectively. For each of these runway combinations, three different statistical analysis have been done:

1. Distribution analysis of aircraft locations
2. Normalization and percentage calculation
3. Comparative visualization and risk analysis overlay

The first analysis captures the **number** of arriving aircraft at various distances (X in NM) from the runway threshold at the moment a departing aircraft begins its take-off roll. This analysis is conducted for each of the two runway combinations (L06/S09 and L18C/S24). It reflects the situation prior and after the implementation of the safety measures and includes the defined criteria with the dependent variable "before-after" ranging from January 2015 to the 14th of July 2022 for before the safety measures and the 15th of July 2022 to March 2025 for after the safety measures.

The aim is to compare the situation before and after the safety measures were introduced to identify how the safety measures have impacted the operation with dependent converging runways inside the UDP with good visibility. To enable a meaningful comparison between the situation before and after the introduction of safety measures, the **percentage** of arriving aircraft at a specific distance X when a departing aircraft starts to roll, was calculated. This calculation will help normalize the data, allowing for a meaningful comparison despite the different lengths of the periods before and after the safety measures were introduced. This is because the number of arriving aircraft before the safety measures is different from the number of arriving aircraft that are positioned at distance X when a departing aircraft starts to roll. The dataset spans from January 2015 to March 2025. Safety measures were introduced in July 2022, so the period before their implementation includes more arriving aircraft, as it covers over seven years of data compared to almost four years after the implementation of the safety measures. To normalize the data and facilitate a valid comparison for both L06/S09 and L18C/S24, the number of aircraft at each distance X was converted into a percentage of the total number of aircraft observed during the respective period (from January 2015 to July 14th, 2022, before or July 15th, 2022, to March 2025). This transformation was performed using the following formula:

$$Percentage_{(Before/after)} = \left(\frac{Number\ of\ arriving\ aircraft\ at\ distance\ X\ (before/after)}{Total\ number\ of\ arriving\ aircraft\ (before/after)}\right) * 100 \quad \textbf{(3.1)}$$

In this formula, the numerator represents the number of aircraft observed at a specific distance X from the threshold prior or after the introduction of safety measures. The denominator reflects the total number of arriving aircraft across all distances X during the same period. This calculation provides the distribution of aircraft positions at distance X relative to the runway threshold before or after the safety measures were applied.

After the percentages of arriving aircraft at a specific distance X were calculated, two graphs were created per runway combination to visualize the distribution of arriving aircraft in percentage of the total amount of aircraft located at a specific distance X from the runway threshold, at roll initiation of departing aircraft. This approach offers a clear and structured overview of aircraft distribution relative to the runway threshold during the initiation of the take-off roll. One graph represents the situation before the safety measures, and the other graph represents the situation after the safety measures. To effectively compare these for the third analysis, the two graphs created per runway combination are then combined into a single graph. This configuration allowed for a side-by-side comparison of the percentage of aircraft at each distance X across both periods. By presenting the percentage of aircraft at each distance X side by side for both time periods, it becomes possible to clearly identify any shifts in operational behavior that may have resulted from the safety measures. It allows for a direct, visual comparison of how aircraft positioning has changed, helping to determine whether the training for the runway controllers was effective.

To analyze in what areas of the risk analysis these aircraft are located in both before and after the safety measures, the combined graph is then overlaid onto the risk charts with color-codes of the risk analysis. This approach highlights how the distribution of aircraft has shifted across different risk zones, offering a more comprehensive understanding of the impact of the safety measures.

3.1.2 Time interval from take-off clearance to roll initiation

The research focuses on evaluating the time interval between receiving take-off clearance and the initiation of the roll, particularly after the implementation of safety measures. The data was collected through sample measurements of radio transmissions and ground radar data during peak periods at Schiphol Airport, specifically for the dependent runway combination L18C/S24.

Data collection and cleaning

Radio transmissions were accessed through IRIS, which is a system of LVNL that stores voice recordings for up to 90 days. Therefore, the research concentrated on one week of data during peak periods from March 2 to March 8, 2025, when the dependent runway combination L18C/S24 was most frequently used. Firstly, the frequency used by RC to give take-off clearance to aircraft departing from runway 24 was identified, which has a frequency of 135.110 Megahertz (MHz). The radio transmissions captured the exact moment the RC began speaking to provide take-off clearance. This timestamp was used as the starting point for measuring the time interval, aligning with the procedure followed in the research before the safety measures were introduced. This method ensured consistency in comparing results before and after the safety measures to identify changes in the time between take-off clearance and roll initiation in situations before and after the safety measures. By focusing on a specific week in March 2025, the research aimed to capture a representative sample of peak period operations, providing a robust dataset for analysis. After recording the timestamp of the start of the take-off clearance, the radar data was analyzed to establish when the aircraft started to move.

Ground radar data was retrieved using the LYNX system of LVNL, which archives all radar recordings. Peak periods were identified when the dependent runway combination L18C/S24 was used alongside another runway, indicating high traffic moments at Schiphol Airport. During these peak periods, multiple aircraft ready for departure on runway 24 were observed. The radar data included aircraft labels showing the type, callsign, and speed. Since the RC often begins with the callsign and may include weather information before issuing clearance, it was essential to verify that the radar data matched the correct aircraft to ensure alignment between the aircraft called by RC and the one on the radar.

The analysis focused on aircraft that made a full stop on the runway before take-off, excluding those that performed a "rolling take-off." The speed data helped determine whether an aircraft performed a rolling take-off. The speed is equal to 0 when the departing aircraft would make a full stop on the runway. The timestamp of the moment the aircraft began moving was recorded as the end point of the interval. The radar data provided a comprehensive view of the aircraft's movements, enabling a detailed analysis of the time intervals involved.

3.1.2.1.1 Data sampling

The data sample included thirty hand-clocked instances per day, with fifteen samples taken in the morning and fifteen in the afternoon, both during peak periods and inside UDP. This sampling strategy was designed not only to capture the time interval between take-off clearance and roll initiation to compare the situations before and after the safety measures but also aimed to identify factors influencing this time interval. This dataset included a total of 12 columns and 195 rows (see table 4). The columns included:

Table 4 Hand-clocked dataset time between take-off clearance to roll initiation

Variables	Definition
Dependent runway combination	This runway combination includes L18C/S24.
Callsign of departing aircraft	The callsign of the departing aircraft, indicating the flight number and the ICAO airline three-letter code (e.g., KLM123, where KLM indicates the airline and 123 the flight number).
Corresponding airline	The airline of the departing aircraft.
WTC	Categorized as Heavy, Light, or Medium.
Aircraft type	The specific make and model of the departing aircraft.
Date	The date of the situation.
Day	The day of the week (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, or Sunday).
Time of day	Including, morning or afternoon (inside UDP).
Weather conditions	Including the weather conditions on runway 24.
Moment of start of providing take-off clearance	The time when the RC starts speaking to provide take-off clearance to the departing aircraft (in seconds).
Moment of roll initiation	The time when the aircraft starts to move on the radar (in seconds).
Total time interval	The time between the start of the RC's message to provide take-off clearance and the roll initiation.

The variables "Aircraft type, WTC, Airline, Day, Time of day, and Weather conditions" are factors that can influence the time interval between take-off clearance and roll initiation. Weather conditions, the day of the week and the time of day including the morning and afternoon were assumed to have a minimal impact on the time interval between take-off clearance and roll initiation. Consequently, these factors have not been analyzed.

Data analysis and visualization

In 2019, prior to the introduction of the 2022 safety measures, a time-based analysis was conducted to examine the interval between the issuance of take-off clearance and the initiation of the take-off roll. This analysis was based on 124 manually recorded observations and supported by operational data from LVNL's radar data and radio transmission systems. The results were visualized using a frequency-based bar chart, which grouped the time intervals into defined ranges to illustrate how often each range occurred. This approach provided a clear overview of the distribution of operational timing behavior, offering insight into variability and potential delays.

The purpose of the analysis of 2019 was to visualize the distribution of these time intervals into a graph in order to identify if the operations have changed since the implementation of the safety measures. By replicating this analysis, the study aims to establish a baseline for comparison. To create this visualization, the "data analysis" function in Excel was utilized to generate an identical bar chart to 2019. This specific chart requires an input range and a bin range. The input range included the time intervals between take-off clearance and roll initiation. The bin range was spanned from t(s) = 0 seconds to t(s) = 50 seconds, consistent with the graph for scenario before the safety measures. Once the input of the number of aircraft taking a specific time from take-off clearance to roll initiation and bin ranges were defined, the graph was generated for the sample of 2025. This allowed for a side-by-side comparison of operational behavior before and after the implementation of the safety measures. To facilitate this comparison, both bar charts were combined into a single visual representation. However, due to the difference in sample sizes, a direct comparison of the situation before and after the safety measures would be misleading. To address this, the data was normalized by converting the number of aircraft in each time interval into a percentage of the total sample size. This normalization allowed for a fair and accurate comparison between the two datasets. The percentage for each interval was calculated using the following formula:

$$Percentage_{(Before/After)} = \left(\frac{Number\ of\ aircraft\ at\ \ a\ specific\ t(s)\ (before/after)}{Total\ number\ of\ aircraft\ analyzed\ (before/after)}\right) * 100 \qquad \textbf{(3.2)}$$

In this formula, the numerator represents the number of aircraft taking a specific number of seconds from the take-off clearance to the roll initiation for both before and after the safety measures. The denominator reflects the total number of aircraft analyzed. This calculation provides the distribution of aircraft taking a specific amount of time from take-off clearance to roll initiation. This formula has been applied to both datasets. Additionally, the average time between the issuance of take-off clearance and the initiation of the take-off roll was calculated for both the 2019 and 2025 datasets. This calculation aimed to quantify any changes in operational timing behavior following the implementation of the 2022 safety measures. By determining the average (mean) time interval for each scenario, the study could assess whether aircraft generally began their take-off roll more quickly, more slowly, or with similar timing after the new procedures were introduced. The average values offer a straightforward and interpretable metric for assessing change over time. Furthermore, the mean values were also computed to provide a more comprehensive understanding of central tendencies in each dataset.

By comparing these averages and means side by side, the study adds a quantitative layer to the visual analysis, reinforcing conclusions drawn from the frequency distribution charts and supporting a more comprehensive evaluation of the impact of the safety measures on runway operations. However, the time between take-off clearance and roll initiation is dependent on multiple factors. Therefore, it is important to examine the factors that could influence the time between take-off clearance and roll initiation. The variables considered are WTC and the type of Airline.

3.1.2.1.2 Influencing factors

The first factor analyzed is WTC. A combined bar chart was created to show the distribution of the time interval between take-off clearance and roll initiation for aircraft in the Medium and Heavy categories. Light aircraft were not included in the sample of 195 aircraft, as they typically take off from runway 22 rather than runway 24. Out of the 195 aircraft analyzed, 150 were categorized as medium and 45 as heavy. Due to the difference in sample sizes, a direct comparison between the heavy and medium categorized aircraft would be misleading. Therefore, formula 3.2 was used to normalize the data. This combined bar chart helps identify whether aircraft weight class influences the time taken to initiate roll after clearance. In addition to the normalized distribution, the average and mean time intervals were also calculated separately for Medium and Heavy aircraft. These statistical measures provide further insight into whether heavy categorized aircraft tend to take longer to initiate roll after clearance compared to medium categorized aircraft.

Next, the influence of the operating airline was examined. Airlines were grouped into two categories: home carriers (KLM, Transavia, EasyJet, TUI, and Corendon) and other carriers. This grouping was based on the “Corresponding airline” variable. Of the 195 aircraft, 152 were operated by home carriers and 43 by other carriers. One combined bar chart was created to compare the time distributions for each group by applying formula 3.2. This combined bar chart aims to reveal whether different carriers have a measurable impact on the time interval between take-off clearance and roll initiation. To complement the visual analysis, the average and mean time intervals were also calculated for each airline group. These values help determine whether home carriers initiate take-off roll more efficiently than other carriers.

3.1.3 Limitations and assumptions

The radar data updates every second. However, due to various reasons, the radar data sometimes updated 5 to 10 seconds later, indicating that some movements were not shown within those seconds. Therefore, some samples are not as accurate, as some aircraft started to move from the start of the runway to a quarter of the runway, with speeds increasing from 0 to, for example, 23 knots, due to the five second gap. Therefore, the analysis focused on the movements of the aircraft rather than the speed.

Additionally, the dataset included 195 rows instead of the intended 210 rows. During the week of March 2, 2025, to March 8, 2025, there was no peak moment on Saturday afternoon when the dependent runway combination L18C/S24 was utilized. Subsequently, these moments were searched in radar data system to determine if there was another peak moment on a Saturday afternoon involving the dependent runway combination L18C/S24 within the last 90 days (as the radio transmission system only retains data for 90 days). Since no such peak moment was found, the dataset includes 195 samples instead of the intended 210 samples.

3.2 Qualitative research

To complement the quantitative data, qualitative research was conducted. The first step of the qualitative research was to conduct a validation study in the Schiphol Airport ATC tower. This was necessary due to a known limitation in the radar data. To validate the hand-timed measurements, thirty samples were live collected directly from the ATC tower. These samples recorded the time from when the RC began speaking to when the aircraft initiated its roll, consistent with the quantitative research. This method eliminates the radar's timing limitations, with the only minor inaccuracy being human reaction time, which is considered negligible. After collecting the live observations, corresponding radar data was analyzed to compare timing accuracy. Two types of radar data were used: individual radar data, which displayed only the observed aircraft, and full radar data, which included all ground traffic at the time. To compare the live observation data with the radar data, three separate bar charts were created, done for each data type. These charts were then combined into a single visual to facilitate direct comparison. Furthermore, the average time between take-off clearance and roll initiation was calculated for each data type, and the mean values were also determined to provide a more comprehensive understanding of central tendencies across the three datasets. This validation allows for a direct comparison between radar data and real-time observations, highlighting any discrepancies and quantifying their magnitude.

Applying visual separation relies heavily on individual discretion, each RC may handle these operations differently. To gain insight into their experiences and decision-making processes, four runway controllers were interviewed. These interviews aimed to explore their perspectives on dependent converging runway operations and assess how training has influenced their approach. The interviews were initially transcribed using Microsoft Teams and Word. However, due to inaccuracies in the automated transcriptions, most of the content was manually corrected. Additionally, the interviews were coded to identify key themes and topics discussed. Full transcripts and coding details are provided in appendices XII to XVI.

Furthermore, six pilot surveys were distributed to pilots operating at Schiphol Airport, of which two were completed. Both respondents were pilots for home carriers. The survey included questions about the 10-second rule introduced in 2022, as outlined in the AIP and SID cards. It provided valuable insights into how pilots interpret and act upon take-off clearance, particularly in relation to this rule. One specific question asked for pilots to specify when they consider take-off clearance to be established, whether during the controller's transmission, immediately after the clearance is given, or following the pilot's readback. The responses offered useful perspectives on cockpit procedures and communication timing. The completed surveys can be found in appendix XI. Moreover, the ethical guidelines for both the interviews and pilot surveys are described in appendix X.

This chapter outlined the methods used to collect, analyze, and validate data on dependent converging runway operations at Schiphol Airport. Despite some limitations, the combination of quantitative and qualitative approaches provided a reliable basis for evaluating the impact of the 2022 safety measures. The findings from this methodology now form the basis for the results presented in the next chapter.

4 Results

This chapter presents the results of the qualitative and quantitative research. Each section highlights patterns observed in radar data, supported by qualitative insights from RC and pilots.

4.1 Quantitative analysis

The following sections will discuss the results from the analysis of aircraft positioning from the runway threshold (distance X) at departure initiation, time from take-off clearance to roll initiation and reported occurrences.

4.1.1 Analysis of aircraft positioning at departure initiation (L06/S09)

The distribution of aircraft positions has been overlaid onto the risk analysis framework (see figure 12 and Appendix VII for more detailed information). This distribution includes both the situation before and after the safety measures.

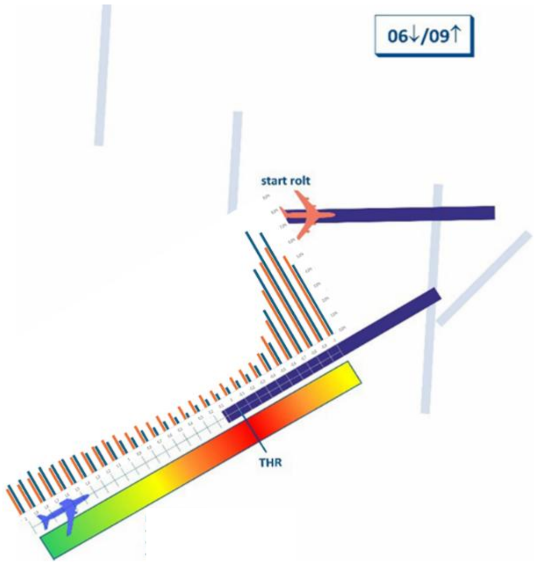

Figure 12 Distribution of distance X at roll initiation including both before and after safety measures plotted on the risk analysis L06/S09

Orange represents the situation before the safety measures, and blue represents the situation after. The horizontal axis indicates distance X from the location of the arriving aircraft in NM to the runway threshold in NM. These values can be both positive and negative. Distance X=0 is equal to the runway threshold of runway 06. While negative values are the distances beyond the runway threshold, the positive values are the distances before the runway threshold. The vertical axis indicates the percentage of aircraft (of the total number of aircraft in the period before the safety measures were introduced) at the corresponding distance X.

The graph reveals two distinct peaks in the distribution of arriving aircraft relative to the runway threshold at the moment a departing aircraft begins its take-off roll. The first peak, located farther from the threshold, shows a slight shift between the two periods. After the safety measures were implemented, this peak occurs at X=1,8NM, where 2,0% of arriving aircraft are positioned, compared to 1,6% before, which is a difference of 0,4%. Prior to the safety measures, the corresponding peak was at X=2,0NM, with 1,7% of aircraft positioned there before and 1,9% after, which is a difference of 0,2%.

From X=-0,5NM to about X=0,3NM, the situations before and after the safety measures stay quite flat and close together and have a higher percentage of arriving aircraft compared to the situation after the safety measures. The lowest percentage of arriving aircraft after the measures is observed at X=-0,4NM, where only 0,3% of aircraft are positioned, compared to 0,9% before, which is a difference of 0,6%. Conversely, the lowest percentage of arriving aircraft before the measures are located at X=0,1NM, with 0,7% of aircraft, compared to 0,4% after, which is a difference of 0,3%. Between X=-0,8NM and X=-0,1NM, there is a sharp increase in the percentage of arriving aircraft for both time periods. The second peak in the distribution, following the implementation of safety measures, occurs at X=-0,8NM, just beyond the runway threshold, where 7,8% of arriving aircraft are positioned at the moment a departing aircraft begins its take-off roll. This represents a 2,0% difference compared to the 5,8% observed at the same location before the safety measures. Prior to the safety measures, the corresponding peak was located slightly farther out at X=-0,9NM, where 6,4% of arriving aircraft were positioned, compared to 7,3% after the measures, a difference of 0,9%.

The implementation of the safety measures resulted in a noticeable shift in aircraft positioning across the risk zones defined in the analysis (see Table 5). This table summarizes the total percentage of arriving aircraft located within each risk zone at the moment a departing aircraft begins its take-off roll, both before and after the safety measures were introduced.

Table 5 Percentage of arriving aircraft positions in the defined areas of the risk analysis L06/S09

Arriving aircraft positions at departure initiation in the defined zones of the risk analysis		
Zones	**Before the safety measures**	**After the safety measures**
Green zones	36,0% of arriving aircraft positioned	39,2% of arriving aircraft positioned
Yellow zones	33,1% of arriving aircraft positioned	32,7% of arriving aircraft positioned
Orange zones	21,9% of arriving aircraft positioned	22,8% of arriving aircraft positioned
Red zones	9,0% of arriving aircraft positioned	5,3% of arriving aircraft positioned

The data in Table 5 shows a clear shift in aircraft positioning across the defined risk zones following the implementation of safety measures. Most notably, the proportion of aircraft located in the high-risk red zones at roll initiation, decreased significantly by approximately 41%. Additionally, the yellow zones saw a modest reduction of 1,2%, while the orange zones experienced a slight increase of 4,1%. The green zones, representing the lowest risk, showed the largest relative increase, rising by 8,9%.

The comparative analysis of aircraft positioning before and after the implementation of safety measures shows a clear shift in aircraft locations at roll initiation. Specifically, there is an increase in the proportion of arriving aircraft located in the green and orange areas, and a corresponding decrease in those positioned in the red and yellow areas at the moment a departing aircraft initiates its take-off roll.

4.1.2 Distribution of arriving aircraft at departure initiation (L18C/S24)

While the trends observed in runway combination L06/S09 suggest improved separation, it is important to assess whether similar patterns emerge for runway combination L18C/S24. This section analyzes the distribution of arriving aircraft relative to the threshold of Runway 18C, as part of the dependent runway combination L18C/S24, at roll initiation. The distribution of aircraft positions has been overlaid onto the risk analysis framework and compares the situations before and after the implementation of specific safety measures (see figure 13 and appendix VIII for more detailed information).

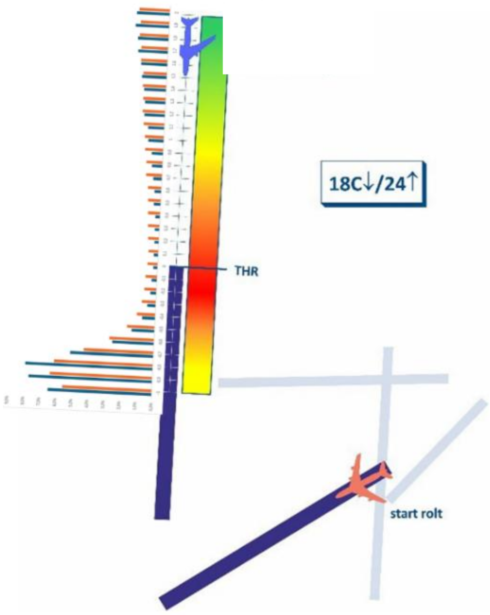

Figure 13 Distribution of distance X at roll initiation including both before and after safety measures plotted on the risk analysis 18C/24

Orange represents the situation before the safety measures, and blue represents the situation after. The horizontal axis indicates distance X from the location of the arriving aircraft in NM to the runway threshold. The vertical axis indicates the percentage of aircraft (of the total number of aircraft in the period before the safety measures were introduced) at the corresponding distance X.

The graph for runway combination L18C/S24 shows two distinct peaks in the distribution of arriving aircraft located at distance X at roll initiation, similar to the pattern observed for L06/S09. Notably, the situation after the safety measures reaches higher peaks than before the safety measures. The first and most prominent peak after the safety measures is located at X=-0,8NM, where 7,9% of arriving aircraft are positioned at the moment a departing aircraft begins its take-off roll, compared to 6,2% before, which is a difference of 1,7%. Prior to the safety measures, the corresponding peak was slightly farther out at X=-0,9NM, with 6,4% of aircraft positioned there before and 7,7% after, which is a difference of 1,3%.

Following this peak, both lines drop very quickly. From X=-0,3NM beyond the threshold to about X=0,6NM before the threshold, the situations before and after the safety measures stay quite flat and close together, with the situation before the safety measures showing slightly higher percentages of arriving aircraft. The lowest percentages of arriving aircraft after the measures are observed between X=-0,1NM to X=0,4NM, where only 0,3% of aircraft are positioned, compared to 0,6% to 0,9% before, which is a difference of 0,3% to 0,6%. Conversely, the lowest percentage of arriving aircraft before the measures are located at X=0NM (at the threshold) and X=0,1NM, with 0,6% of aircraft, compared to 0,3% after, which is a difference of 0,3%. However, starting around X=0,7NM to about X=1,9NM, the arriving aircraft between those distances start to increase for both situations. The increase here is much more gradual and smoother compared to the sharp spike earlier in the graph.

The second peak in the distribution occurs farther from the threshold. After the safety measures, this peak is located at X=1,9NM, where 2,1% of arriving aircraft are located at the moment of departure initiation after and 1,8% before, which is a difference of 0,3%. Before the safety measures, the corresponding peak was at X=2,0NM, with 1,9% of aircraft positioned there before and 2,1% after, which is a difference of 0,2%. The implementation of safety measures resulted in a noticeable shift in aircraft positioning across the risk zones defined in the analysis (see Table 6). This table summarizes the total percentage of arriving aircraft located within each risk zone at the moment a departing aircraft begins its take-off roll, both before and after the safety measures were introduced.

Table 6 Percentage of arriving aircraft positions in the defined areas of the risk analysis L18C/S24

Arriving aircraft positions at departure initiation in the defined zones of the risk analysis		
Zones	**Before the safety measures**	**After the safety measures**
Green zones	39,1% of arriving aircraft positioned	41,4% of arriving aircraft positioned
Yellow zones	41,4% of arriving aircraft positioned	43,9% of arriving aircraft positioned
Orange zones	12,5% of arriving aircraft positioned	11,3% of arriving aircraft positioned
Red zones	6,9% of arriving aircraft positioned	3,4% of arriving aircraft positioned

The data in Table 6 shows a clear shift in aircraft positioning across the defined risk zones following the implementation of safety measures. Most notably, the proportion of aircraft located in the high-risk red zones at roll initiation, decreased significantly by approximately 50,7%. Additionally, the yellow zones saw a slight increase of 6,0%, while the orange zones experienced a modest decrease of 9,6%. The green zones, representing the lowest risk, showed the largest relative increase, rising by 5,9%.

This paragraph has examined the distribution of arriving aircraft at the moment a departing aircraft is starting its take-off roll, focusing on how these positions relate to the defined areas of the risk analysis. After the safety measures were introduced, fewer aircraft were positioned in the red and orange areas, while more were located in the green and yellow areas. The most notable improvement was a 50,7% reduction in aircraft positioning in red areas.

4.1.3 Timing analysis between take-off clearance and roll initiation

This section presents a comparative analysis of aircraft behavior at Schiphol Airport for runway combination L18C/24, focusing on the time interval between receiving take-off clearance and initiating the roll. The data is segmented into two periods: the year 2019, representing the situation before the implementation of safety measures (orange bars), and the year 2025, reflecting the conditions after these measures were introduced (blue bars) (refer to figure 14).

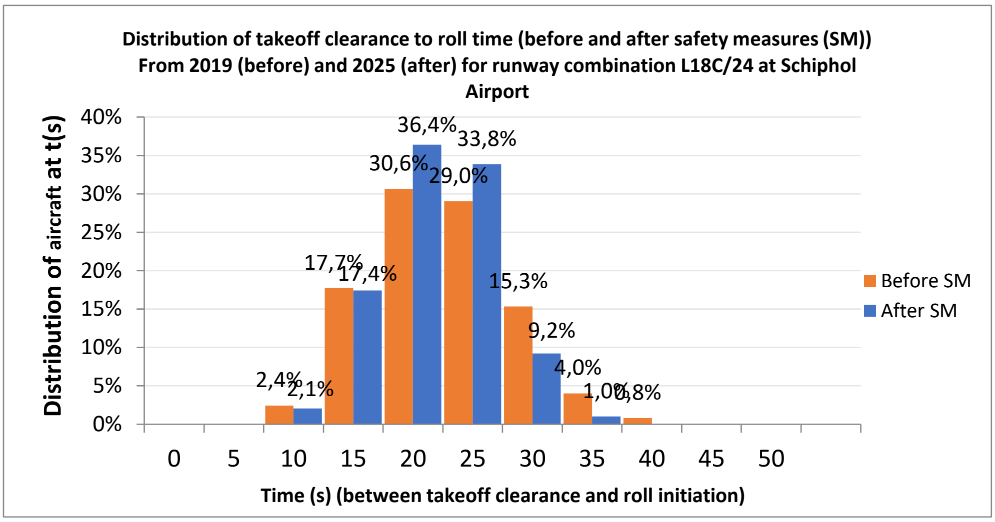

Figure 14 Interval from take-off clearance to roll initiation in percentage before and after the safety measures

The horizontal axis represents the interval in seconds, segmented in steps of 5 seconds. The vertical axis shows the percentage of aircraft that initiated their roll within each time interval. The bar-chart shows that in both 2019 and 2025, the most common time interval for aircraft to initiate their take-off roll is between 20 and 25 seconds after receiving clearance before the safety measures. These two-time bins together account for 70,2% of all aircraft in that year. In 2019, the data shows a broader and more evenly distributed pattern, with the majority of aircraft initiating their roll between 20 and 25 seconds as well as the situation after the safety measures, specifically, totaling 59,6%. The average time between take-off clearance and roll initiation before the safety measures was 19,8 seconds with a mean of 20 seconds.

After the safety measures, the average was 19,6 seconds with a mean of 20 seconds. The percentage at 15 seconds remains similar to 2019 at 17,4%, but the proportion of aircraft initiating roll at 30 seconds drops with 6,1% in 2025. Additionally, the tail of the distribution beyond 30 seconds becomes thinner, with only 1,0% of aircraft rolling at 35 seconds and none beyond 40 seconds. The data also shows that the number of aircraft initiating roll at 10 seconds has slightly reduced with 0,3% from 2019 to 2025, with no aircraft initiating their roll at 5 seconds or less in either year.

In summary, the data shows that the most frequent roll initiation times are consistently between 20 and 25 seconds in both years. The percentages at 15 seconds are nearly identical, while the percentages at 10 seconds and beyond 30 seconds are generally lower, especially in 2025. The distribution is more concentrated in the 20 to 25 second range in 2025 with an average of 19,6 seconds, while in 2019, there is a slightly broader spread across the 15 to 35 second range with an average of 19,8 seconds.

WTC-based variation in take-off clearance to roll time

This section analyzes the distribution of aircraft based on the time, in seconds, between receiving take-off clearance and initiating the take-off roll, segmented by WTC (heavy (orange) and medium (blue)) (refer to figure 15).

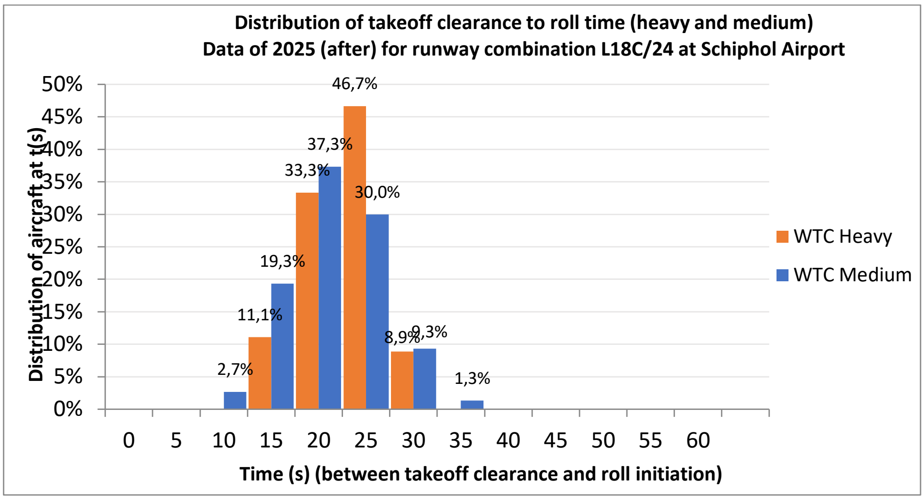

Figure 15 Interval from take-off clearance to roll initiation in percentage of heavy and medium aircraft

The horizontal axis represents the total time in seconds between issuing take-off clearance and the initiation of the take-off roll, segmented in steps of 5 seconds. The vertical axis shows the number of aircraft that take t(s) seconds between take-off clearance and roll initiation. The bar-chart reveals that the majority of aircraft in both WTC categories initiated their take-off roll between 20 and 25 seconds after receiving clearance, with 67,3% of medium aircraft and 80,0% of heavy aircraft falling within this interval. Heavy aircraft showed a higher concentration at the 25-second mark, while medium aircraft were more likely to initiate roll earlier, with a difference of 8,9% rolling at 15 seconds and 2,7% initiating at 10 seconds, whereas no heavy aircraft did so. No aircraft in either category began rolling at 0 or 5 seconds, and at 35 seconds, only 1,3% of medium aircraft initiated roll, with none from the heavy category. Additionally, no aircraft rolled at 40, 45, or 50 seconds. On average, medium aircraft initiated roll at 19,3 seconds with a mean of 19 seconds, while heavy aircraft averaged 20,6 seconds with a mean of 21 seconds.

In summary, the data shows that both Medium and Heavy aircraft most frequently initiate take-off roll between 20 and 25 seconds after clearance, with heavy aircraft showing a stronger concentration at 25 seconds. Medium aircraft show slightly more variation, with higher percentages at earlier times such as 10 and 15 seconds, and a small presence at 35 seconds. Heavy aircraft are more concentrated in the central time bins and absent from both the earliest and latest intervals.

Carrier-based variation in take-off clearance to roll time

This section analyzes the distribution of aircraft based on the time, in seconds, between receiving take-off clearance and initiating the take-off roll, segmented by airline type. The comparison is made between home carriers (Transavia, EasyJet, Corendon, KLM, and TUI) (blue bins) and other carriers (orange bins) (refer to figure 16).

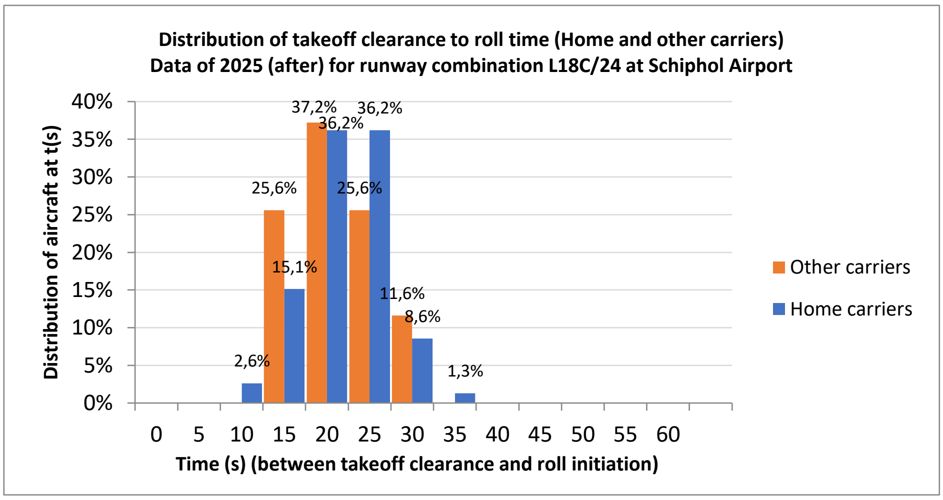

Figure 16 Interval from take-off clearance to roll initiation in percentage of home- and other carriers

The horizontal axis shows the time in 5-second intervals from 0 to 50 seconds, and the vertical axis shows the percentage of aircraft initiating roll within each interval. The bar-chart indicates that both home carriers and other carriers most frequently initiate their take-off roll between 20 and 25 seconds after receiving clearance. This 5-second interval accounts for 72,4% of home carriers and 62,8% of other carriers. However, other carriers tend to initiate roll slightly earlier, with 25,6% doing so, compared to 15,1% at 15 seconds compared to home carriers. At 10 seconds, 2,6% of home carriers began rolling, while no aircraft from other carriers did. Neither group initiated roll at less than 10 seconds. At 30 seconds, 8,6% of home carriers rolled compared to 11,6% of other carriers. Additionally, at 35 seconds, 1,3% of home carriers initiated roll, while no aircraft from other carriers did. No aircraft in either group rolled at 40, 45, or 50 seconds. On average, home carriers initiated roll at 19,7 seconds, while other carriers averaged 19,3 seconds with both having a mean of 20 seconds.

In summary, the graph and table show that both home and other carriers most commonly initiate their take-off roll between 20 and 25 seconds after clearance. Home carriers are more evenly distributed between these two bins, while other carriers show a stronger concentration at 20 seconds with an average of 19,3 seconds. Home carriers are the only group with any aircraft initiating roll at 10 or 35 seconds, with an average of 19,7 seconds. Beyond 30 seconds, the frequency of roll initiation is low for both groups, with no aircraft rolling after 35 seconds.

4.1.4 Reported occurrences before and after safety measures

The table below provides an overview of reported incidents involving conflicts between a departure and a missed approach during dependent departure and arrival runway operations in good visibility within UDP, covering the period from 2011 to 2021 (see table 7).

Table 7 Incidents reported from 2011 to 2021

Month/Year	Landing RWY	Departing A/C	Take-off RWY	Arriving A/C	Solution
Feb 2011	18C	B739	24	A332	ATC aborts take-off
May 2015	18C	A320	24	E190	ATC applies visual separation
Oct 2015	18C	A319	24	B77L	ATC aborts take-off
Jan 2016	22	B737	18L	A333	ATC applies visual separation
Apr 2016	18C	B737	24	A319	ATC aborts take-off
Aug 2016	18C	A321	24	B752	ATC applies visual separation
Jun 2017	22	A321	18L	E190	ATC applies visual separation
Mar 2018	06	A319	09	A333	ATC aborts take-off
Mar 2018	18C	B737	24	B738	ATC applies visual separation
May 2019	06	A320	09	B77L	ATC aborts take-off
Sep 2019	18C	A388	24	B788	ATC aborts take-off
Mar 2020	18C	A320	24	E190	ATC applies visual separation
May 2021	06	A21N	09	E75L	ATC aborts take-off

The first column ("Month/Year") indicates the date of the incident. The second column (Take-off RWY) specifies the runway used for the departing aircraft. The third column (Departing A/C) lists the type of departing aircraft. The fourth column (Landing RWY) identifies the runway designated for the arriving aircraft. The fifth column (Arriving A/C) shows the type of arriving aircraft. The final column (Solution) describes the action taken by RC to prevent the two aircraft from meeting each other at the common point simultaneously.

In the first table, which spans a ten-year period before the safety measures, a total of 13 incidents are recorded. These incidents involve a variety of runway combinations, with runway 18C being the most frequently used for landing and 24 for take-off, as they appear in 8 out of the 13 cases. The aircraft types involved vary widely, including narrow-body aircraft such as the A319, A320, and B737, as well as wide-body aircraft like the A332, A333, B77L, and A388 (see figure 3 for a visualization of the aircraft types). The solutions applied by ATC are split between aborting the take-off and applying visual separation. Specifically, 6 incidents resulted in an aborted take-off, while the other 6 were resolved through visual separation.

While this table includes the reported occurrences in the period from 2011 to 2021, a new table was created, covering the period after the safety measures from 2022 to 2025. This table also provides an overview of reported incidents involving conflicts between a take-off and a missed approach during dependent departure and arrival runway operations in good visibility within UDP (refer to table 8).

Table 8 Incidents reported from 2022 to 2025

Month/Year	Take-off RWY	Departing A/C	Landing RWY	Arriving A/C	Solution
Mar 2023	09	B78X	36R	-	ATC aborts take-off
May 2023	36C	BC3	27	A319	ATC aborts take-off
Sep 2023	24	A319	18C	B772	ATC aborts take-off
Jan 2024	24	A21N	18C	-	ATC aborts take-off
Oct 2024	24	B738	18C	A21N	ATC aborts take-off

The columns in this table are the same as those described for table 7. Additionally, table 8 covers a shorter period of three years after the implementation of the safety measures, which lists five incidents. All of these incidents resulted in aborted take-offs. None were resolved using visual separation. The runways involved are more varied, with take-offs occurring from runways 09, 36C, and 24, and landings on 36R, 27, and 18C. In two of the five cases, the arriving aircraft type is not specified. The aircraft types involved in departures include both narrow-body and wide-body aircraft, such as the B78X, A21N, and B738.

4.2 Qualitative analysis

The following sections will discuss the results from a complementary analysis in the Schiphol Tower, interviews and surveys with air traffic controllers and pilots.

4.2.1 Complementary analysis in Schiphol Tower

A total of thirty hand-timed samples were collected from the control tower at Schiphol Airport. These samples measured the time interval between the moment the Runway Controller began issuing take-off clearance and the moment the aircraft initiated its take-off roll. Specifically, the time was recorded at the start of the Runway Controller's transmission and when the aircraft physically began to move. To assess how these live observations compare to radar-based data, two sets of radar analyses were conducted after the tower measurements were completed. The first radar dataset included only the aircraft that were part of the hand-clocked sample, while the second included all aircraft visible on the ground at the time of each sample. Comparing these different sources helps show how closely radar data matches what actually happens in real time, and whether there are any noticeable differences.

Comparison between live observations and radar data

This section analyzes the distribution of the time interval between take-off clearance and roll initiation. The analysis compares data from live observations and two types of radar data. It highlights the differences between live measurements (blue bins) and what is recorded in the radar system, both for the specific aircraft sampled (orange bins) and for all aircraft on the ground at the time (gray bins) (see figure 17).

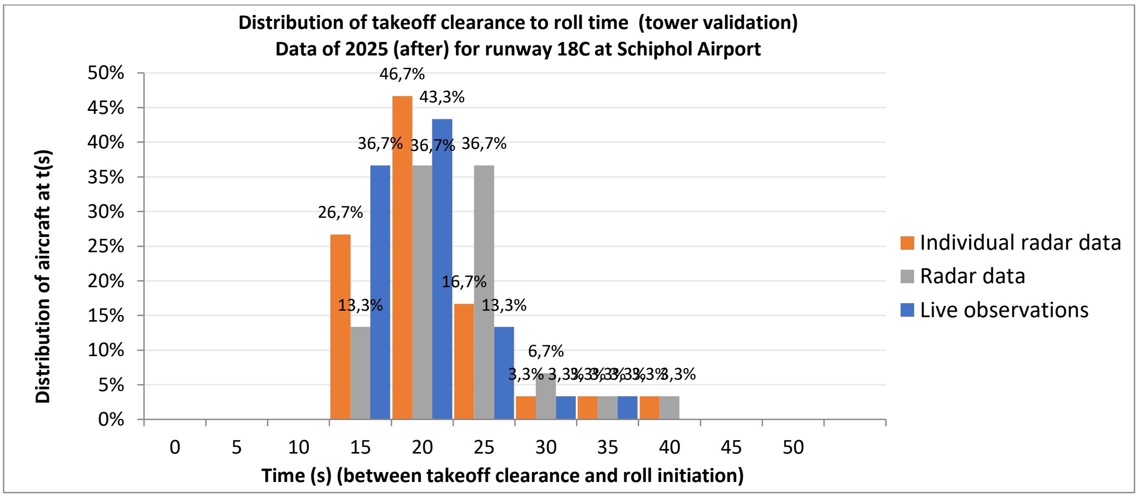

Figure 17 Interval from take-off clearance to roll initiation in percentage difference in observations

The horizontal axis represents the total time in seconds between issuing take-off clearance and the initiation of the take-off roll, segmented in steps of 5 seconds. The vertical axis shows the number of aircraft that take t(s) seconds between take-off clearance and roll initiation. The live data has an average of 17,5 seconds and shows that most aircraft begin rolling between 15 and 20 seconds after clearance, with 36,7% moving at 15 seconds and 43,3% at 20 seconds. When looking at the radar data for the same aircraft, with an average of 19,2 seconds, the distribution shifts slightly. While 46,7% of aircraft still begin rolling at 20 seconds, fewer are recorded at 15 seconds (26,7%), and more are shown taking longer, 17% at 25 seconds and small percentages even at 30 and 40 seconds. The full radar dataset, which includes all aircraft on the ground at the time of each sample, has an average of 21 seconds and shows an even broader spread. Only 13,3% of aircraft are recorded rolling at 15 seconds, and the peak is split between 20 and 25 seconds, each with 36,7%. This version of the data also shows more aircraft taking 30 seconds or more to begin rolling.

In summary, the live data shows a more concentrated response, with most aircraft beginning their take-off roll between 15 and 20 seconds after clearance. In contrast, both the individual radar data and the full radar dataset show a broader spread, with more aircraft taking longer to initiate movement.

Limitation
Although no dependent runway operations were active during the live observations, the expectation that aircraft would begin rolling promptly after receiving take-off clearance applies to all runways. However, in the absence of the use of dependent runway take-off and landing combinations, there is generally less pressure to initiate a rapid departure.

4.2.2 Insights from interviews and pilot survey

The following sections present the findings from four interviews conducted with runway controllers and two completed pilot surveys.

Understanding operational decision-making in the tower

The interviews revealed that runway controllers rely heavily on visual cues, such as the deployment of thrust reversers, the nose gear touching down, or the aircraft leveling out, to determine whether an aircraft has truly landed. These visual cues, combined with their professional experience, help them decide when it is safe to clear the next aircraft for take-off. However, several controllers also pointed out that these signs can be misleading. Just because the wheels touch the ground does not mean the aircraft will not go around again. This awareness leads them to stay cautious and avoid making assumptions too early.

Training plays a big role in shaping how controllers think and act in these situations. Many said that recent training, especially the use of the color-coded charts from the risk analysis, showing which runway combinations are more critical, helped them become more aware of the risks involved. This led to changes in behavior, such as being more careful with timing and feeling less pressure to push traffic through quickly. However, some mentioned that the training materials are not always easy to access when needed. They expressed a desire for quick-reference tools that could be used during shifts or shared with new trainees. While simulation training was generally seen as useful, several participants noted that it does not always reflect real-life conditions. In the simulator, aircraft respond instantly to instructions, but in reality, pilots may be dealing with high workload, which can delay their reactions.

Timing is a constant focus in the tower. Controllers described how they adjust their timing based on a range of factors, including aircraft type, weather, and how stable the approach looks. Many said they try to avoid the red area. Even if the rules technically allow a departure, they often choose to wait a few extra seconds to be safe. When go-arounds do occur, controllers adopt one of two main strategies: non-intervention or active steering. Some prefer to let the aircraft proceed without interference, while others steer the aircraft. Although steering can be effective, it was also described as stressful and unreliable, as the workload is high in the cockpit at that time. Some controllers expressed frustration that steering is often treated as a fallback solution, even though it does not always work smoothly in practice.

Aircraft type also plays a big role in how decisions are made. Smaller aircraft are generally more flexible and respond more quickly to instructions, while heavier aircraft take longer to maneuver and climb. These differences affect how controllers sequence departures and how much space they leave between aircraft. Heavy categorized aircraft also tend to have higher approach speeds, which adds another layer of complexity when planning take-offs and landings. Additionally, there is also a lot of variation between different airlines and flight crews. Some pilots respond to take-off clearance immediately, while others take their time. Controllers mentioned that airlines like Delta tend to roll immediately, while others like KLM and Transavia are often slower to get moving. These patterns influence how early or late controllers give clearances. Over time, they develop expectations based on experience with specific airlines. In some cases, they adjust their timing based on how they expect a particular crew to behave.

Another challenge is balancing safety with other demands, like noise restrictions and runway capacity. Some controllers admitted that they sometimes take small risks to meet these demands, even if it is not ideal from a safety perspective. There is constant tension between doing what is safest and keeping the airport running efficiently. Additionally, they emphasized the importance of understanding what is happening in the cockpit, not just on their own side. Some mentioned that because things usually go well, it can lead to complacency. Cancelling take-off clearance is seen as a serious decision. It is only done in the very early stages of the roll because stopping an aircraft that is already accelerating can be risky. There is a chance of hot brakes, engine strain, or even needing emergency services. Controllers try to avoid getting to that point by making careful decisions ahead of time. If something does not feel right, like if the approach looks unstable or the weather is questionable, they will rather cancel early than take a chance.

Finally, communication with pilots is not always as effective as it could be. Some controllers felt that pilots do not fully understand how dependent the runway setup is, or that they assume everything is perfectly coordinated. Even when controllers provide traffic information, pilots do not always act on it. This can create a false sense of safety. There is a need for better communication and shared understanding between pilots and controllers to make sure everyone is on the same page.

Pilot perspective on take-off clearance procedures

The pilot survey provided valuable insights into how pilots interpret and act upon take-off clearance, particularly in relation to the 10-second rule mentioned in the AIP and SID cards. First, Pilot1 explicitly states that he is not familiar with the rule requiring take-off roll to begin within 10 seconds after receiving clearance. This pilot explained that delays are typically not reported to ATC unless a specific procedure requires it, such as a post-de-icing engine run-up. In such cases, the engines must run at 60% power for 30 seconds to remove residual ice, and this is communicated to the tower. However, Pilot2 provided a slightly different perspective. Unlike the first, this pilot was familiar and confirmed awareness of the 10-second rule. He mentioned that the 10-second rule is not specifically highlighted during regular briefings but is covered during initial route training, especially for pilots new to the company or transitioning from another division.

Regarding the exact moment when take-off clearance is considered active, the pilots outline a multi-step cockpit protocol. The clearance is first read back, then, if needed, control of the aircraft is transferred (only the captain can taxi on the Embraer). The pilot flying then says “cleared,” and the pilot monitoring responds with “checked.” This “cleared-checked” call is the mutual confirmation that take-off clearance has been received and understood. This moment marks the operational “go” for initiating the take-off roll. The pilots confirm that this “cleared-checked” call is the standard verbal confirmation used in the cockpit to acknowledge take-off clearance (as seen in figure 18, retrieved from KLM).

TAKEOFF - ACTIONS AND CALLOUTS		
	PF	PM
Aircraft on the runway and takeoff clearance received	**"CLEARED"** • Advance thrust levers to 40% N1 to allow engines stabilization. • Advance, or make sure the AT has advanced, the thrust levers to the TO/GA detent before 60 KIAS. **"CHECK THRUST".**	**"CHECKED".** • Verifies that the N1 reached is the target N1, the engine parameters are normal and that ATTCS is as desired. **"THRUST CHECKED".**

Figure 18 Cockpit procedures take-off clearance KLM

In terms of training, the pilot notes that there is no specific emphasis on the 10-second rule. However, training does highlight the importance of absolute clarity regarding take-off and landing clearance. If there is any doubt, even if one pilot is confident, the clearance is always reconfirmed with the tower.

Limitation

It is important to note that these insights are based on two pilots' experience and may not reflect the practices or awareness levels of all pilots. Broader surveys or interviews would be needed to draw more general conclusions.

5 Discussion

This chapter looks at what the results mean and how they relate to the objectives of this research. It connects the data, observations, and interviews to show how the safety measures have influenced daily operations. The discussion also highlights areas where improvements have been made, as well as where challenges still remain.

5.1 Impact of safety measures on aircraft positioning

As seen in figures 12 and 13 and appendices VI and VII, there are two peaks visible in these graphs. As the most prominent peak in both graphs is located beyond the threshold, the aiming point must be situated in the negative values of distance X. According to the FAA, the aiming point marking serves as a visual guide for aircraft during landing. These markings consist of two broad white stripes, one on each side of the runway centerline. Pilots plan to land on or slightly past these markings (*Airport Marking Aids And Signs*, z.d.). To determine the aiming point on runway 06, the distance was calculated using Google Maps for the two dependent runway combinations (refer to figure 19 for L06 and figure 20 for L18C).

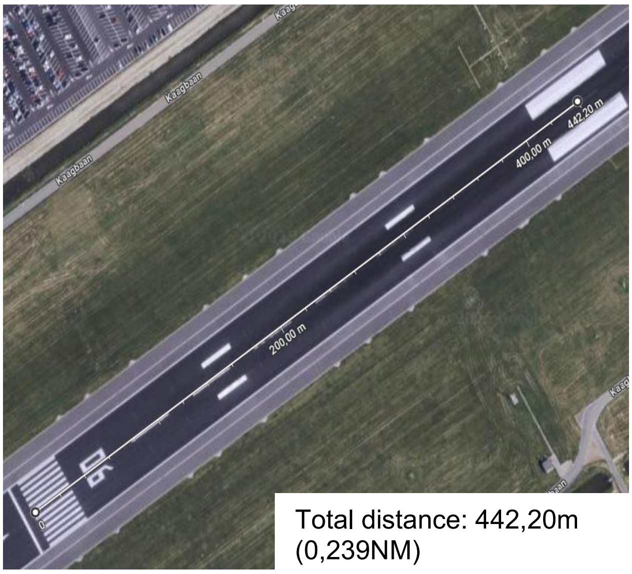

Figure 20 Aiming point 06

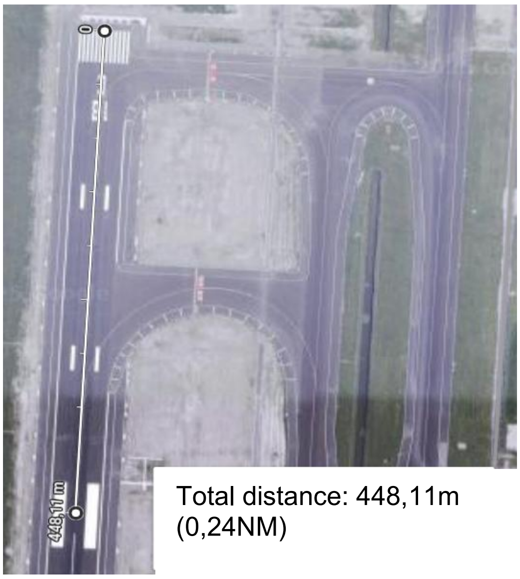

Figure 19 Aiming point 18C

The distance from the threshold of runway 06 and 18C to the center of the aiming point is approximately 0,24NM. In the graphs, this distance is represented as X=-0,24NM, indicating that the aiming point is located beyond the runway threshold. Consequently, an assumption has been made: all aircraft positioned between X=-0,3NM and X=-1NM beyond the runway threshold have landed. These ranges are excluded from the analysis (see figure 21 for L06/S09 and figure 22 for L18C/S24, both including the situation before (orange) and after (blue) the safety measures). Below these graphs, the color-coded risk chart is presented, covering the area from X=-0,2NM (just before the center of the aiming point) to X=2NM before the threshold. In this analysis, the runway threshold is marked by a black line at X= 0NM.

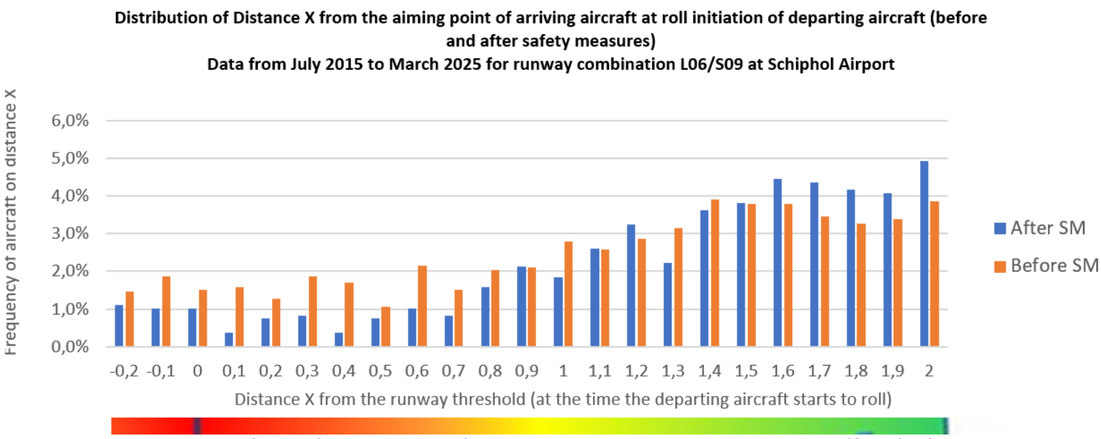

Figure 21 Distribution of aircraft at distance X from the aiming point at roll initiation L06/S09 (before and after safety measures (SM))

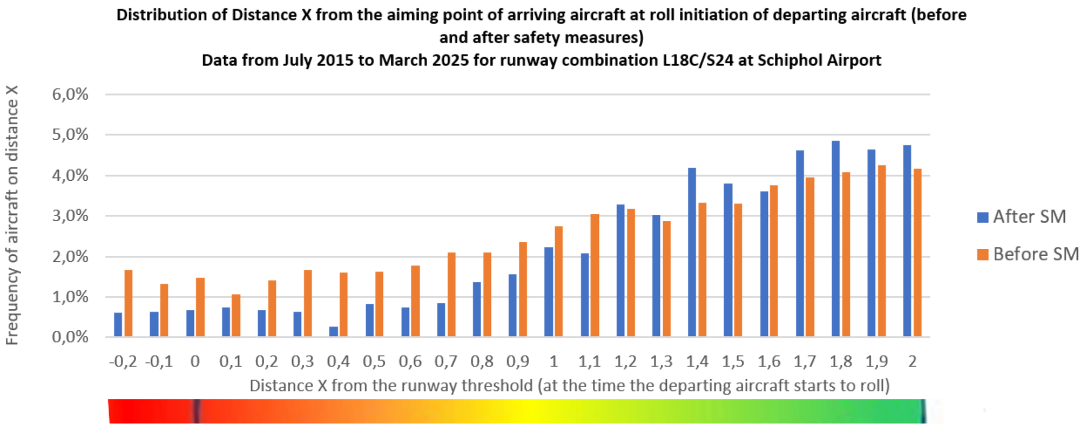

Figure 22 Distribution of aircraft at distance X from the aiming point at roll initiation L18C/S24 (before and after safety measures)

There is a clear indication that after the safety measures were introduced a reduction in frequency in the red and orange area is shown for both runway combinations. At the same time, there is a noticeable increase in aircraft positioned further away, especially in the green zones, indicating that there are more aircraft located around two miles from the runway threshold at the time the departing aircraft is starting to roll. This change strongly suggests that the RC training has had a significant impact. Many runway controllers reported that the training, especially the use of color-coded risk charts, highlighting the most critical runway combinations, helped raise their awareness of the risks involved. As a result, they became more cautious with timing and felt less pressure to prioritize throughput over safety. However, some controllers also noted that the training materials are not always easily accessible during operations. They expressed a need for quick-reference tools that could be used during shifts or shared with new trainees.

5.2 Controller behavior and decision making

Since the training, timing has become a central focus in the tower. Controllers explained how they now adjust their timing based on several factors, including aircraft type, weather conditions, and the stability of the approach. For example, all RCs mentioned that they are more careful with heavies, as RC4 mentioned “If it is a heavy, my red zone is much larger than what is shown on the chart.” Furthermore, many stated that even when procedures technically allow departure, they often choose to wait a few extra seconds to give take-off clearance. This behavioral shift is reflected in the graphs, which show a clear movement of aircraft positioning toward the green zones.

Even though the number of aircraft in the red and orange areas has gone down, there are still a few that end up there. This is likely due to the many different factors that play a role in these operations. For example, RC3 said, “Ideally around 2 miles, and once it is touched down. If it is just in the red zone and still looks good, I let it go.” RC1 mentioned, “I never start a departure when the arriving aircraft is within 1 mile.” And RC2 explained, “I give take-off clearance when the approaching aircraft is around 2NM out, or even when it is over the landing zone, around X=1,4NM is what I prefer. It depends on visibility and aircraft type. You are technically allowed to depart, but I personally avoid the red zone. If the aircraft is already over X=-0,4NM or X=-0,6NM, I will still give take-off clearance. It is a quick risk calculation you make in that moment.”

5.3 Reported incidents and risk awareness

These examples show that while the safety measures and training have clearly improved the situation, controllers still rely heavily on their own judgment and experience to make decisions. The overall trend in the data confirms that the safety measures, particularly the training, have had a positive impact on daily operations. However, this improvement is not reflected in the number of reported occurrences. When comparing the two tables in 4.1.4, some patterns become clear. Before the safety measures were introduced, there were 13 reported incidents over a 10-year period, averaging 1,3 incidents per year. After the safety measures, there were 5 incidents over three years, which averages to 1,66 incidents per year, an increase of 27,7%. This suggests that the number of incidents has not decreased, despite the improved operational behavior shown in the graphs. However, the type of ATC intervention changes significantly. Before the safety measures, ATC used both visual separation and take-off aborts, while after the measures, only take-offs were aborted. The absence of visual separation after the safety measures may also indicate that ATC is aware of the risks and that the training has made them more aware of the operational risks involved. However, the incidents reported are dependent on the number of departures and arrivals on the dependent runway combinations within these periods.

There are several reasons why incidents may still occur. One of these reasons could be the one that RC4 mentioned "The downside of this job is that things almost always go well, which can make you complacent." In other words, because things usually run smoothly, it is easy to let your guard down. Another example is that RC1 mentioned that he aborts take-off when the arriving aircraft is within the red zone, but this decision also depends on other factors, such as whether the approach appears stable. RC2 explained, "If I think the approach looks unstable, then I will not start the departure." Similarly, RC4 said, "Only in the very early stage, when it just starts rolling, can you still say 'abort,' but you do not want to do that. If I think the chance of a go-around is higher than usual, I will say 'cancel take-off clearance' because the aircraft is barely rolling." RC3 added, "If the weather is good, I do not abort. I just look very closely and think ahead about what I will do if something happens. You want them to start rolling. If they do not, you are kind of on edge."

5.4 Timing between clearance and roll initiation

As RC3 noted, "you want them to start rolling. If they do not, you are kind of on edge," highlighting the importance of aircraft beginning their take-off roll as soon as possible after receiving clearance. This is because the longer the delay, the closer the arriving aircraft gets to the red area of the risk analysis. Despite the introduction of safety measures, the average time between take-off clearance and roll initiation has changed very little. Before the safety measures, the average time was 19,8 seconds. After the measures, it was 19,6 seconds, a minimal improvement. This is still well above the 10-second guideline stated in the AIP and SID cards. RC4 explained how controllers sometimes anticipate delays by giving take-off clearance earlier, saying, "Sometimes, because you know they will not roll immediately after 'cleared for take-off,' you give the clearance a bit earlier, thinking, 'If they wait 10 seconds, I have accounted for that.' With Delta Airlines, I wait 10 seconds before giving clearance, otherwise they will go too early." This shows how controllers adapt their timing based on the behavior of different airlines.

5.4.1 Airline and aircraft type differences

The time between take-off clearance and roll initiation could be dependent on multiple factors, such as the time when the pilots start to give power to the engines to start their roll, the type of aircraft, but also on the airline. The results of 4.1.3 reveal that the most common time for aircraft to initiate take-off roll after clearance is consistently between 20 and 25 seconds, with a more concentrated distribution in 2025 compared to 2019. On average, heavy aircraft initiated their take-off roll after 20,6 seconds with a mean of 21 seconds, while medium aircraft averaged 19,3 seconds with a mean of 19 seconds. Although achieving a 10-second response time appears unlikely for heavy aircraft based on the data, three out of four interviewed runway controllers noted that Delta Air Lines, operating only heavy aircraft into Amsterdam, tend to initiate take-off almost immediately after receiving clearance. RC1 remarked, *"KLM's Airbus A330s take a very long time… Delta goes immediately."* Similarly, RC3 observed, *"Delta, the Americans, they really stand out. You say, 'cleared for take-off' and boom, they go."*

When comparing airline types, home carriers took an average of 19,7 seconds with a mean of 20 seconds, whereas other carriers began rolling slightly earlier, averaging 19,3 seconds, with also a mean at 20 seconds and a noticeable peak at the 15-second mark. This shift suggests improved procedural adherence following the implementation of safety measures. Several runway controllers pointed out that some airlines are consistently slower to begin rolling. According to three out of four runway controllers, "Transavia also takes forever to start rolling," and "Transavia and KLM often delay rolling." One RC even joked, "If I had to make a top 3, it would be Transavia, KLM, and then some unknown third." Another added, "One crew is fully ready, hand on the throttle, and when I say 'cleared,' they go. Another one hears 'cleared for take-off' and it's like, 'Okay, coffee's finished.'" This variation in response times highlights a broader issue: communication between pilots and controllers is not always as effective as it could be. Some controllers felt that pilots do not fully understand how dependent the runway setup is, or they assume everything is perfectly coordinated. Even when controllers provide traffic information, pilots do not always act on it.

5.5 Limitations of radar data and observations

Live observations have been done in the Schiphol tower to show how closely radar data matches what actually happens in real time, and whether there are any noticeable differences (see appendix IX). The comparison between live observations and radar data reveals that radar systems tend to record slightly longer response times between take-off clearance and roll initiation. While live data shows a sharp peak at 15 and 20 seconds, individual radar data shifts some of that activity to later bins, particularly 25 and 30 seconds. The full radar dataset shows an even broader distribution, with fewer aircraft initiating roll at 15 seconds and more doing so at 25 seconds or later. Therefore, the radar data tends to show a slightly slower response time compared to what was observed live.

To better understand why there has been little to no change in the timing between clearance and roll initiation, a pilot survey was conducted. One pilot noted that they were not aware of any rule requiring take-off roll to begin within 10 seconds of receiving clearance. Delays are typically not reported to RC unless a specific procedure requires it. Both the pilots also described the cockpit protocol that defines when take-off clearance is considered active. After the clearance is read back, control of the aircraft may be transferred. The pilot flying then announces “Cleared,” and the pilot monitoring responds with “Checked.” This “cleared-checked” exchange serves as the mutual confirmation that take-off clearance has been received and understood. Only after this point does the take-off roll begin, which may explain why pilots take longer than 10 seconds. To explore this further, a bar-chart was created to compare how long it takes aircraft to start rolling after two different moments: when the RC starts speaking (orange bars) and when the pilot finishes reading back the clearance (blue bars) (see figure 23).

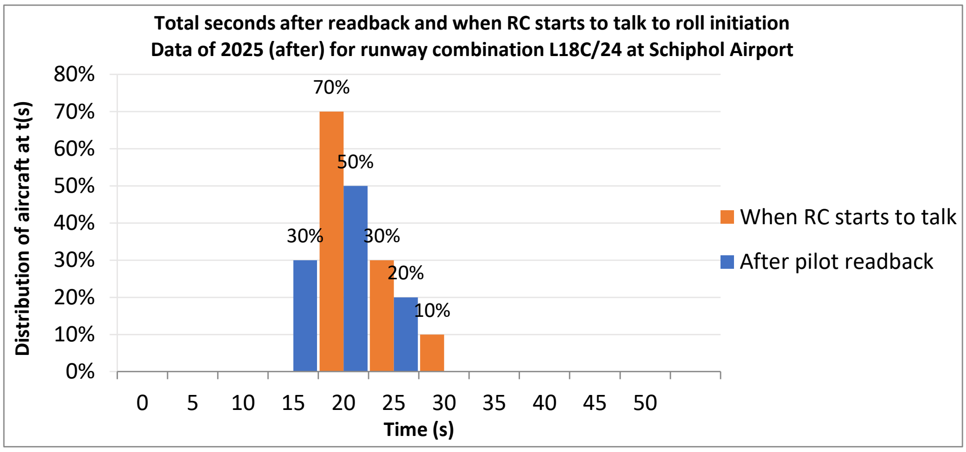

Figure 23 Interval from take-off clearance to roll initiation in percentage when RC starts to talk and after the readback

Based on 10 samples from Schiphol’s runway combination L18C/S24 in 2025, most aircraft started rolling between 15 and 25 seconds after the pilot finished reading back the take-off clearance. When measuring from the moment the RC started speaking, most aircraft began rolling a bit later, between 20 and 30 seconds, with an average of 17,9 seconds. Notably, none of the aircraft began rolling at 15 seconds when measured from the RC’s initial transmission, whereas 30% of aircraft did so when measured from the readback. Also, fewer aircraft rolled at 25 seconds and none at 30 seconds in the readback data, whereas those times were more common when measured from the moment the RC started talking. After the readback it took an average of 15,5 seconds. This indicates that the time from the pilot’s readback to roll initiation is generally shorter than the time from the RC’s initial call. In some cases, the time from readback to roll initiation comes closer to the expected 10-second window.

Lastly, insights from runway controllers highlight the importance of mutual understanding between the tower and the cockpit. As RC1 explained, “We need to understand what is happening in the cockpit, and the cockpit needs to understand what is happening on our side.” This emphasizes the need for shared awareness and communication. RC1 further noted that this message should be reinforced during pilot briefings and training, especially for new pilots operating at Schiphol: “At Schiphol, when you are cleared, you need to start rolling and here is why.” According to RC1, repeating this message regularly helps ensure smooth operations. He also mentioned that sometimes pilots cannot roll right away, and that is okay, as long as there is understanding on both sides.

6 Key findings

This chapter summarizes the main findings from the analysis of aircraft positioning, controller behavior, and timing patterns before and after safety measures were introduced at Schiphol.

- Aircraft are positioned further from the runway threshold at roll initiation, reducing presence in high-risk zones after 2022 safety measures, which reflects increased risk awareness of runway controllers.

- The nature of interventions changes by runway controllers where only take-offs were aborted when the arriving aircraft conducts a go-around, indicating that the departing aircraft was still on the ground, compared to before the safety measures where the runway controllers applied visual separation as well as aborting the take-offs.

- RC training positively influenced behavior but color-coded risk carts from the training need better accessibility, and the simulator does not reflect on real-world conditions.

- Average time between take-off clearance and roll initiation remains high (averaging from 19,8 seconds to 19,6 seconds), exceeding the 10-second guideline stated in the AIP and SID charts. Some pilots are unaware of the 10-second rule and of the risks associated with dependent converging runway combinations, highlighting a need for improved communication and shared awareness.

- Home carriers and heavy aircraft initiate their roll later than other carriers and medium aircraft, affecting controller timing strategies.

- KLM cockpit procedures delay roll initiation until after the “cleared–checked” exchange, meaning clearance is operationally acknowledged only after readback.

- Radar data shows longer roll initiation times than live observations; measuring from pilot readback provides a more accurate reflection of actual behavior.

The findings show improved controller awareness and aircraft positioning, but it also highlights ongoing challenges such as delayed roll initiation and communication gaps. These insights support the recommendations in chapter 7.

7 Recommendations

Based on the key findings of this study, several recommendations can be made to further improve the application and effectiveness of the 2022 safety measures for converging runway operations at Schiphol Airport, particularly under good visibility conditions inside the UDP.

1. **Make quick-reference tools more accessible for controllers and improve the realism of the SIM for runway controllers**

Runway controllers expressed that training materials, especially the color-coded risk charts for each dependent runway combination, are not easily accessible. These tools are valuable for both experienced runway controllers and trainees, yet many have not seen them since their last training session. It is recommended that these materials be made easily available in the Schiphol tower, either digitally or in printed form, to support decision-making and training. Additionally, while simulation training is generally effective, several RCs noted that it does not always reflect real-world conditions. In simulations, aircraft respond immediately to instructions, whereas in live operations, pilot response times can vary due to workload, stress, or technical issues. Therefore, simulation scenarios should be updated to include more realistic delays and variability in pilot behavior, helping controllers develop more accurate expectations and responses.

2. **Reinforce awareness of the 10 second rule and the risks associated with dependent converging runway operations to pilots**

The data and the pilot survey revealed limited awareness of the 10-second guideline introduced in the AIP and SID charts. To improve compliance, it is recommended that this rule be emphasized more clearly in, for example, pilot briefings or training programs, as it is possible to initiate the take-off roll after receiving clearance. As an initial step, a meeting including all chief pilots operating at Schiphol Airport should be organized. This session should include practical examples and explanations of the risks involved with dependent converging runway operations and why it is important to start rolling as fast as possible after receiving clearance.

3. **Address airline specific behavior**

The study found that home carriers tend to take longer to initiate take-off roll after receiving clearance compared to other carriers. This pattern was consistently observed in both the data and interviews with RC. Runway controllers are aware of this and often give these carriers clearance earlier, knowing these carriers take more time. In contrast, the RC gives take-off clearance at the right time to other carriers. Therefore, it is important to address this matter to the home carriers at Schiphol Airport.

4. **Establish the cockpit procedures for after take-off clearance per airline operating at Schiphol Airport**

It is important to establish and compare the cockpit procedures used by the various airlines operating at Schiphol Airport following the issuance of take-off clearance, as these procedures may differ for each airline. At KLM, the timing of roll initiation is based on an internal cockpit confirmation step after the readback, not the moment clearance is received from the RC. If other airlines follow a different procedure, such as initiating the take-off roll immediately after receiving clearance, even before the readback, this discrepancy could affect the timing. Therefore, it is recommended to conduct a comprehensive review of the cockpit procedures of all major carriers at Schiphol.

5. **Measure from the readback to roll initiation at the next evaluation**

If it is found that all airlines follow a procedure similar to KLM's, then future evaluations of take-off timing should measure the interval from the readback to roll initiation, rather than from the initial clearance transmission. Additionally, the radar data tends to show a slightly slower response time compared to what was observed live. As a result, live measuring the roll initiation from the pilot's readback rather than the controller's initial transmission provides a more accurate reflection of actual behavior and brings the timing closer to the 10-second guideline.

8 Conclusion

This research aimed to evaluate *how the 2022 safety measures are applied in daily operations for converging runway combinations at Schiphol Airport, and to what extent they reduce operational risks under good visibility conditions inside UDP.* Through a combination of quantitative data analysis and qualitative analysis including live observations, interviews with RCs and pilot input, the study provides a comprehensive understanding of how these measures have affected the operation inside UDP with good visibility of a CB higher than 2000ft and VIS of 5km and more.

The results show that the 2022 safety measures are actively applied in daily operations. Runway controllers have clearly adapted their behavior, often waiting longer before issuing take-off clearance, especially when arriving aircraft are close to the runway threshold. This is supported by aircraft positioning data, which shows a significant shift away from the red areas and towards the green areas of the risk analysis, where there is a lower risk that the two aircraft, where the arriving aircraft conducts a go-around and a simultaneous departure, will meet at the common point of the dependent converging runways. Many controllers reported that the training they received, particularly the use of the color-coded risk charts from the training, helped them become more aware of the risks involved in dependent runway operations. As a result, they now make more cautious decisions, often choosing to wait a few extra seconds even when procedures technically allow them to proceed. However, many also noted that these materials are not easily accessible. They expressed a desire for quick-reference tools that could be used during shifts or shared with new trainees. To maintain the effectiveness of the training, it is recommended that these tools are made available and easily accessible for controllers in the tower in both digital and printed formats. While the simulation training was seen as helpful, controllers noted that it does not always reflect real-life conditions as aircraft respond instantly to instructions in the simulator, but in reality, pilots may be dealing with high workload, which can delay their reactions. It is therefore recommended to enhance realism in simulator training.

Despite the improvements in controller behavior, the average time between take-off clearance and roll initiation has changed very little. Before the safety measures, the average time was 19,8 seconds; after the measures, it was 19,6 seconds. This remains significantly above the 10-second guideline introduced in the AIP and SID charts. Based on the data, it can depend on different factors, such as the WTC and the type of carrier, as home carriers and heavy categorized aircraft tend to take longer between take-off clearance to roll initiation compared to other carriers and medium categorized aircraft. Runway controllers tend to give take-off clearance to home carriers earlier because they know home carriers will take a lot of time before they start rolling, while they tend to wait to the exact moment to give take-off clearance to other carriers. This highlights the need to address airline specific behavior directly, particularly with home carriers. Furthermore, the pilot survey revealed that some pilots are not always aware of the “10-second rule” and of the risk associated with dependent converging runway operations. Additionally, it is recommended to reinforce awareness of the 10 second rule guideline and of the risks associated with this type of runway operations in chief pilot meetings. In cockpit procedures, particularly those used by KLM, take-off clearance is not considered active until after the pilot monitoring confirms the clearance with a “checked” response following the readback. Furthermore, the radar data tends to show a slightly slower response time compared to what was observed live. As a result, live measuring the roll initiation from the pilot’s readback rather than the controller’s initial transmission provides a more accurate reflection of actual behavior and brings the timing closer to the 10-second guideline.

When it comes to reported incidents, the number has not decreased since the implementation of the safety measures. There were 13 incidents over a 10-year period before the measures and 5 incidents over three years after, resulting in a slight increase in the annual average. This number is dependent on the frequency of dependent runway combinations used. However, the nature of ATC interventions has changed. Before the safety measures, incidents were resolved using both visual separation and take-off abortions. After the measures, all incidents were resolved through take-off abortions, suggesting that all these aircraft were still on the ground. This change in behavior aligns with the increased risk awareness reported in the interviews.

In conclusion, the 2022 safety measures have improved controller behavior and aircraft positioning, but challenges remain. The unchanged roll initiation timing, limited pilot awareness, and airline-specific delays highlight areas for improvement. Reinforcing pilot training, improving access to tools, and enhancing simulation realism are essential to fully realize the intended safety benefits.

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Evaluation of the LVNL 2022 safety measures in converging runway operations at Schiphol Airport

Appendices

Table of content

Appendix I *Reflection*

Looking back on the past semester, I feel incredibly grateful for the experiences, opportunities, and growth I have had during my internship and research project. Overall, I can say that this has been one of the most enriching periods of my academic journey, both professionally and personally.

From the very beginning, I felt welcomed and supported by everyone at the LVNL. When I needed data for my research or had specific questions, I received answers quickly and with enthusiasm, I often felt encouraged. I was even invited to join the department's weekly safety meetings, which made me feel like a true part of the team. The research project itself was fascinating, and I was genuinely excited to work on it. The topic aligned well with my interests, and the depth of the subject kept me engaged throughout.

What stood out most was the strong support from my supervisors. I had two company supervisors and one HvA supervisor, and I had weekly meetings with each of them, on Monday, Tuesday, and Wednesday. This structure worked very well, as it allowed me to discuss progress consistently, ask questions when needed, and keep everyone updated. These regular check-ins also created a space for reflection and improvement.

At the end of the second semester, I presented my research findings to the safety department. It was a great moment of closure and recognition. I received a lot of positive feedback, not only about the content of my research but also about how I presented it. People were taking notes during my presentation, discussing how they could implement my recommendations, and genuinely engaging with my work. I was told that my research was detailed and valuable and that it was refreshing to have someone who could conduct this type of in-depth analysis. That felt incredibly rewarding.

One point of reflection for me is that I sometimes held back from sharing my report before I felt it was "perfect." As a result, I missed opportunities for early feedback, which meant I had to revise a lot at the end. Going forward, I want to improve this by sharing my work more frequently, even if it is still a draft. Feedback is not about being finished, it is about learning and improving along the way.

Lastly, the time I spent with other students and colleagues at the company was genuinely enjoyable. From field trips and shared lunches to spontaneous learning moments, I built connections and memories that made this experience even more meaningful.

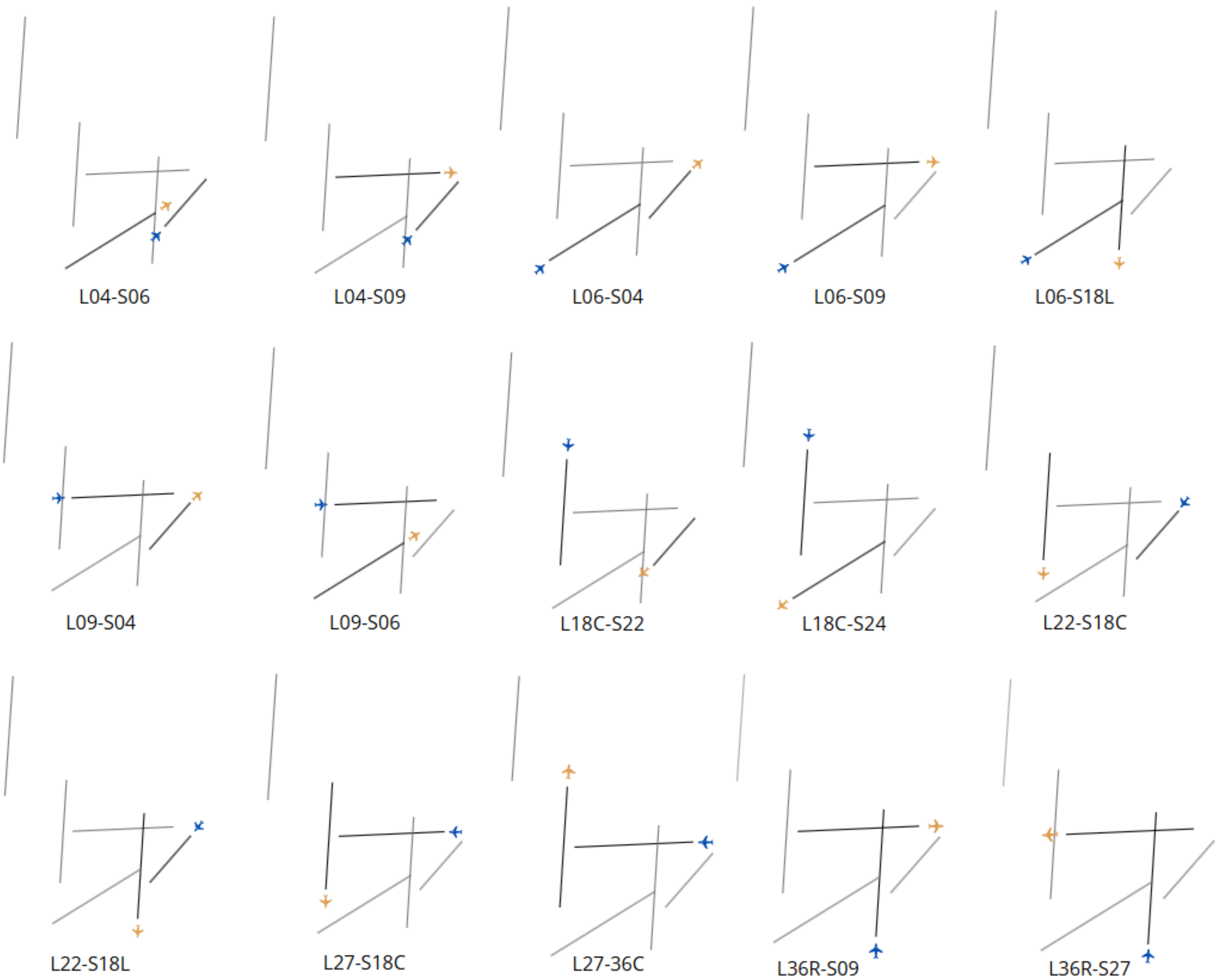
In conclusion, this internship has helped me grow as a researcher, a communicator, and a young professional. It sharpened my skills and gave me a better understanding of my own strengths and areas for growth. I am proud of what I accomplished and excited to take all these lessons with me into the future.

Appendix II *Uniform Daylight Period 2024*

UNIFORM DAYLIGHT PERIODS 2024														
	DEC (2023)		JAN		FEB		MAR		APR		MAY		JUN	
	period		period		period		period		period		period		period	
Day	from	to	from	to	from	to	from	to	from	to	from	to	from	to
1	0710	1547	0733	1554	0706	1642	0610	1735	0459	1829	0355	1921	0311	2006
2	0711	1547	0733	1555	0704	1644	0608	1737	0457	1831	0353	1922	0310	2007
3	0713	1546	0733	1556	0703	1646	0605	1739	0454	1833	0351	1924	0309	2008
4	0714	1546	0733	1557	0701	1647	0603	1741	0452	1835	0349	1926	0308	2009
5	0716	1545	0732	1558	0659	1649	0601	1743	0450	1836	0347	1927	0308	2010
6	0717	1545	0732	1559	0658	1651	0559	1744	0448	1838	0345	1929	0307	2011
7	0718	1544	0732	1601	0656	1653	0557	1746	0445	1840	0344	1930	0307	2012
8	0719	1544	0731	1602	0654	1655	0554	1748	0443	1841	0342	1932	0306	2012
9	0720	1544	0731	1603	0652	1657	0552	1750	0441	1843	0340	1934	0306	2013
10	0722	1544	0730	1605	0651	1659	0550	1751	0439	1845	0339	1935	0306	2014
11	0723	1543	0730	1606	0649	1700	0547	1753	0436	1847	0337	1937	0305	2015
12	0724	1543	0729	1608	0647	1702	0545	1755	0434	1848	0335	1938	0305	2015
13	0725	1543	0728	1609	0645	1704	0543	1757	0432	1850	0334	1940	0305	2016
14	0726	1543	0727	1611	0643	1706	0541	1758	0430	1852	0332	1942	0305	2016
15	0726	1543	0727	1612	0641	1708	0538	1800	0428	1853	0331	1943	0304	2017
16	0727	1544	0726	1614	0639	1710	0536	1802	0425	1855	0329	1945	0304	2017
17	0728	1544	0725	1616	0637	1712	0534	1804	0423	1857	0328	1946	0304	2018
18	0729	1544	0724	1617	0635	1713	0531	1805	0421	1859	0326	1948	0304	2018
19	0729	1544	0723	1619	0633	1715	0529	1807	0419	1900	0325	1949	0305	2018
20	0730	1545	0722	1620	0631	1717	0527	1809	0417	1902	0324	1951	0305	2019
21	0731	1545	0721	1622	0629	1719	0524	1811	0415	1904	0322	1952	0305	2019
22	0731	1546	0719	1624	0627	1721	0522	1812	0413	1905	0321	1953	0305	2019
23	0732	1546	0718	1626	0625	1723	0520	1814	0410	1907	0320	1955	0305	2019
24	0732	1547	0717	1627	0623	1725	0517	1816	0408	1909	0319	1956	0306	2019
25	0732	1548	0716	1629	0621	1726	0515	1817	0406	1910	0317	1957	0306	2019
26	0733	1548	0714	1631	0619	1728	0513	1819	0404	1912	0316	1959	0307	2019
27	0733	1549	0713	1633	0616	1730	0511	1821	0402	1914	0315	2000	0307	2019
28	0733	1550	0712	1634	0614	1732	0508	1823	0400	1916	0314	2001	0308	2019
29	0733	1551	0710	1636	0612	1734	0506	1824	0358	1917	0313	2002	0308	2019
30	0733	1552	0709	1638			0504	1826	0356	1919	0312	2004	0309	2018
31	0733	1553	0707	1640			**0501**	1828			0311	2005		

UNIFORM DAYLIGHT PERIODS 2024												
	JUL		AUG		SEP		OCT		NOV		DEC	
	period		period		period		period		period		period	
Day	from	to	from	to	from	to	from	to	from	to	from	to
1	0310	2018	0347	1944	0437	1841	0527	1731	0621	1626	0711	1547
2	0310	2017	0349	1942	0439	1839	0528	1729	0622	1624	0713	1546
3	0311	2017	0351	1941	0441	1837	0530	1727	0624	1622	0714	1546
4	0312	2017	0352	1939	0442	1834	0532	1725	0626	1620	0715	1545
5	0313	2016	0354	1937	0444	1832	0533	1722	0628	1619	0717	1545
6	0314	2015	0355	1935	0446	1830	0535	1720	0630	1617	0718	1544
7	0315	2015	0357	1934	0447	1827	0537	1718	0631	1615	0719	1544
8	0316	2014	0358	1932	0449	1825	0538	1716	0633	1614	0720	1544
9	0317	2013	0400	1930	0450	1823	0540	1713	0635	1612	0721	1544
10	0318	2013	0402	1928	0452	1820	0542	1711	0637	1611	0722	1543
11	0319	2012	0403	1926	0454	1818	0543	1709	0639	1609	0723	1543
12	0320	2011	0405	1924	0455	1816	0545	1707	0640	1608	0724	1543
13	0321	2010	0406	1922	0457	1814	0547	1704	0642	1606	0725	1543
14	0322	2009	0408	1920	0459	1811	0549	1702	0644	1605	0726	1543
15	0324	2008	0410	1918	0500	1809	0550	1700	0646	1603	0727	1544
16	0325	2007	0411	1916	0502	1807	0552	1658	0647	1602	0728	1544
17	0326	2006	0413	1914	0503	1804	0554	1656	0649	1601	0729	1544
18	0327	2004	0415	1912	0505	1802	0556	1654	0651	1559	0729	1544
19	0329	2003	0416	1910	0507	1759	0557	1652	0652	1558	0730	1545
20	0330	2002	0418	1908	0508	1757	0559	1649	0654	1557	0730	1545
21	0331	2001	0419	1905	0510	1755	0601	1647	0656	1556	0731	1546
22	0333	1959	0421	1903	0512	1752	0603	1645	0657	1555	0731	1546
23	0334	1958	0423	1901	0513	1750	0604	1643	0659	1554	0732	1547
24	0336	1957	0424	1859	0515	1748	0606	1641	0701	1553	0732	1547
25	0337	1955	0426	1857	0517	1745	0608	1639	0702	1552	0733	1548
26	0338	1954	0428	1855	0518	1743	0610	1637	0704	1551	0733	1549
27	0340	1952	0429	1852	0520	1741	**0612**	1635	0705	1550	0733	1550
28	0341	1951	0431	1850	0522	1738	0613	1633	0707	1549	0733	1551
29	0343	1949	0433	1848	0523	1736	0615	1631	0708	1548	0733	1551
30	0344	1947	0434	1846	0525	1734	0617	1630	0710	1548	0733	1552
31	0346	1946	0436	1843			0619	1628			0733	1553

Appendix III *All 15 dependent converging runway combinations at Schiphol Airport*



Appendix IV *Risk charts for each dependent runway combination at Schiphol Airport*

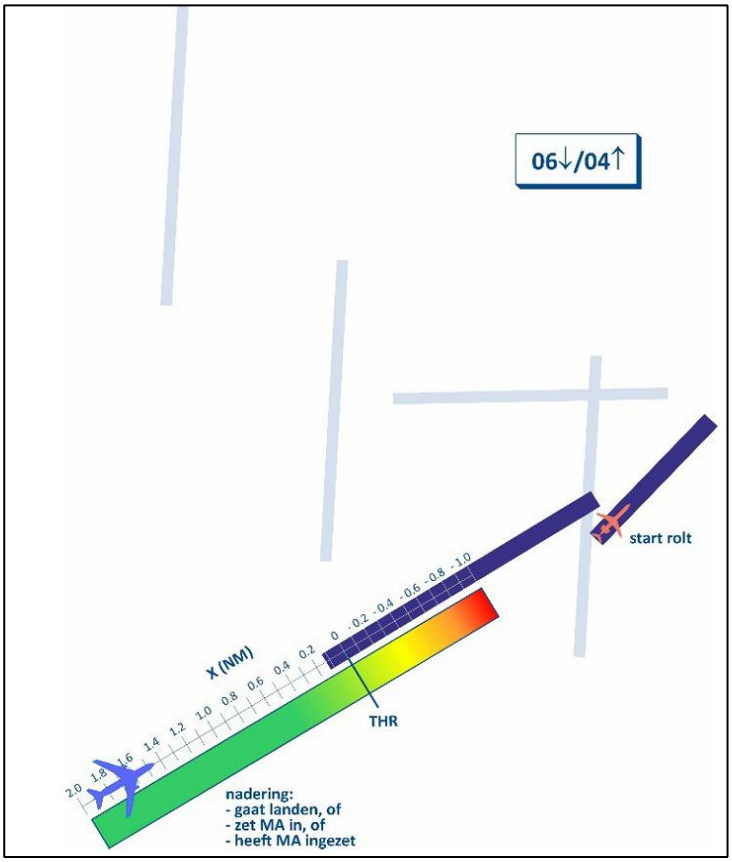


Figure 26 risk chart 06/04

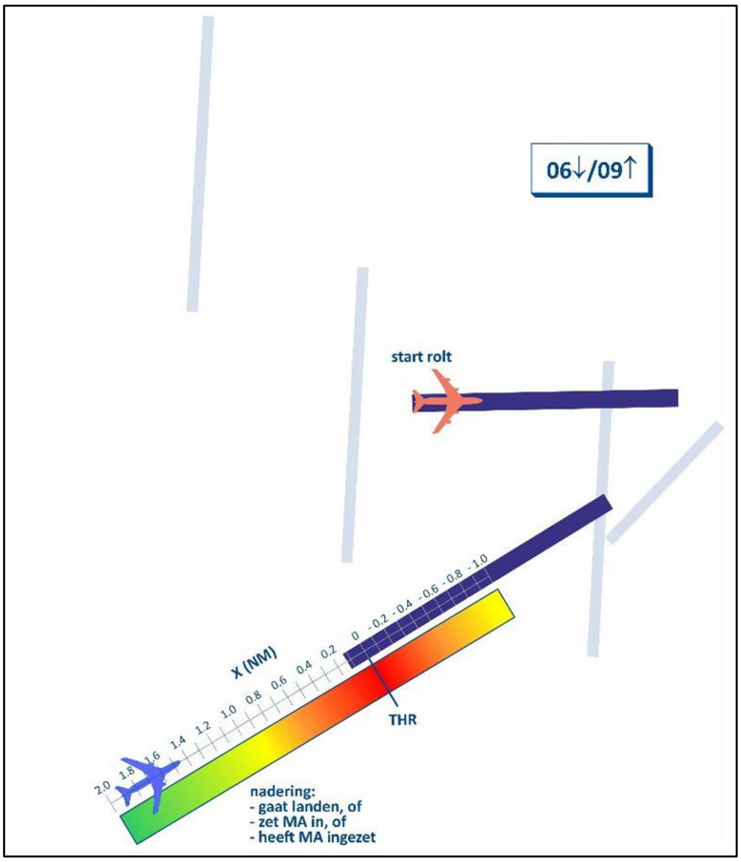


Figure 27 Risk chart L06/S09

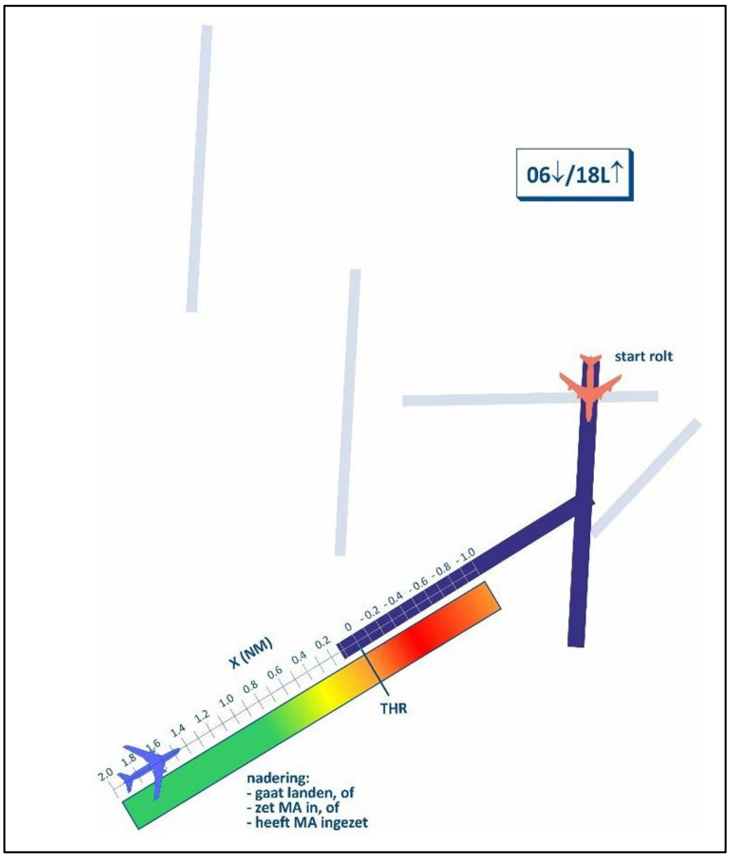


Figure 25 Risk chart 06/18L

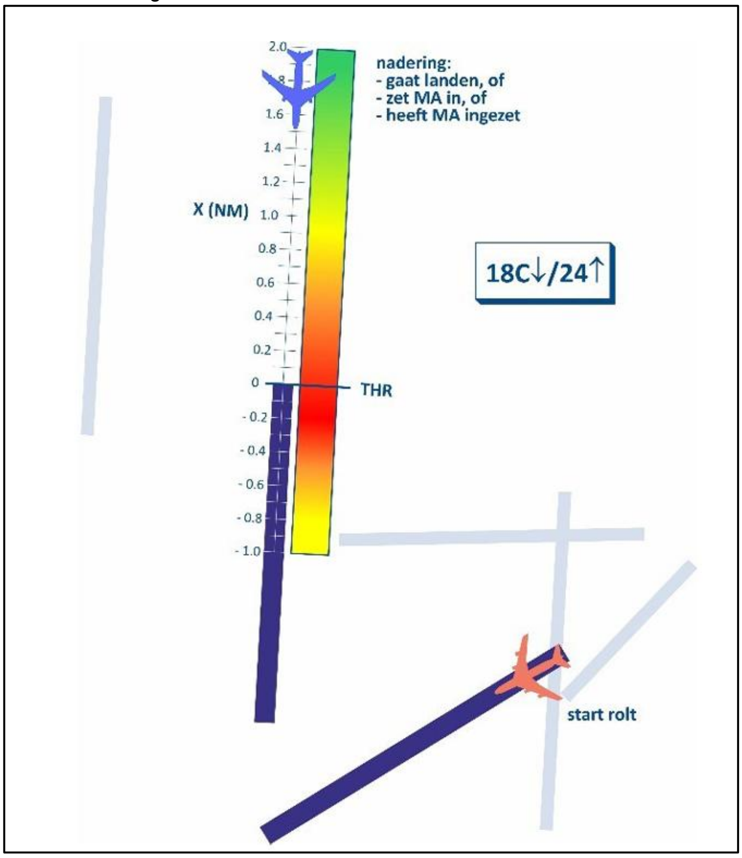


Figure 24 Risk chart 18C/24

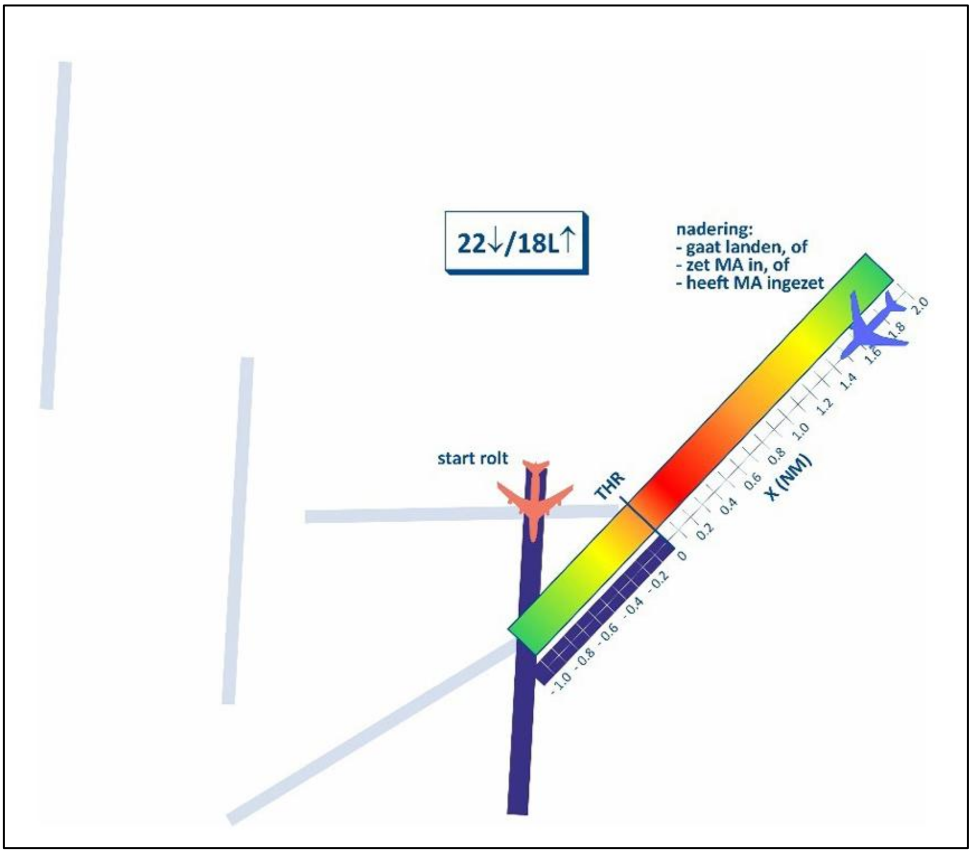


Figure 28 Risk chart 22/18L

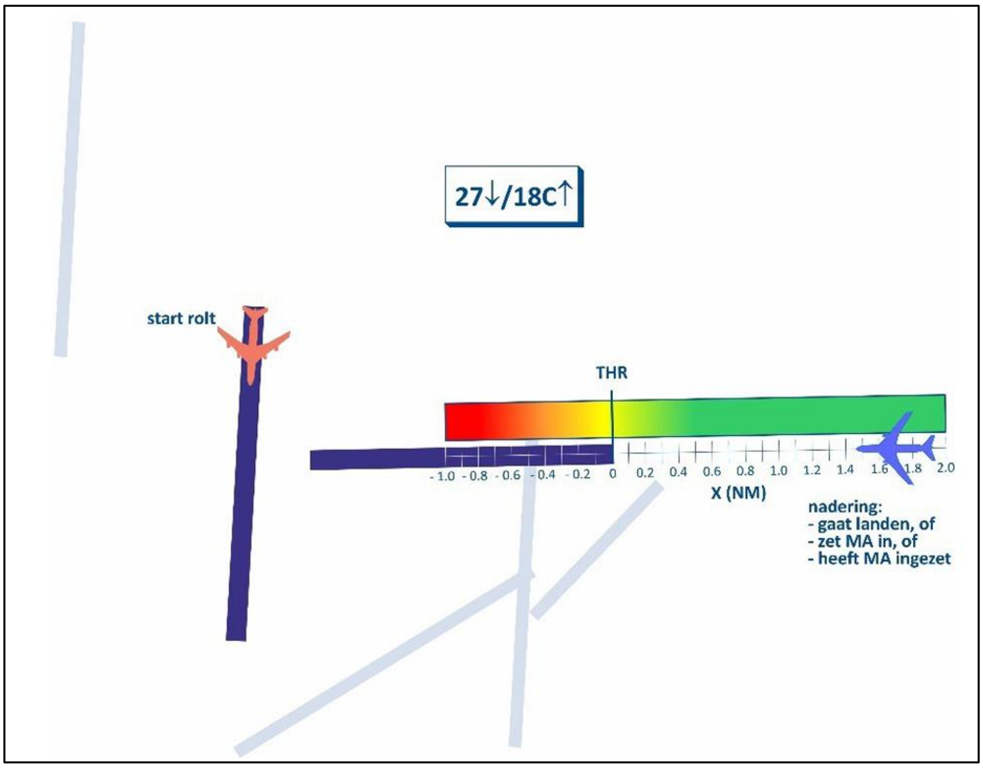


Figure 29 Risk Chart 27/18C

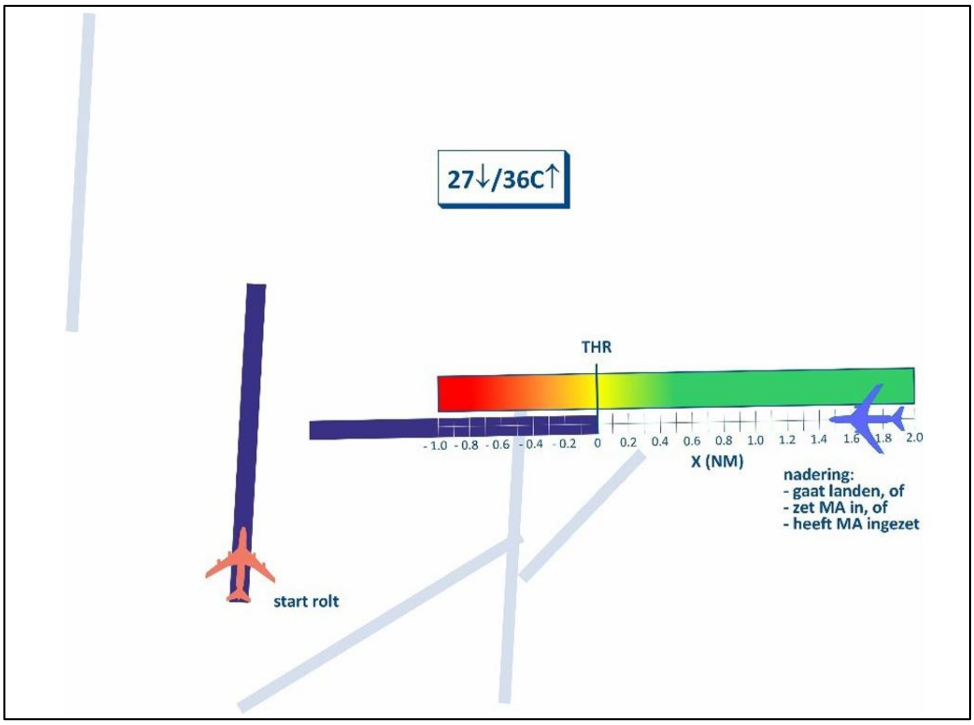


Figure 30 Risk chart 27/36C

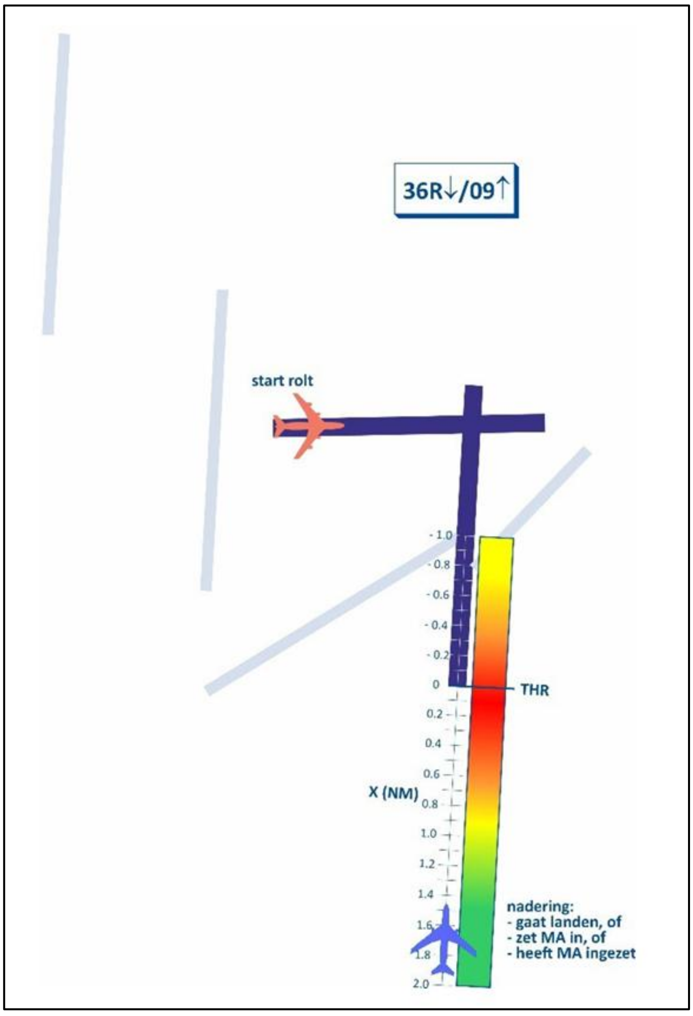


Figure 31 Risk chart 36R/09

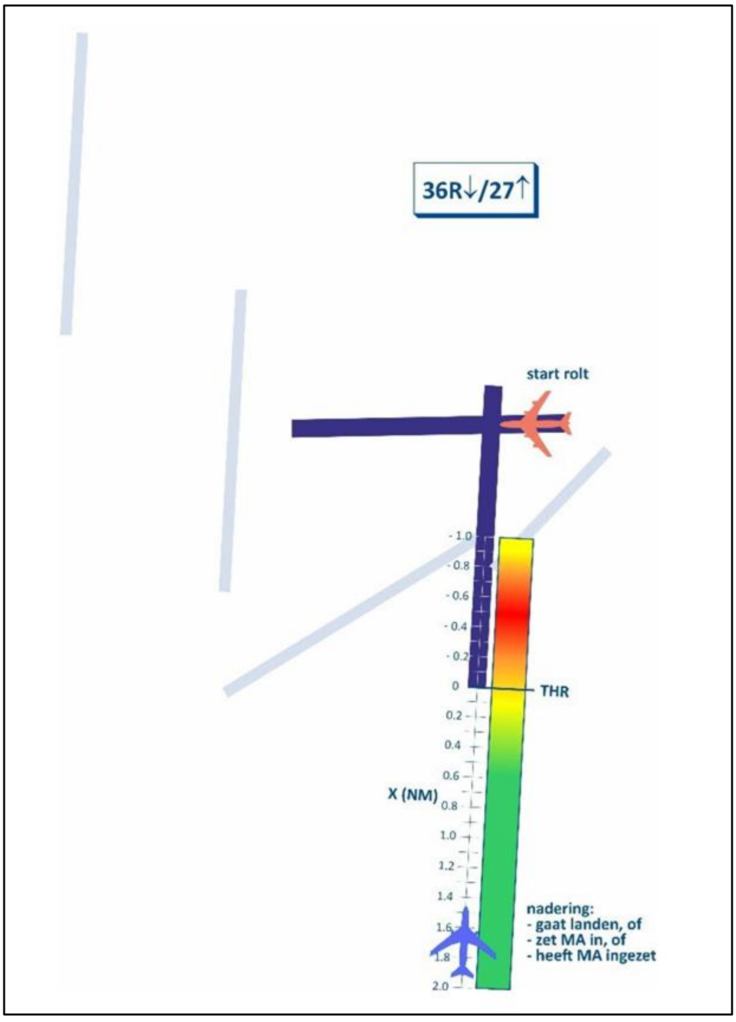


Figure 32 Risk chart 36R/27

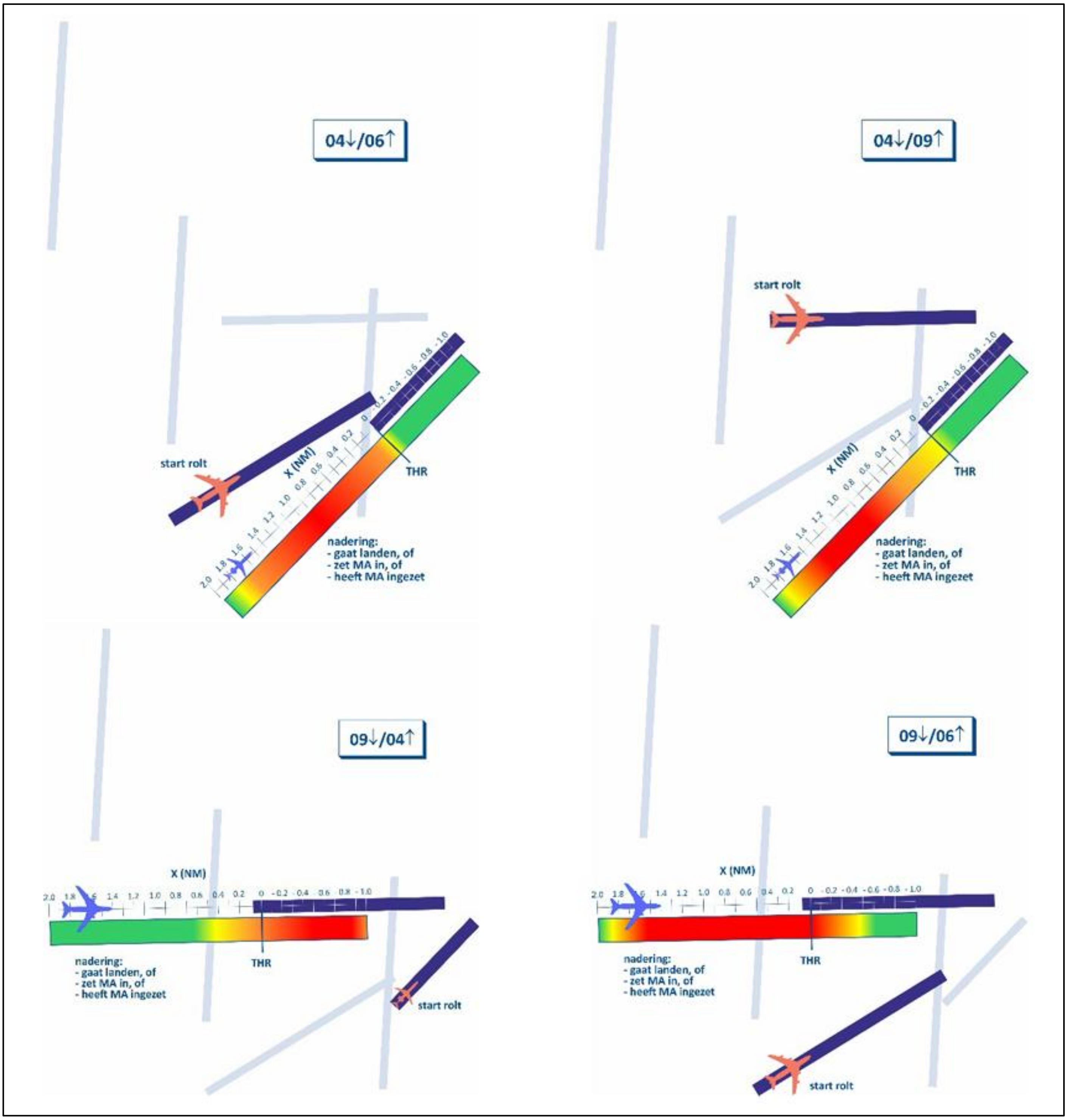
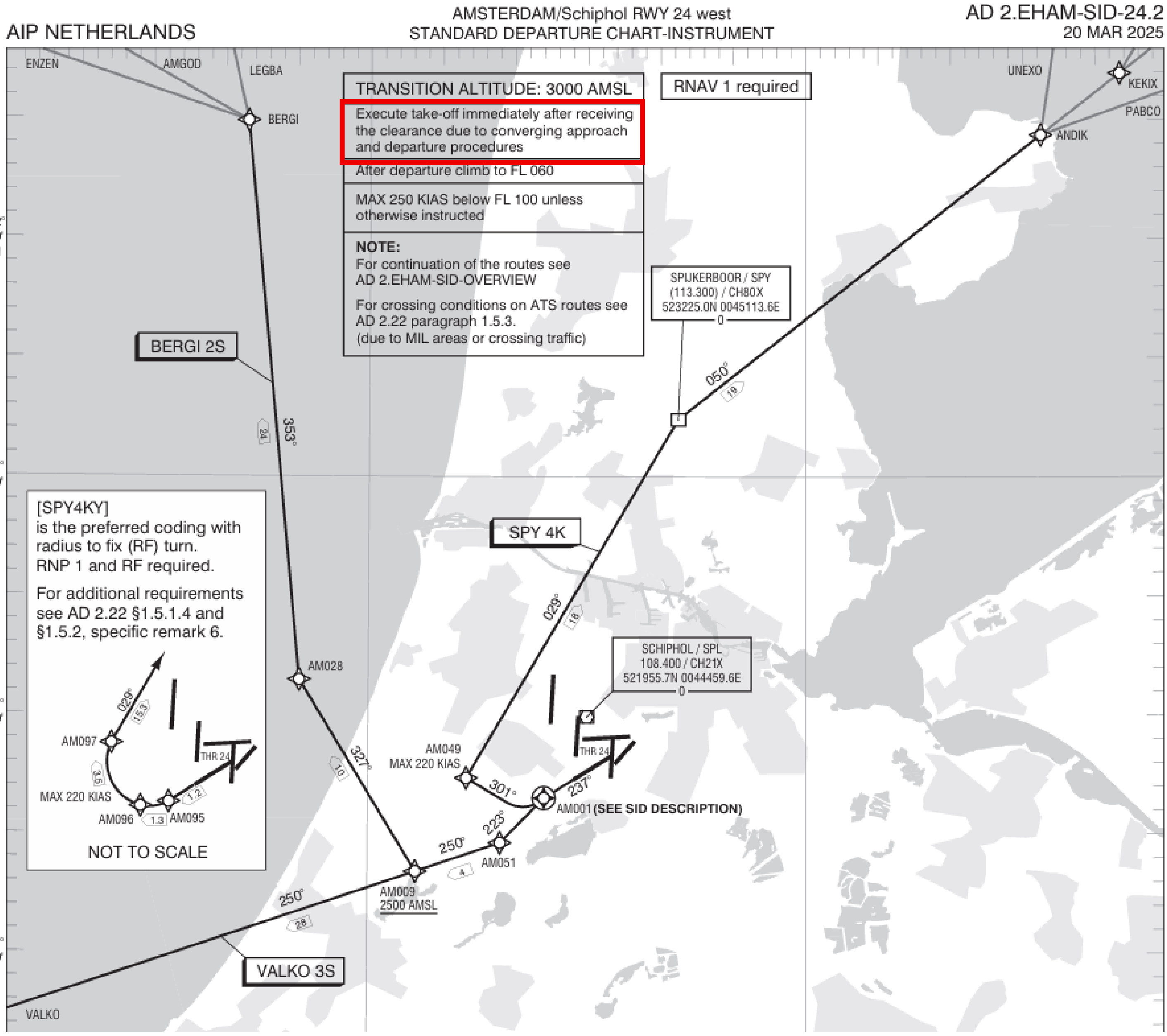


Figure 33 Risk charts (04/06, 04/09, 09/04 and 09/06)

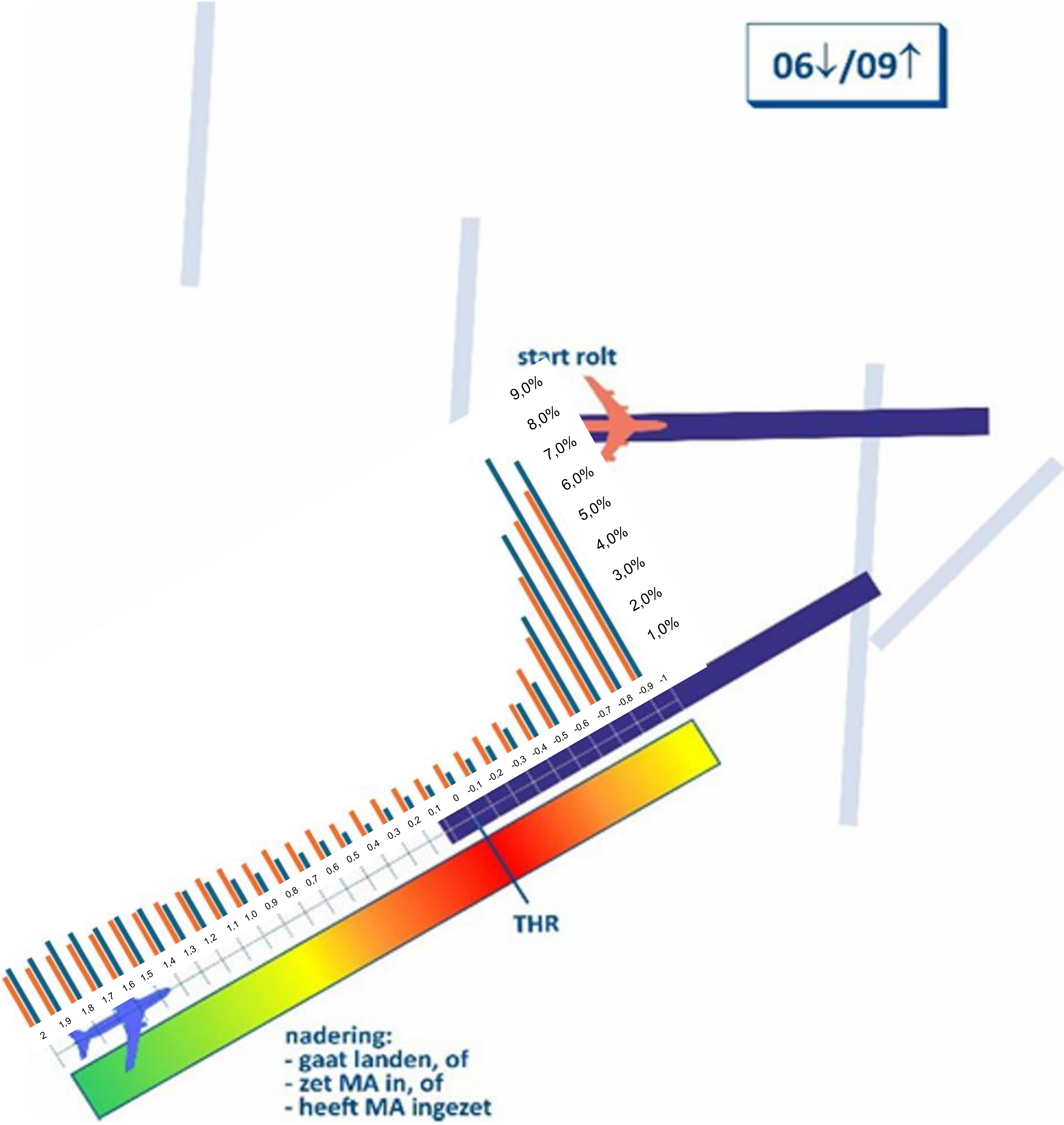
Appendix V *SID card of runway 24*



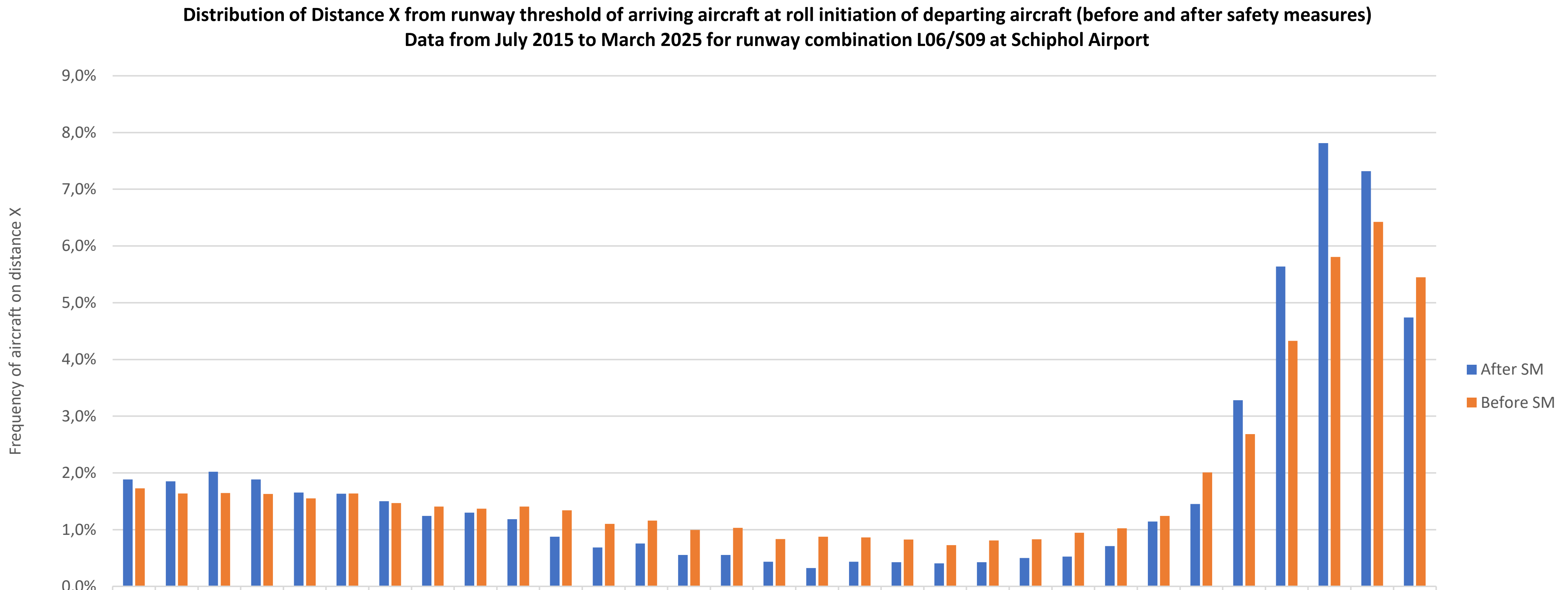
Appendix VI *Dataset analysis distance X*

RWY_COMB	ARR_RW	DEP_RW	NUM_ARR	UDP	Sight	CB1	VIS1	DEP_F_ID	DEP_CALLSIGN	DEP_ACTYPE	DEP_WTC	DEP_PREV_WTC	DEP_ATD	TIME OF ROLL	ARR_F_ID	ARR_CALLSIGN	ARR_ACTYPE	ARR_WTC	ARR_ATA	ARR_PROPTYPE	ARR_DIST
'L18C-S24'	'18C'	'24'	0	'Buiten UDP'	'GOOD'	1900	10000	11678648	'KLM37N'	'E190'	'M'		January-19	1-1-2019 05:59	' '						
'L18C-S24'	'18C'	'24'	1	'Buiten UDP'	'GOOD'	1900	10000	11678653	'KLM49W'	'B737'	'M'	'M'	January-19	1-1-2019 06:02	11678631	'KLM569'	'B772'	'H'	1-1-2019 06:03	'JET'	3,434418969
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678665	'TAP669'	'A319'	'M'	'M'	January-19	1-1-2019 06:04	11678631	'KLM569'	'B772'	'H'	1-1-2019 06:03	'JET'	-1,108103923
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678665	'TAP669'	'A319'	'M'	'M'	January-19	1-1-2019 06:04	11678627	'KLM1328'	'B737'	'M'	1-1-2019 06:06	'JET'	3,150218386
'L18C-S24'	'18C'	'24'	1	'Buiten UDP'	'GOOD'	1900	10000	11678662	'TRA6507'	'B738'	'M'	'M'	January-19	1-1-2019 06:06	11678627	'KLM1328'	'B737'	'M'	1-1-2019 06:06	'JET'	-0,955607557
'L18C-S24'	'18C'	'24'	1	'Buiten UDP'	'GOOD'	1900	10000	11678657	'AZA75C'	'A319'	'M'	'M'	January-19	1-1-2019 06:07	11678628	'KLM96F'	'B738'	'M'	1-1-2019 06:08	'JET'	2,805046577
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678664	'SWR737'	'A320'	'M'	'M'	January-19	1-1-2019 06:09	11678628	'KLM96F'	'B738'	'M'	1-1-2019 06:08	'JET'	-1,019008897
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678664	'SWR737'	'A320'	'M'	'M'	January-19	1-1-2019 06:09	11678632	'KLM36L'	'E75L'	'M'	1-1-2019 06:10	'JET'	3,221551951
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678661	'TRA89A'	'B738'	'M'	'M'	January-19	1-1-2019 06:11	11678632	'KLM36L'	'E75L'	'M'	1-1-2019 06:10	'JET'	-0,662826434
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678661	'TRA89A'	'B738'	'M'	'M'	January-19	1-1-2019 06:11	11678630	'KLM80Z'	'E190'	'M'	1-1-2019 06:12	'JET'	1,772091401
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678660	'VLG831Y'	'A320'	'M'	'M'	January-19	1-1-2019 06:12	11678630	'KLM80Z'	'E190'	'M'	1-1-2019 06:12	'JET'	-0,848210406
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678660	'VLG831Y'	'A320'	'M'	'M'	January-19	1-1-2019 06:12	11678629	'KLM44R'	'B739'	'M'	1-1-2019 06:13	'JET'	3,013680192
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678646	'TRA16M'	'B738'	'M'	'M'	January-19	1-1-2019 06:14	11678629	'KLM44R'	'B739'	'M'	1-1-2019 06:13	'JET'	-1,055667239
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678646	'TRA16M'	'B738'	'M'	'M'	January-19	1-1-2019 06:14	11678644	'KLM84X'	'E75L'	'M'	1-1-2019 06:15	'JET'	2,628192506
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678671	'EZY61CM'	'A320'	'M'	'M'	January-19	1-1-2019 06:16	11678644	'KLM84X'	'E75L'	'M'	1-1-2019 06:15	'JET'	-0,739620553
'L18C-S24'	'18C'	'24'	2	'Buiten UDP'	'GOOD'	1900	10000	11678671	'EZY61CM'	'A320'	'M'	'M'	January-19	1-1-2019 06:16	11678650	'KLM1350'	'B737'	'M'	1-1-2019 06:17	'JET'	2,110197854
'L18C-S24'	'18C'	'24'	1	'Buiten UDP'	'GOOD'	1900	10000	11678659	'MPH6121'	'B744'	'H'	'M'	January-19	1-1-2019 06:17	11678650	'KLM1350'	'B737'	'M'	1-1-2019 06:17	'JET'	-1,081539945
'L18C-S24'	'18C'	'24'	1	'Buiten UDP'	'GOOD'	2100	8000	11678694	'KLM11P'	'B738'	'M'		January-19	1-1-2019 06:43	11678683	'KLM58R'	'B738'	'M'	1-1-2019 06:43	'JET'	-0,896931282
'L18C-S24'	'18C'	'24'	1	'Buiten UDP'	'GOOD'	2100	8000	11678725	'KLM61Z'	'B738'	'M'	'M'	January-19	1-1-2019 06:46	11678679	'KLM71C'	'E190'	'M'	1-1-2019 06:47	'JET'	2,255676868
'L18C-S24'	'18C'	'24'	1	'Buiten UDP'	'GOOD'	2100	8000	11678704	'TRA37B'	'B738'	'M'	'M'	January-19	1-1-2019 06:48	11678679	'KLM71C'	'E190'	'M'	1-1-2019 06:47	'JET'	-1,074475604
'L18C-S24'	'18C'	'24'	0	'Buiten UDP'	'GOOD'	1800	7000	11678744	'EZY48KP'	'A320'	'M'	'M'	January-19	1-1-2019 06:50	' '						
'L18C-S24'	'18C'	'24'	1	'Buiten UDP'	'GOOD'	1800	7000	11678746	'KLM45C'	'B738'	'M'	'M'	January-19	1-1-2019 06:51	11678678	'TVF97SC'	'B738'	'M'	1-1-2019 06:52	'JET'	2,0579368

Appendix VII *L06/S09 aircraft distribution plotted into the risk analysis*



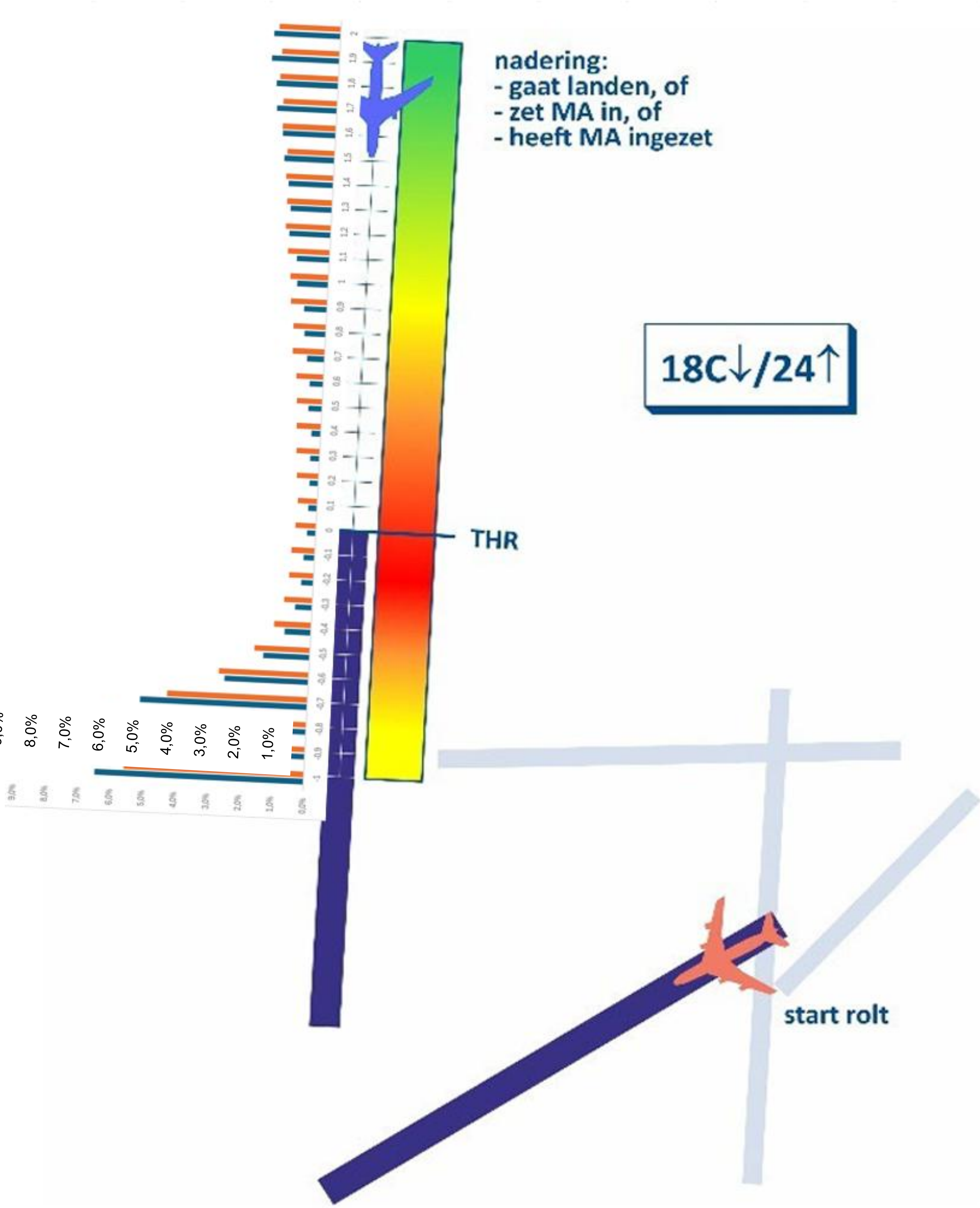
SM = Safety Measures



	2	1,9	1,8	1,7	1,6	1,5	1,4	1,3	1,2	1,1	1	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	0	-0,1	-0,2	-0,3	-0,4	-0,5	-0,6	-0,7	-0,8	-0,9	-1
After SM	1,9%	1,9%	2,0%	1,9%	1,7%	1,6%	1,5%	1,2%	1,3%	1,2%	0,9%	0,7%	0,8%	0,6%	0,6%	0,4%	0,3%	0,4%	0,4%	0,4%	0,4%	0,5%	0,5%	0,7%	1,1%	1,5%	3,3%	5,6%	7,8%	7,3%	4,7%
Before SM	1,7%	1,6%	1,6%	1,6%	1,6%	1,6%	1,5%	1,4%	1,4%	1,4%	1,3%	1,1%	1,2%	1,0%	1,0%	0,8%	0,9%	0,9%	0,8%	0,7%	0,8%	0,8%	0,9%	1,0%	1,2%	2,0%	2,7%	4,3%	5,8%	6,4%	5,4%

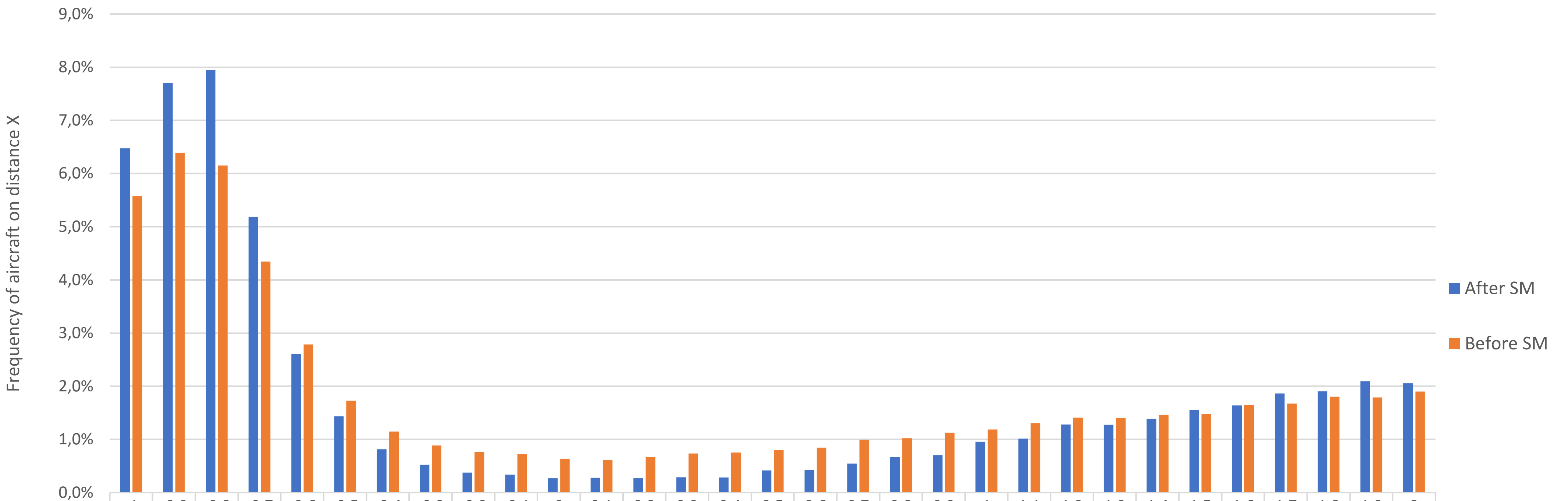
Distance X from the runway threshold (at the time the departing aircraft starts to roll)

Appendix VIII *L18C/S24 aircraft distribution plotted into the risk analysis*



Distribution of Distance X from runway threshold of arriving aircraft at roll initiation of departing aircraft (before and after safety measures)

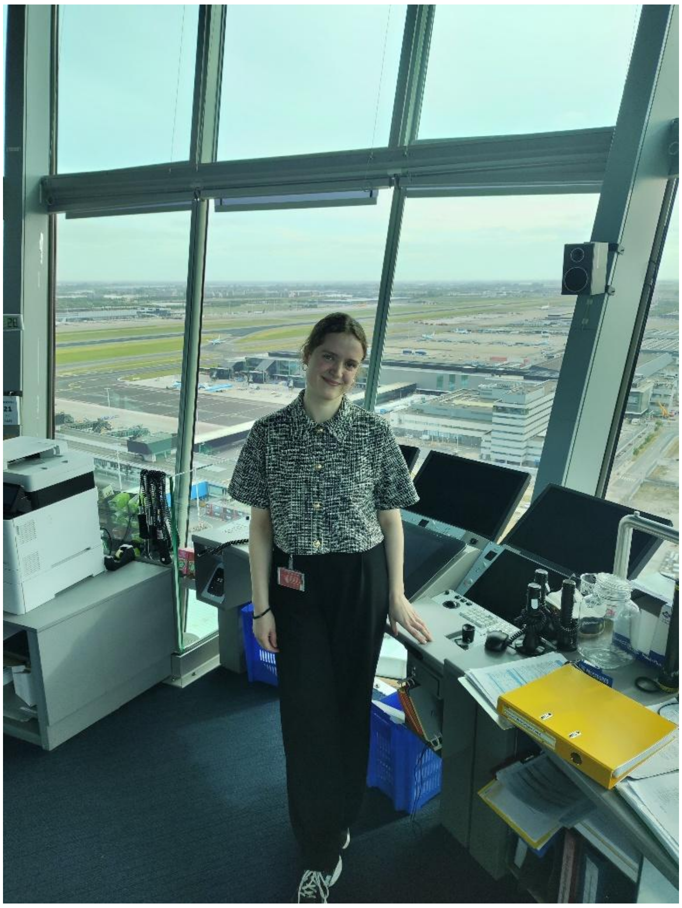
Data from January 2015 to March 2025 for runway combination L18C/24 at Schiphol Airport

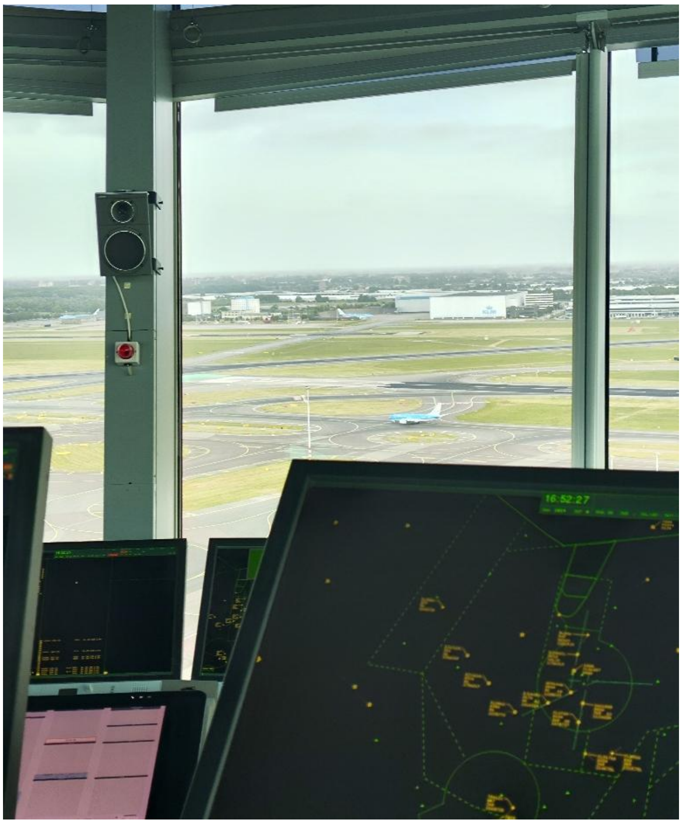


	-1	-0,9	-0,8	-0,7	-0,6	-0,5	-0,4	-0,3	-0,2	-0,1	0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	1,9	2
After SM	6,5%	7,7%	7,9%	5,2%	2,6%	1,4%	0,8%	0,5%	0,4%	0,3%	0,3%	0,3%	0,3%	0,3%	0,3%	0,4%	0,4%	0,5%	0,7%	0,7%	1,0%	1,0%	1,3%	1,3%	1,4%	1,6%	1,6%	1,9%	1,9%	2,1%	2,1%
Before SM	5,6%	6,4%	6,2%	4,3%	2,8%	1,7%	1,1%	0,9%	0,8%	0,7%	0,6%	0,6%	0,7%	0,7%	0,8%	0,8%	0,8%	1,0%	1,0%	1,1%	1,2%	1,3%	1,4%	1,4%	1,5%	1,5%	1,6%	1,7%	1,8%	1,8%	1,9%

Distance X from the runway threshold (at the time the departing aircraft starts to roll)
X = 0 indicates the runway threshold

Appendix IX *Schiphol Tower visits*






Appendix X E*thical guidelines*

The following ethical guidelines are applied during the research:

- Everyone who took part was told clearly what the study was about before they agreed to join.
- Full consent was obtained from the participants before the interviews
- Taking part in the interviews and surveys was completely up to the participants.
- All personal data collected was kept confidential and anonymized to protect participant identities.
- Participants were debriefed when appropriate and given the opportunity to ask questions about the study.

Appendix XI *Pilot survey (answered by two pilots of home carrier Medium categorized aircraft)*

Pilot 1

Are you familiar with the rule in the AIP that states an aircraft must begin take-off within 10 seconds after receiving take-off clearance?

No.

What do you do if you know you will not be able to meet the 10-second requirement? Is this always actively reported to air traffic control?

In principle, no, unless we have a procedure that requires a run-up of the engines. For example, after de-icing, the engines must always run for 30 seconds at 60% power to shake off any ice that may be inside. This 60% power can only be applied on the runway (taxi power is between 30–40%). This is reported.

What is, for you personally, the exact moment when you consider that you have received take-off clearance? (When is the moment that you and your co-pilot agree that you are cleared for take-off?)

- When the clearance is fully spoken? ✓

- While the clearance is being spoken? ✓

- After the pilots have read it back? ✓

- Or at another moment?

At another moment. In our procedures, the take-off clearance is read back, then the controls may be handed over (on our Embraer, only the captain can taxi). After that, the pilot flying says "Cleared," followed by the pilot monitoring saying "Checked." That is the moment we both agree that we are cleared for take-off. So, in practice, this means:

- Tower gives take-off clearance.
- We read back the clearance.
- (Possibly a change of controls)
- "Cleared" – "Checked" call.

Begin spooling up the engines (this sometimes already starts during the "Cleared/Checked" call for timing reasons, but it is not strictly procedural)

Is attention given to this rule during your training or briefing?

Other than it being part of the SOP (Standard Operating Procedure), no. However, there is a broader focus during training on ensuring there is no doubt about take-off or landing clearance. In case of doubt, it is always double-checked with the tower, even if your colleague is "sure."

Pilot 2

Are you familiar with the rule in the AIP that states an aircraft must begin take-off within 10 seconds after receiving take-off clearance?

Certainly.

What do you do if you know you will not be able to meet the 10-second requirement? Is this always actively reported to air traffic control?

In principle, I would not line up and would inform ATC how much time we need. If I notice that we are not obstructing anyone, I might line up a bit more slowly to create more time. But usually, I am just honest and leave it to ATC to decide whether we are still next or should give way.

What is, for you personally, the exact moment when you consider that you have received take-off clearance? (When is the moment that you and your co-pilot agree that you are cleared for take-off?)

- When the clearance is fully spoken? ✓

- While the clearance is being spoken? ✓

- After the pilots have read it back? ✓

- Or at another moment?

when the clearance is received and read back to ATC.

Is there a standard moment or phrase in the cockpit where the captain and co-pilot confirm that take-off clearance has been received and understood?

Yes:

TAKEOFF - ACTIONS AND CALLOUTS		
	PF	PM
Aircraft on the runway and takeoff clearance received	"CLEARED" • Advance thrust levers to 40% N1 to allow engines stabilization. • Advance, or make sure the AT has advanced, the thrust levers to the TO/GA detent before 60 KIAS. "CHECK THRUST".	"CHECKED". • Verifies that the N1 reached is the target N1, the engine parameters are normal and that ATTCS is as desired. "THRUST CHECKED".

Is attention given to this rule during your training or briefing?

This is actually part of route training. So, during the first weeks when coming from another division or new to the company.

Appendix XII *Interviews coded (RC1, RC2, RC3, RC4)*

CODE	SUBCODE	EVIDENCE
Landing confirmation	Visual Cues	“I go by when I see the thrust reversers deployed.” (RC1)
		When the nose gear comes down and the pitch flattens, that’s when I consider it landed.” (RC2)
		“I look outside — not at the radar screen... I really check: are you down? Are you really down? All wheels actually on the ground?” (RC3)
		“You have to really see that it’s landed — the speed drops, and it vacates the runway. It’s something you learn from experience. You recognize a proper landing." (RC4)
	Caution against false positives	“When I see the wheels touch the asphalt, and sometimes a puff of smoke... but that doesn’t necessarily mean it will not go around."(RC2)
		“Just because the wheels touch the ground doesn’t mean it will not go around.” (RC4)
Training and procedures	Awareness and behavioral change	“I found the color-coded training helpful in identifying which runway combinations are more critical...” (RC1)
		“It was more of a renewed awareness of the risks...” (RC2)
		“People started timing more during the day...” (RC2)
		“The training was always good... it keeps you sharp.” (RC4)
		“I have started to feel less pressure to push everything through.” (RC4)
		“It was really helpful to see which combinations allow more room and which ones do not.” (RC4)
	Retention and accessibility	“It should be easy to find so I can quickly look up all the distances. That color-coded chart would be great as a refresher after some time, to remind you what’s considered critical and what’s still acceptable. I want to be able to tell trainees: this is time-critical, this is not." (RC1)
		"I’d really like to have that risk analysis easily accessible." (RC1)
		"The data gives you insight into what’s critical and what’s not. That’s why I think it’s necessary to be able to look this up. I want to be able to tell trainees: this is time-critical, this is not. I think it’s pretty bad that it’s hard to look things up.” (RC3)
		“I should be able to find the chart ... but it’s not easy.” (RC4)
	Limitations	“The sim doesn’t feel real to me... but it’s useful to train.” (RC2)
		”In the sim, if you say, “turn left heading,” the aircraft immediately turns left. But in real life, it depends on why the go-around is happening. If something’s wrong in the cockpit, they are not going to immediately follow your

		instructions — they are focused on stabilizing the aircraft. So, I do not find the sim very realistic." (RC3)
		“Everything always works in the sim. If you tell a sim pilot “turn right immediately,” they turn within a second. But if you say that to an Airbus Cargo pilot, it takes longer. So, you get this false sense of confidence — “If there’s a go-around, I will just steer them.” But in real life, I do not have that confidence. I always have a bit of hesitation. “(RC4)
Timing & Safety strategy	Timing adjustments	“If there’s a crosswind and I see the aircraft wobbling on approach, I think, ‘Okay, the chance of a missed approach is a bit higher.’ Then I will time it accordingly. I always time it...(RC1)
		“If I think the chance of a go-around is high, I will wait.” (RC2)
		“Even during the day, I time more — especially with heavies.” (RC3)
		“If I find the visibility questionable, then I will time it. I will not take the risk. I still let it [the takeoff] go... but I watch very closely.” (when the arriving aircraft is within 2 miles) (RC3)
		“I just time it. Only in extremely busy situations do I push it.” (RC4)
	Avoidance of critical zones	"I never start a departure when the arriving aircraft is within 1 mile." (RC1)
		“I give takeoff clearance when the approaching aircraft is around 2 NM out, or even when it’s over the landing zone, around 1,4NM is what I prefer. Ideally, the aircraft should already be rolling before it reaches 2.5 NM. There’s no fixed point... it depends on visibility and aircraft type. You’re technically allowed to depart, but I personally avoid the red zone. If the aircraft is already over -0.4 or -0.6 NM, I will still give takeoff clearance. It is a quick risk calculation you make at that moment." (RC2)
		“Controllers who mostly work radar and only occasionally work in the tower tend to be more cautious.” (RC2)
		“I do not do that on purpose (referring to giving clearance when the aircraft is in the red zone). Ideally around 2 miles, and once it’s touched down. If it’s just in the red zone and still looks good, I let it go.” (RC3)
		“I prefer to stay out of the red zone, even in good visibility.” “It’s better to prevent it upfront than to apply emergency measures. “I now think, I will just wait through the critical moment. Eventually, you reach a point where you think, If it goes around now, it’s going to be a mess. Even in good visibility and good conditions, I’d still wait out that red zone a bit. If it’s a heavy... I usually think, ‘I will just wait.” “I personally avoid the red zone.” (RC4)
		“If it’s a heavy, my red zone is much larger than what’s shown on the chart. If there’s a lot of crosswind and gusts, then I mentally expand that critical zone.” (RC4)

Go-around handling	Non-Intervention	"If the pilot says, 'missed approach' or 'going around,' I just say 'roger' and do nothing. I want the missed approach to proceed without interference. I could, for comfort, give a turn… but in principle, I do nothing." (RC1)
		If it's a heavy that's just airborne — you can't really do anything with that. If the heavy on approach goes around — you do not want to deal with that either." (RC4)
	Steering	"I turned the go-around aircraft to the right… kept the departure lower. It was visual separation, not radar separation. You want to detect a missed approach as early as possible." (RC2)
		"You might steer the go-around rather than the departure. If the approach looks unstable… I will not start the departure." (RC3)
		"I personally get more and more frustrated that we often rely on steering the go-around as a solution… it doesn't always work in practice" (RC4)
		"Steering the go-around doesn't always work in practice." "If the aircraft goes around, then I will take action and steer it behind the departure." "You must already have a solution in mind — that's drilled into you during training." "Steering them behind is always better than trying to go in front." "You might think: I'd rather do that with a KLM pilot… than with some Chinese pilot where you're not sure if they will understand." (RC4)
Aircraft variability	Maneuverability and Flexibility	"An Embraer is more flexible and maneuvers more easily and quickly than a heavy." (RC2)
		"A heavy reads it back, and then it still takes a while before it starts moving." (RC2)
		"Mediums are more flexible, can turn faster, can give you a good rate of climb more quickly." (RC3)
		"Heavies are simply less flexible — slower to steer or climb." (RC3)
		"Smaller aircraft much more maneuverable than a big heavy from some airline that only comes here once every five years." (RC4)
	Approach Speed Differences	"A larger, heavier aircraft has a higher final approach speed than a smaller one, and I take that into account." (RC1)
		"They all have different speeds… heavies usually have a higher approach speed." (RC2)
	Departure timing adjustments	"For a large aircraft, I might already avoid starting a departure when it's at 2.5 miles…" (RC1)
		"With a fast aircraft, I will stop departures earlier." (RC1)
		"With a heavy, you want more confirmation that it's really on the ground before you let another heavy start rolling." (RC2)
		"If it's a heavy… I usually think, 'I will just wait.'" (RC4)

		"If it's a heavy, my red zone is much larger than what's shown on the chart." (RC4)
Operator variability	Take-off roll and response time	"One crew is fully ready, hand on the throttle, and when I say 'cleared,' they go. Another one hears 'cleared for takeoff' and it's like, 'Okay, coffee's finished.'" (RC1)
	Airline specific patterns	"KLM's Airbus A330s take a very long time... Delta goes immediately." (RC1)
		"Transavia also takes forever to start rolling." (RC1)
		"Delta — the Americans — they really stand out. You say, 'cleared for takeoff' and boom, they go." (RC3)
		"KLM always takes a bit longer... foreign crews too." (RC3)
		"Transavia and KLM often delay rolling." "If I had to make a top 3, it would be Transavia, KLM, and then some unknown third. " (RC4)
		"Other carriers usually start rolling faster than Transavia or KLM." (RC4)
	Expectations and experience	"With a home carrier like KLM, you sometimes trust them a bit more than some random Turkish or Chinese airline. You still look at how the approach is developing... not just the airline." (go-around) (RC2)
		"Sometimes, because you know they will not roll immediately after "cleared for takeoff," you give the clearance a bit earlier, thinking, "If they wait 10 seconds, I have accounted for that. With Delta Airlines... I wait 10 seconds before giving clearance, otherwise they will go too early." (RC4)
Safety vs. Capacity and Noice	Capacity and noise Constraints	"You're taking a safety risk for the sake of noise, and that's a conscious choice." (RC1)
		"There's always tension with capacity. If you want to apply rules within UDP for converging runways, then you simply can't achieve the same capacity." (RC4)
Human factors	Cognitive and situational awareness	"We need to understand what's happening in the cockpit, and the cockpit needs to understand what's happening on our side." (RC1)
		"You're constantly scanning, and each scan takes a few seconds. Those seconds might be just enough to stop the departure in time—or just too late. "On paper it's all numbers... but in practice there are so many factors you consider that you can't get from the numbers." (RC2)
		"In the sim, if you say, 'turn left heading,' the aircraft immediately turns left. But in real life... they are focused on stabilizing the aircraft." (RC3)
		"The downside of this job is that things almost always go well, which can make you complacent." (RC4)
Cancel take-off clearance	Physical risk of aborting	"Stopping them at that point is a big decision. They are already accelerating fast, and stopping can be dangerous—there's risk of fire, emergency services, all that." (RC1)

		“I have had to stop an aircraft during training—twice, actually, with a student... I have done it once myself, but it rarely happens.” (RC1)
		“If it’s already well into the roll and I cancel the takeoff, then you’re dealing with hot brakes, reverse thrust... that can have a big impact. So no, you do not do that lightly. Only in the very early stage, when it just starts rolling, can you still say ‘abort,’ but you do not want to do that." (RC4)
	Anticipation and judgement	"I: So, if the approaching aircraft is in the red zone, you abort the takeoff? RC1: Definitely. Yes. I: Even if the approaching aircraft doesn’t go around? RC1: Yes."
		"Sometimes you end up in a situation where you think, “Ah, this is not ideal,” but there’s not much you can do. Then you have to decide: do I stop them now? Because technically, nothing has gone wrong yet, they have not gone around. But if they do, I will have a problem." (RC1)
		“If I think the approach looks unstable... then I will not start the departure.” (RC2)
		“If the weather is good, I do not abort. I just look very closely and think ahead about what I will do if something happens. You want them to start rolling. If they do not, you’re kind of on edge.” (RC3)
		“Only in the very early stage, when it just starts rolling, can you still say ‘abort,’ but you do not want to do that. If I think the chance of a go-around is higher than usual... I will say ‘cancel takeoff clearance’ because the aircraft is barely rolling.” (RC4)
Pilot interaction	Limited pilot awareness and assumptions	“I do not think pilots are very aware that the runway combination is dependent.” (RC2)
		“Pilots often assume it’s all coordinated. The answer is: not really.” (RC4)
		Some pilots have been flying to Schiphol for years and assume it’s all coordinated — like a mirror system.” (RC4)
	Communication gaps and ineffective information use	"One of the conditions for allowing takeoff in good visibility is that you provide traffic information about the landing aircraft. But pilots often do not do much with that information. It’s kind of an empty phrase. Even home carriers who are familiar with the airport do not always act on it. If you tell Turkish Airlines, “Traffic is departing from 24,” they will just say “okay.” They have no idea. So, it doesn’t mean much. I think there’s a bit of false safety in that." (RC1)
		“If they need time, they usually say so in advance when lining up... But they do not usually say, ‘We need 10 more seconds.’”

Appendix XIII *Interview RC1*

I: Could you please introduce yourself and briefly explain your role?

RC: I have been working here since 2018, so that is seven years now. I work both in the tower and in approach. I was contacted by SUP1—SUP1—you've been in touch with him too, right?

I: Yes.

RC: Okay. I work in the procedures department, but I am also somewhat familiar with the other departments we have here on the office side. SUP1 is on the safety side, and I work with two other operational experts for air traffic controllers on the procedures side. So that is kind of the—well, I would not call it a division, but procedures and safety go hand in hand, although they sometimes conflict. It is a good example of how procedures must be safe, of course, but SUP1's role is more defensive, while we tend to be a bit more offensive. In the end, that leads to the best solutions. So that is my role in the organization.

I: And do you also work in the tower?

RC: Yes, yes, both in approach, behind the radar, and in the tower. It varies.

I: It varies?

RC: Yes, but this topic is only relevant to the tower. As a radar controller, you're not involved in dependent departures and arrivals, so I am curious.

I: Have you experienced dependent departures and arrivals before?

RC: Departures and arrivals, definitely. I also did the training three or four years ago—I am not sure exactly. The one with the color-coded risk analysis?

I: Yes, that is right.

I: What are your experiences with dependent departures and arrivals?

RC: My experiences?

I: How does that process work for you?

RC: I know that I apply the rules more strictly than I technically have to. The rule is that in good visibility—under certain conditions—you're allowed to initiate take-off whenever you want. In lower visibility, you have to time it with the two-mile separation. But I always time it. Not necessarily with the two miles, but I always make sure that if the arriving aircraft goes around, it will pass behind the departing one. I am a bit more conservative because, in my view, once a missed approach is initiated, there is nothing more you can do. In the past, the assumption was that you could just vector the aircraft, but I have received a lot of feedback from pilots saying, "My priority is to keep the aircraft flying, and if there is no mountain, I am not turning." So, I do not want my handling to depend on whether or not the aircraft turns. I found the color-coded training helpful in identifying which runway combinations are more critical and which offer more room. It gave good insight into what is possible and what is not, and when it is a bad moment to initiate a take-off. So, I always time it, even if that costs some capacity. But I feel more comfortable that way. It is uncomfortable when you try to time it, but the aircraft starts rolling later than expected. Then you're stuck thinking, "Should I stop it now or not?" Those are uncomfortable situations. Nothing happens externally, but in your head, you're thinking, "If it goes around now, what do I do?" That is not a situation you want to be in because you lose a bit of control—and we do not like that.

I: Okay, and suppose the aircraft does go around—how do you handle that?

RC: That is why I always time it. If the pilot says, "missed approach" or "going around," I just say "roger" and do nothing. I let them go. I let the departure go as well. Of course, I make an assessment: will it pass behind? And I check whether that is still the case, because your assessment might differ from what actually happens. If it still looks good, I let it happen and do not intervene. That is my goal—not to have to do anything. I could, for comfort, give a turn or something, like a slight left turn if they are close, but in principle, I do nothing. I want the missed approach to proceed without interference because there is already a lot going on in the cockpit. That is also emphasized in training—the workload is high. One of the conditions for allowing take-off in good visibility is that you provide traffic information about the landing aircraft. But pilots often do not do much with that information. It is kind of an empty phrase. Even home carriers who are familiar with the airport do not always act on it. If you tell Turkish Airlines, “Traffic is departing from 24,” they will just say “okay.” They have no idea. So, it does not mean much. I think there is a bit of false safety in that.

I: What do you say to the pilot in those situations?

RC: “In the event of a missed approach, expect a left turn or right turn.” That way, the pilot knows what to expect if they go around. My interpretation is that if a pilot is in a high-workload situation, they should immediately know what action to expect. That is what I apply myself, it is something I came up with. It is not written down anywhere. Other colleagues do not necessarily do it. But I think that if I have to apply an emergency measure, this helps the pilot understand what is coming and increases the chance they will follow through. Because they’ve just been told what to expect, rather than suddenly having to adjust to a new instruction in a critical moment. That often does not work. So, this is how I try to contribute to a smoother response.

I: In terms of timing, do you use a specific distance from the runway threshold that the approaching aircraft must be at?

RC: No, that is hard to say. In the risk analysis, you see neat values like 1.9, 1.8, 1.7 miles, but I do not have that on my radar screen. There is a distance indicator with a number, but it is measured differently—it refers to another point in the approach. The critical point is much further along. So that distance is not entirely accurate. We do not have the right information sources to determine that precisely. So, it is a bit of a gut feeling. You do have the track vector, which helps. Do you know what a track vector is?

I: No, not really.

RC: It is a white line on the radar that shows where the aircraft will be in one minute. But it is based on the current speed. If the aircraft goes around, it flies faster, so the line becomes inaccurate. If you fly faster, you’ll be in a completely different spot in one minute than if you fly slower. So, we do not really have support for that—it is kind of a “miss is miss” situation. That is basically the reality. It is also difficult to fully automate this in systems because you do not know how fast the aircraft will fly. One aircraft flies faster, another climbs better—you just do not know. There are many uncertainties when it comes to timing. Also, if there is a strong headwind, the aircraft takes longer to reach the runway, which affects timing. With a tailwind, they get there faster. The problem is that our procedure is described in terms of distance—2 miles—but the issue is actually time-critical. That is a bit odd. I think in the future we should have support tools that are time-based, because this is really a timing issue. Depending on the wind, the time it takes to cover 2 miles varies. With a headwind, it takes longer than with a tailwind. So, I have always found it strange that we try to solve a time problem using a distance-based rule.

I: And regarding aircraft types, how does that affect operations during dependent departures and arrivals?

RC: Well, a larger, heavier aircraft has a higher final approach speed than a smaller one, and I take that into account. The time it takes to cover the same distance is shorter for a larger aircraft. So, for a large aircraft, I might already avoid starting a departure when it is at 2.5 miles, because timewise it is the same as a small aircraft at 1.5 miles. I do take that into account. I know the rule is 2 miles, but sometimes I will start a departure within 2 miles if the arriving aircraft is very slow. That is a conscious decision. So, in that case, I am slightly inside the rules. But with a fast aircraft, I will stop departures earlier—so I am slightly outside the rules. That is my interpretation of a distance-based procedure for a time-based problem. It might sound complicated, but that is how I apply it. Sometimes I wonder if I am allowed to do what I am doing, but there is a clear rationale behind it. I can justify it to myself. I stand behind it 100%I’d do it again tomorrow. But I know it is not officially the rule. It is just how you sometimes have to interpret rules to make the Schiphol system work.

I: With the right capacity—?

RC: Yes, and with the noise regulations. Often this is driven by noise. For example, if you use runway 18L for departures, you do not have this problem anymore. You do not need to time it. But we often use the L18C/S24 combination because runway 24 (Kaagbaan) is preferred for noise. So, you're taking a safety risk for the sake of noise, and that is a conscious choice. I do bend the rules a bit to make that work, because that is what the system wants. A safer option would be to use a completely different runway, but then everyone complains about the noise. So, we're caught in that balancing act, and we have to find a solution. That is really unique to Schiphol—it makes it interesting, let's say. Not many other airports have this issue.

I: Outside the UDP, there are fixed, stricter rules of 2 miles, and the departing aircraft must already have started rolling. How do you handle that within the UDP? Is it also around 2 miles?

RC: Around 2 miles, definitely. But I never start a departure when the arriving aircraft is within 1 mile. I found the color-coded risk analysis helpful—it shows you per runway combination, like L18C/S24, what you're dealing with. And with 22/18L, it is different. I'd really like to have that risk analysis easily accessible—just in my reference materials—so I can quickly look up all the distances. That color-coded chart would be great as a refresher after some time, to remind you what is considered critical and what is still acceptable.

I: Would you be able to find that risk analysis now?

RC: No, not that I know of. We had it once in a training session, but if I had to look it up now, it would take me half a day. It should be easy to find. Just give me a quick reference… But that is more of a training and maintenance issue. I had it once, but I would not know where to find it now.

I: Okay, there was a refresher course a couple of years ago, I believe—two years ago?

RC: That could be.

I: Do you remember the refresher course?

RC: Yes, I do. The thing is, we get so many announcements and training bulletins. I just did some three or four days ago, and I already have ten new ones. So, something like that refresher course becomes just one of those ten. Will I still remember it in three years? No idea. It is just a huge amount of information, and you constantly have to refresh it. That is part of our job, but it has to be easily accessible. That is often lacking. I am sure it is somewhere, but I can't easily find it. It should be much easier to locate. Honestly, I'd prefer something like an AI—like ChatGPT—where I can just ask, "What are the critical distances for converging to L18C/S24?" and get an answer. Right now, I have to use search terms, and if the search term does not work, I have to dig through training bulletins. Is it in the OPS manual? It is really hard to find. You have to know exactly where to look.

I: What would you suggest as an alternative?

RC: Like I said, we're too focused on using a search bar. That takes time. But with something like ChatGPT, you just ask a question and get an answer. The system searches through all the documentation for you. I do not care if the answer comes from an info bulletin, a training bulletin, a safety document, or the OPS manual. I just want the answer. That is how we search for things in everyday life—like when we book a vacation. But we're still stuck in the old way of searching with keywords. That takes a lot of time just to find the right document. So, there is definitely room—and a need—for improvement.

I: Okay, and to what extent do you feel the original training enables you to remain proficient in this operation?

RC: You still have to figure out a lot on your own. We trained this four years ago. You can draw your own conclusions about how effective that is for something so time critical. I haven't done that training since.

I: Do you handle things differently now than before the safety measures were introduced?

RC: No, I was already timing things back then. But it was more of an estimate. Now it is calculated—this is time-critical, this is still okay. For example, if I look at the distance here [referring to the risk analysis], at 1.4 or 1.5 miles it is still green. That is within two miles. So, I have concluded that even though the rule says two miles, 1.8 is still fine. That is just my logic, and I have adjusted it based on the data. Before, it was strictly two miles, but now I see that 1.8 is still acceptable. The data gives you insight into what is critical and what is not. That is why I think it is necessary to be able to look this up. Next week I am giving a tower training session in the simulator, and I want to be able to tell trainees: this is time-critical, this is not. But right now, I would not know where to find that information. That is pretty strange.

I: Okay, and when do you consider an aircraft to have landed? What do you look for?

RC: Good question. I go by when I see the thrust reversers deployed. Aircraft usually decelerate using engine thrust, and you can see the reversers flip back. That is when I know from pilots: they are not going airborne again.

I: And is that when you let the departing aircraft roll? Or only when the approaching aircraft is around 1.8 miles out?

RC: It depends. The aircraft does not just start rolling like opening an app—it has to be told, the pilot has to report it and perform the actions. So sometimes I see the aircraft in the flare, and I already give the take-off clearance to the other one. But the departing aircraft is still moving slowly, so if the arriving one does a touch-and-go, I can still stop the departure at low speed. You anticipate that so you can still act if needed. But you also want to roll on time for the next one, which is already a minute behind. If I wait until I actually see the thrust reversers before giving take-off clearance, I will run into problems with the next arrival. So, I give the clearance before I have fully confirmed the landing, but I do check afterward to make sure it actually happened. There is a difference between issuing the clearance and verifying that the landing is complete. I have learned that once the thrust reversers are deployed, they are not going airborne again. As long as they are not deployed, a go-around is still possible. Touch-and-go's are the trickiest—you think they've landed, and then suddenly they are back in the air. That is where we've had the most issues.

I: So once the thrust reversers are deployed, there is no chance of a go-around?

RC: No, they are not going airborne again at that point. It is not possible anymore.

I: And how do different aircraft types play a role in this operation?

RC: Honestly, I do not know enough about that. Sometimes you can clearly see that the speed is so low that the aircraft is definitely not going around anymore. But it can take a moment before you can really confirm, "Yes, it is down, yes, it is down." That takes a bit of time. It remains a tricky thing.

I: Is there a moment when you cancel the clearance?

RC: Yes, immediately if the aircraft goes around. That is straightforward. The more difficult situation is when the aircraft starts rolling much later than when you gave the clearance. Our manuals say, "You must start rolling immediately," but not every aircraft does that. For example, I know that KLM's Airbus A330s take a very long time. So, I give them take-off clearance earlier because I know they take 30 seconds to get moving. An American carrier like Delta goes immediately. So, I take that into account. It really depends on the airline, the aircraft type, whether it is a home carrier or not. Transavia also takes forever to start rolling, and I factor that into my timing.

I: Why do you think some airlines take longer?

RC: It is just their own way of interpreting things. One crew is fully ready, hand on the throttle, and when I say "cleared," they go. Another one hears "cleared for take-off" and it is like, "Okay, coffee's finished," just as a joke. It really depends on the type, the people, the airline—I do not know what is going on in the cockpit.

I: And do you inform pilots that the situation is time-critical?

RC: Yes, well, it is already mentioned in the AIP, in Schiphol's documentation, to avoid me having to say it to every aircraft. Pilots generally know that Schiphol is busy, so if you're cleared, you should go. It does not happen often, but sometimes I am thinking, "Go, go, go!" It is difficult. You can only emphasize to them that there is a reason they need to start rolling, and if they can't, they should say so.

I: Do pilots do that?

RC: Yes, regularly, but not always. Never always. For example, pilots will inform us if they need to do an engine run-up. Sometimes they need to run the engines for 20 seconds before they can go, especially in cold or icy conditions. They usually report that. But it makes timing difficult. Sometimes you end up in a situation where you think, "Ah, this is not ideal," but there is not much you can do. Then you have to decide: do I stop them now? Because technically, nothing has gone wrong yet, they haven't gone around. But if they do, I will have a problem. And stopping them at that point is a big decision. They are already accelerating fast, and stopping can be dangerous—there is risk of fire, emergency services, and all that. It is very time critical. They accelerate like a Formula 1 car. It has a big impact. I have had to stop an aircraft during training—twice, actually, with a student. It was still at low speed, but even then, the pilot needed time to reassure passengers, check brakes, etc. It really has an impact. That is why it is a tough decision for us.

I: Have you ever had to stop rolling aircraft in real operations?

RC: Yes, like I just said—with a student. And there is an extra layer there because I was not the one working the position. I had to tell the student to stop, and the student had to tell the pilot, and the pilot had to act. So, there is more delay. I have done it once myself, but it rarely happens. Because I time things, I have never really had a serious issue. I try to avoid it, because I do not think there is a good solution once it happens.

I: So, if the approaching aircraft is in the red zone, you abort the take-off?

RC: Definitely. Yes.

I: Even if the approaching aircraft does not go around?

RC: Yes.

I: And how do pilots know they are operating under a dependent runway configuration?

RC: Hmm, I think it is mentioned in the ATIS. I believe it is in the AIP, in the documentation. But I do not think pilots are specifically informed that they are in a dependent landing/take-off situation. I do not see it mentioned often. With converging approaches, yes, that is communicated. But with dependent landing and take-off, I do not think so.

I: So, you do not announce it over the frequency to the pilots?

RC: Well, if you want to start within two miles, you have to give traffic information, so then we do say it. But if you start outside two miles, you do not have to. If you're timing it, you do not have to say anything. So, I do not think it is communicated.

I: Because you time it before the aircraft reaches two miles?

RC: Yes, you have to be rolling before the arriving aircraft is at two miles. That is the procedure.

I: Right, that is the procedure outside the UDP. And within the UDP—

RC: Or when there is a low cloud base or poor visibility conditions.

I: And with good visibility and within the UDP?

RC: Then you're allowed to start within 2 miles, provided you give traffic information—so you must inform the pilot. That is the condition for being allowed to start within 2 miles.

I: Is much attention paid to the time between take-off clearance and the moment the aircraft starts rolling?

RC: Absolutely. The focus is mainly on the landing, because you want to detect a missed approach as early as possible. But you're constantly switching your attention: "Okay, there is the landing—has the departure started rolling yet? There is the landing—has he started rolling?" You're checking both constantly. That is why it is really frustrating when pilots do not start rolling. It remains an issue. You can try to influence it by saying things like "prepare for an immediate departure," so that when I give the clearance, they know they have to roll immediately. Or "make it rolling"—do not stop on the runway first and then start rolling. Just go straight through. That is how you can try to manage it, but still… I do not know what is going on in the cockpit. Some pilots are more proactive; others take their time. It is always a bit of a gamble. Most of the time it goes fine, but sometimes it does not, and then you end up in a situation you'd rather avoid. It remains difficult.

I: Do you notice a difference in the time between clearance and rolling now compared to before the safety measures were implemented?

RC: That is hard to say. Generally, it goes well. It is the exceptions that stick with you. But overall, it is manageable. I think it is important that this is emphasized in communication with pilots—during briefings, for example—so that the importance of this is clear. And that new generations of pilots also understand how things work at Schiphol. That should be part of their training: "At Schiphol, when you're cleared, you need to start rolling—and here is why." That message needs to be repeated constantly. That is all you can really do. We need to understand what is happening in the cockpit, and the cockpit needs to understand what is happening on our side. That usually leads to good outcomes. Of course, sometimes a pilot will say, "I know, but I couldn't do it this time because of […]." And that is fine.

I: As long as they communicate it?

RC: Exactly. That usually happens, but I would not say it is necessarily because of training. It is more that if you keep bringing it up, a lot of issues are avoided. Just by understanding each other's situations better. More mutual understanding let's say.

I: So, you also take into account aircraft type, different carriers, and different speeds?

RC: Definitely. And weather conditions too. For example, if there is a crosswind and I see the aircraft wobbling on approach, I think, "Okay, the chance of a missed approach is a bit higher." Then I will time it accordingly.

I: So you assess the stability of the approach?

RC: Absolutely. Is it flying fast? Is it making strange turns? Does it look stable? Sure, it could still go around, but it is about estimating the likelihood. If I think the chance of a go-around is high, I will wait.

Appendix XIV *Interview RC2*

This interview was conducted with a runway controller who was actively working in Tower West at the time. I was allowed to come to the tower to conduct the interview there, which is why the conversation jumps straight into the topic. Additionally, since take-off clearances were being issued during the interview, those parts have been removed from the transcript.

I: [Shows a diagram of the risk analysis for runway combination L18C/S24] This is what you received during the 2022 training, with different zones. I have plotted the results of my research next to this risk analysis [shows the risk analysis with the results overlaid]. Orange represents the situation before the safety measures, and blue represents after the measures.

RC: Yes.

I: The vertical axis shows the percentage of approaching aircraft positioned at distance X from the runway threshold, and the horizontal axis shows distance X to the threshold, where 0 equals the threshold. [Shows an example] At this distance X, 1% of approaching aircraft were at 0.1 NM from the threshold at the moment the departing aircraft began to roll before the safety measures, and now after the measures, it is about half a percent. So still in the red zone. This graph shows that a change has occurred between the pre- and post-measure implementation periods.

RC: So orange is how it used to be, and blue is how it is now?

I: Yes.

RC: Okay.

I: So, this shows the position of the approaching aircraft when the departing aircraft begins to roll.

RC: Begins to roll, or when take-off clearance is given?

I: Begins to roll.

RC: Because that is a different moment than when take-off clearance is given.

I: Yes.

RC: Right.

RC: So clearly, more aircraft are already on the runway now. So, what you had here [points to the pre-measures red zone in the risk analysis] has now shifted to here [points to the first peak].

I: Correct, and also here [points to the second peak, further from the threshold].

RC: Yes, that is definitely a big difference.

I: Yes.

RC: So that is basically because more aircraft are already on the runway.

I: Yes.

RC: Yes.

I: When do you consider the approaching aircraft to have landed?

RC: That depends. It also depends on the aircraft type. Sometimes it is very clear, and sometimes it is hard to judge when you can say it is really landed.

I: The OM states that you must monitor the landing?
RC: Yes, that is correct.

I: Do you actually confirm that the aircraft has landed?

RC: Yes, the confirmation you can use is when you see the wheels touch the asphalt, and sometimes you see a little puff of smoke. So that is a kind of touchdown. But that does not necessarily mean it will not go around. In theory, it still could. So, when I look outside and see it in the touchdown zone, and the nose gear comes down and the pitch flattens, that is when I consider it landed.

I: Okay, and is that the moment you give take-off clearance to the departing aircraft?

RC: No, that depends on the circumstances. If we have to time it, then that is the moment I give take-off clearance. Basically, I start speaking when I see the aircraft is about to land, because that gives me about five seconds—which I need if the aircraft is already lined up—so it starts rolling in time before the next one is at 2 NM. But within the UDP and with good visibility, it is less critical because I can visually monitor and manage it if something unexpected happens.

I: Right.

RC: So, within the UDP, if you're talking in terms of risk, you could say that you're taking a different kind of risk than you would outside the UDP, where you really have to time it precisely.

I: Okay.

RC: So, if you really wait until it is fully landed and begins decelerating, that can be difficult. Because then you have to follow other rules. Within the UDP, those are more like guidelines, but outside the UDP, you have to give take-off clearance very precisely if you want to make it work with the next aircraft already at 2 NM.

I: You mentioned that this can vary depending on several factors. What are those factors?

RC: Aircraft type, which you definitely take into account. A small aircraft versus a heavy—there is a difference. With a heavy, you want more confirmation that it is really on the ground before you let another heavy start rolling on a converging runway. If it is two Embraer's, I still want to see a positive landing, but I have more flexibility to act if something unexpected happens.

I: Yes.

RC: They also start rolling faster, and there is less mass behind them. With a heavy, the timing between when you give take-off clearance and when it actually starts rolling is tricky. It takes time to get going. You can see that here too. If I give take-off clearance to this one [aircraft on the runway, a KLM Embraer], it reads back the clearance and starts rolling almost two seconds later, already picking up speed.

I: Yes.

RC: A heavy reads it back, and then it still takes a while before it starts moving. So, you have to handle the timing differently compared to an Embraer or a 737.

I: And how does that differ by aircraft type on approach?

RC: On approach, they all have different speeds. Heavies usually have a higher approach speed than mediums.

I: Yes.
RC: Or at least compared to a Category D aircraft—those have different approach speeds.

I: Suppose there is a heavy aircraft on final approach, and it performs a go-around. I can imagine that a heavy has more difficulty turning than, say, an Embraer?

RC: In theory, they all have the same bank angle limits and such. But yes, I also estimate that an Embraer is more flexible and maneuvers more easily and quickly than a heavy. That is true. They will initiate a turn more quickly, whereas a heavy, if you had to describe it, moves much more in slow motion. Everything takes longer—also because it is such a massive machine.

I: Yes.

RC: [Issues take-off clearance to a departing Embraer aircraft] See, it immediately picks up speed and now it is off. You saw earlier with the heavy—it took longer. That is a real difference. This one accelerates right away.

I: And do you notice any difference now that the safety measures have been implemented? The AIP states that pilots must begin rolling as soon as possible after receiving take-off clearance.

RC: I actually do not know.

I: So that is not really monitored?

RC: No, I do not really pay attention to that. I can't say. I know that when I want them to start rolling immediately, I sometimes apply a technique—like when departing from 18L while landing on 27, which is a conflict. And if aircraft are spaced 2–3 miles apart, I will tell the aircraft that is first in line: "Prepare to roll on my call." Then they know that as soon as I start speaking, they need to begin rolling. That way I gain time and prepare them. Once the landing has passed the intersection, I say: "Cleared for immediate take-off, start your roll now." That is how I indicate: you must start rolling immediately. No time to wait or spool up engines, you just have to go.

I: And for L18C/S24?

RC: You can apply that there too.

I: Okay.

RC: Yes, but those are things you apply more often outside the UDP and when there are many departures compared to landings. But what we do nowadays—because it is a conflict we want to avoid, especially outside the UDP—is that when we're landing on 18/18 with a lot of outbound traffic, we also start using 18L to avoid that conflict.

I: And how does wind play a role in this?

RC: Wind always plays a role. It affects approach speeds and how quickly an aircraft climbs out. With strong wind, it climbs faster. A go-around can also reach altitude more quickly with strong wind. So yes, that definitely has an impact. The aircraft's weight, approach speed, and performance also affect the go-around. They have a go-around button they press to initiate it. If the aircraft is overpowered—like when it is very light—it climbs like crazy. In the past, they often overshot the maximum altitude for the go-around. The procedure specifies an altitude—for example, 1000 ft for 18R and 18C, and 3000 ft for 27. You'd sometimes see them overshoot that.

I: And what does that mean? What happens if they overshoot?

RC: In principle, it can create a potential conflict. The assumption is that a go-around stays at 2000 ft, so it remains below any departing aircraft.

I: Oh, so it flies under the departing aircraft?
RC: Yes, that way you try to maintain or create the 1000 ft vertical separation, because you're still within 3 NM. Or by the time they call in to the radar controller, you want to have that 1000 ft separation.

I: Before the interview, you mentioned you once experienced a go-around from 18C while an aircraft was departing from 24. How did that go?

RC: Yes, that was within the UDP, with quite a bit of cloud cover. It was a 737 and a 757. The

757 was departing from 24, and the 737 appeared to be landing—it was over the runway and looked like it had touched down. So, I started the 757's take-off roll. But it turned out the 737 had touched the runway with its wheels but still performed a go-around. Very late, very strange.

I: [I showed the risk analysis profile] Where, in which zone, was the 737 approximately when the 757 began to roll?

RC: That must've been around here [-0.4]. It had definitely touched the runway.

I: Oh wow, that is quite far past the threshold.

RC: Yes, exactly. That was really far. That is one of those moments where you assume the aircraft has landed, but it hasn't.

I: So, you expect it to land around the aiming point (around -0.3)?

RC: Yes.

I: But if it is already at -0.4, you'd expect it to have landed.

RC: Yes, exactly. It was really between -0.4 and -0.6. Very late. So, what happens is, you're scanning between the two runways. You look at one runway and see the aircraft in the touchdown zone, where it is supposed to be, and you see it flaring. Then you look at the departure runway and think, "Okay, we're starting now because the next one is already coming." You say, "cleared for take-off," it shows up on the screen, the pilot reads it back, and then you look back at the other runway—and the aircraft is not where you expected. It is in a go-around. So now you have to react to that aircraft. How fast is it going? You're constantly scanning, and each scan takes a few seconds. Those seconds might be just enough to stop the departure in time—or just too late, because the aircraft is already going too fast to stop. That is something you have to consider. If it is already going fast, saying "stop immediately" could be dangerous. Aborting a take-off at high speed is really risky.

I: And what actions did you take in that situation?

RC: I turned the go-around aircraft to the right—it listened, thankfully. I turned the departure to the left and kept it lower initially, so it stayed underneath. It was visual separation, not radar separation. By the time both aircraft called in to radar, the 1000 ft and 3 NM minimum separation was restored.

I: Do you remember when this happened?

RC: No idea.

I: But it was with good visibility?

RC: It was within the UDP, but there were quite a few clouds. The go-around disappeared into the clouds and then came back out. I think it was 8 to 10 years ago. A long time ago.

I: So quite a while back.

RC: Yes, another one! [At that moment, a go-around occurred on runway 24, which we could see from the tower in good visibility and within the UDP.] But again, nothing on the runway. Is it the wind causing this?

[It was due to late landings (far beyond the aiming point]

I: And how often does a go-around like that happen?

RC: Three in one day is a lot (we had seen three within an hour), especially with these weather conditions. No, this is really quite a lot. I think we usually have, how many go-arounds—two per week on average? [She asked a supervisor.]

Supervisor: No, definitely more than that.
RC: More?

Supervisor: Yes, definitely about once a day.

RC: Once a day?

Supervisor: Yes, we've already had three in one hour.

RC: Yeah, but this is really a lot. I remember once during a storm, I was working here [Tower West], and I think I had about 15 go-arounds in 1 hour and 20 minutes. It was insane.

I: Fifteen?

RC: Yes, I have never had that many go-arounds. But there was a lot of wind and storm and who knows what else. It was completely crazy. There were more aircraft going around than actually landing—it was kind of funny, actually.

I: And when an aircraft is approaching, at what position relative to the runway threshold do you give take-off clearance to the departing aircraft?

RC: There is no fixed point. There really is not a fixed point where you do that. It depends on how good the visibility is. You have the limitation of 5 km and 2000 ft, but even if it is better than that, it might still not be great—like if it is raining or cloudy. And then it also depends on what kind of aircraft is on the runway and what kind is approaching.

I: Could you give an example?

RC: Ideally, I give take-off clearance when the approaching aircraft is around 2 NM out, or even when it is over the landing zone. That is when I feel most comfortable—around 1.4 NM is what I prefer. But if it is already over -0.4 or -0.6 NM, I will still give take-off clearance.

I: Then it is already past the aiming point.

RC: Yes, and at that point, I figure that if it does go around, I can still stop the departure. If I can stop it within 5 seconds, that is still acceptable to me, based on the speed at which the aircraft would need to abort the take-off.

I: Okay, and suppose the approaching aircraft is a heavy and the departing aircraft is a medium—what difference does that make?

RC: Well, if it is a heavy approaching, I will wait until it has actually landed.

I: Okay, so really when the wheels touch the ground?

RC: Yes.

I: And if the approaching aircraft is a medium and the departing aircraft is a heavy?

RC: Then I'd probably wait until the medium is about 1.2 NM out and in the touchdown zone. Then I trust it. The heavy takes a while to get going, so I can still stop it if needed. But I do not want to risk the heavy already picking up speed and then having to abort the take-off because the landing aircraft goes around. That would be a real problem. Aborting a take-off at high speed in a heavy aircraft is dangerous, it is heavy, and then you're dealing with serious risks. So that is definitely something to avoid.

I: So, with heavies, you're mainly focused on where the approaching aircraft is before giving take-off clearance?

RC: Yes, definitely. Whether it is a heavy landing or a heavy departure.

I: And what if both are mediums?

RC: Then you have more flexibility—at least I do. But that varies per controller. It depends on whether the controller works regularly in the tower. I am one of those; I do this almost every day. I am not saying I take more risks, but I do have more experience, which means I assess the situation differently and use the options I have differently to manage the conflict. Controllers who mostly work radar and only occasionally work in the tower tend to be more cautious, because they are more used to the radar picture and not the tower view, which is a different way of observing. There are no clear-cut A-B-C answers for this.

I: Outside the UDP, there is a strict rule: at 2 NM from the threshold—

RC: Yes, at 2 NM the aircraft must have already started rolling. So, you give take-off clearance before it reaches 2 NM.

I: And how many NM in advance do you give take-off clearance?

RC: At the latest, at 2.5 NM. That way, the aircraft can begin rolling before it reaches 2 NM. You need more space for that. And sometimes, if aircraft are nicely lined up on the ILS at 3 NM, with one landing every 3 NM, it is almost impossible. You need a positive landing, and the next one is already at 2 NM—then you do not have room to give take-off clearance. You really need to start talking before the aircraft reaches 2 NM if you want to issue clearance in time. And even then, I feel like 2 NM is cutting it close.

I: What would you prefer?

RC: Ideally, the aircraft should already be rolling before it reaches 2.5 NM. So, you need to start talking at 3 NM. But that is just not feasible, there is no room. That is why they eventually decided that if there are too many landings and a lot of departures, we do not use the L18C/S24 combination anymore. It is almost impossible to time correctly with the talking, the positive landing, and the next aircraft already at 2–3 NM. So, we switch to independent operations and use 18L for departures.

I: So instead of using 18C, you use 18L?

RC: You keep landing on 18C, but you stop departing from 24. Instead, you depart from 18L, and then there is no conflict.

I: And this only applies to operations outside the UDP?

RC: Yes, we only do this outside the UDP.

I: Suppose this aircraft [points to the risk analysis] is about 2 NM from the threshold within the UDP. If you give take-off clearance then, where is the aircraft approximately when the departing aircraft starts rolling?

RC: No idea, I can't give you a fixed number. It depends on the approach speed of the aircraft, which depends on the aircraft type. And even within the same type, speeds vary. If it is heavily loaded, it has a higher approach speed than if it is light. If there is a lot of wind, the approach speed is high, but the groundspeed is low. So, you're not just dealing with approach speed, but also with groundspeed, which is affected by wind.

I: Wow.

RC: Yes, there are a lot of factors. For example, with strong westerly winds, we often use runway 27, which is currently under maintenance. There, aircraft might fly at 160–170 knots, but with 30–40 knots of headwind, the groundspeed is only 110–120 knots. So, you have the airspeed—the speed the aircraft flies through the air—and the groundspeed, which is the speed over the ground. And that can be much lower due to wind.

I: Do you see the groundspeed of aircraft on your screens?

RC: Yes, we do see the groundspeed. I do not see their indicated air speed, although sometimes they report it as their final approach speed. But the speed I see displayed here includes wind correction—it is the groundspeed. Actually, I am not even sure. [Asks the supervisor] We see the groundspeed, right?

Supervisor: Yes.

RC: At approach, they can see a lot more data—like what speed has been set and also the altitudes. That is helpful.

I: But you can't see that?

RC: No, because I do not use that data for separation. I am not allowed to use radar for separation. I use the data to clarify the picture I have—it is just a tool. For me, radar is a support tool. The only radar we use for actual separation is the ground radar for ground control, and that is only for taxiing aircraft—not airborne ones. For anything flying, I am not allowed to use radar for separation. I can only use it to support my situational awareness.

I: Okay, and would you give take-off clearance earlier for approaching aircraft with high groundspeed?

RC: No, actually the opposite—because they reach the runway faster. So, I have to account for the fact that they will enter the red zone sooner relative to the departure.

I: So, if this approaching aircraft [from the risk analysis] has a high groundspeed, at what position would you give take-off clearance to the departing aircraft?

RC: Then it would need to be further out before I give clearance—or already on the runway.

I: Oh, so with slower speeds, you could give take-off clearance closer to the threshold?

RC: Yes, exactly. A higher approach speed also increases the chance of a go-around.

I: Why is that?

RC: Yes, because it could indicate that the aircraft are less stable on approach. If it is approaching too fast, it becomes harder for the pilot to land. It could also indicate a technical issue. Aircraft have different configurations for take-off and landing. When taking off, they extend the wings using flaps to generate more lift, allowing them to get airborne more quickly with the help of wind and speed. For landing, they want lower speeds but still need lift. So, they use devices like slats (on the front of the wing) and flaps (on the back) to increase the wing's surface area and change its shape. The slats make the front of the wing more curved, which changes the air flow and allows the aircraft to fly at lower speeds. These configurations are necessary for a successful landing. If the aircraft is flying too fast, it might not be able to configure the wing properly, which could lead to a go-around because the wing is not set up correctly for landing. So that is all part of it. We do not directly take that into account, but I do consider that if an aircraft has a high approach speed, it might be more likely to go around because it is not flying at a stable, lower speed.

I: So, in that case, you're more inclined to wait for a confirmed landing?

RC: Yes, or I will choose to start the departure outside the 2 NM range.

I: And when exactly do you cancel take-off clearance? Is there a specific moment for that?

RC: When the aircraft goes around.

I: Only when the approaching aircraft goes around? Or are there other moments—like if the approach enters the red zone?

RC: No, not in the red zone within the UDP. Outside the UDP, I do have to cancel. For example, if I gave take-off clearance outside the 2 NM range but the aircraft does not start rolling until after it is already within 2 NM, then I have to abort the take-off. But that is only outside the UDP. Within

the UDP, that is not required. So, it is up to me whether I let it continue or not. If I do let it continue, I stay very alert for a possible go-around so I can intervene immediately.
I: So, if this approaching aircraft [from the risk analysis] is in the red zone, and the departing aircraft takes a long time to start rolling, causing the approach to enter the red zone, you could still let it go?

RC: Yes, I do not have to stop it. I can, but I do not have to. It is up to the controller to decide. It is a quick risk calculation you make at that moment.

I: In your case, what would you have done in that situation?

RC: I would have let it go. But that also depends on how the approach looks. If it looks stable and I have no reason to believe it will go around—good visibility, calm weather, the previous aircraft has vacated the runway, no signs of technical issues—then I will not abort a take-off just because the landing enters the red zone. But if I think the approach looks unstable, or the wind is gusty, or the previous aircraft is still vacating the runway—those are all factors that increase the chance of a go-around. Then I will not start the departure.

I: And do aircraft types play a role in that?

RC: Less so, but with a heavy, you always handle things differently than with a medium.

I: In what way, during a go-around?

RC: They are less flexible, less maneuverable. And if you have to abort a take-off with a heavy, the weight makes it harder. It takes longer to get going, but also longer to stop. You need a lot of brake force, which puts stress on the brakes and can lead to overheating or even tire blowouts. With a heavy, you're more cautious—not because it is riskier per se, but because the consequences of an aborted take-off are more severe due to the mass involved.

I: And how about different carriers? There are home and other carriers. How do you handle that?

RC: Yes, you take that into account too. With a home carrier like KLM, you sometimes trust them a bit more than some random Turkish or Chinese airline. That is just how it is. Yes, you do take that into account, but you still look at how the approach is developing, using the radar and the speeds you see there, and by looking outside and seeing how it develops visually. Look there [she pointed to an approaching aircraft on runway 24], a triple is coming in, and it looks very calm and neat. It might be an airline you'd normally be more cautious with, but because it looks very stable and calm, you factor that into your decision of whether or not to start with L06/S09. For example, if it is hanging there [in front of runway 06], and I want to start with 09, and an aircraft is taking off straight ahead, then I will just go ahead and start. Because then I can turn left with that [departing aircraft] and I will always be behind the departure. But if an aircraft takes off and turns right after departure, then I would not do it so quickly, because then I might be heading into a potential conflict. Because the departure turns in the direction of the go-around. You take that into account too. So that is the funny thing — on paper it is all numbers, fine, you know, these are the numbers, these are the distances, but in practice there are so many factors you consider that you can't get from the numbers. You'll never get those from the numbers.

I: Wow!

RC: Yes, really a lot!

I: If a dependent runway combination is in use, are pilots aware of that?

RC: It is published on the ATIS, which runways we're using, but I do not think pilots are very aware that the runway combination is dependent. I know some pilots who are aware, and they all assume that we have procedures in place that ensure it never becomes a conflict, and so they are not aware that that is not necessarily the case.

I: So, you never inform the pilots verbally?

RC: It is mentioned on the ATIS, and the frequency they can listen to is broadcast, how exactly I do not know, but it is mentioned. And in principle, they are required to request and listen to the arrival information of the airport they are flying to, and such things are mentioned in that. But whether that actually happens and is used in practice, I do not know, and I cannot check. And then there is a phrase like "converging approach is in progress," those kinds of texts are mentioned, and I do not know to what extent they understand what that means.

I: But as RC, you do not inform them?

RC: No, what I do apply — and I can do this with L18C/S24 and also with L06/S09 — is if I decide not to wait in the green zone to start with the aircraft from the converging runway, and the inbound is flying out of the green zone, that is the best scenario. So, when it flies out of the green zone, if I then decide to start, I tell the inbound "departure runway 24." If it is landing on 18C, I say, "cleared to land 18C, traffic departing runway 24," and with that I try to make them aware of the fact that they are landing here [18C], but there is a departure from this [24] runway.

I: And the departing aircraft does not hear that?

RC: No, I only say it to the landing aircraft, because the landing is the one that could cause a problem by initiating a go-around. The departure can't cause a problem because it is just departing. The only potential conflict is if the landing is not complete and initiates a go-around — then that is the one that could cause the issue. That is the one who needs to be aware that there is a departure, which implies that if they go around, they can expect an immediate instruction from me due to the departure from the converging runway.

I: Okay, and you always mention that when using a converging runway combination?

RC: I mention it when we're coming out of the green zone. If it is in the green zone, I know for sure it will not be a conflict.

I: So really around 1NM from the runway threshold?

RC: Yes, something like that. And then I only mention it to the aircraft that could potentially come into conflict with the departure — I will not say it to the next aircraft behind it.

I: [shows the risk analysis profile of L18C/S24] This was also part of the training in 2022, do you recognize this?

RC: Yes, definitely.

I: And there was also a refresher course, right? Do you remember when that was?

RC: No, I can't remember. We had the training, and then a refresher course, but I have no idea when. We have to go into the simulator once or twice a year, and various topics and exercises are covered. But which exercises and topics were covered in which training, I really couldn't tell you. I definitely remember the first training, but whether we had a follow-up course after that, I do not know. We do so many exercises that I really can't remember which ones were trained. And you're not really focused on that — you just follow a program with exercises, and whether that was a refresher course, I do not remember.

I: And to what extent do you think the original training helps maintain professional competence?

RC: Well, it was really nice to see it that way again, because it was kind of — I do not feel like it improved my professional competence, but that is probably because I am a tower controller and I am here almost daily, both at this tower and the other one. Maybe for the approach controller, who is less often in the tower, it was more of a bonus and helped with their competence. But for me, it was not like that. It was more of an eye-opener — not really, but more of a renewed awareness of the risks and the constant risk calculation we do every time. So that was it. It was a kind of awareness, which is always good. You know what the risks are, you know the theory behind it, you know what actions to take, you know why we time things outside of UDP, but it is nice to see it again with those numbers and visualizations. That is what it was.

I: And do you also feel that the situation has changed from before the measures to now (with the training)?

RC: The biggest change for me was when we started applying timing outside of UDP. That was really an eye-opener — like, okay, we're actually going to do this because otherwise we're just operating too close to the margins, and we simply shouldn't do that. So, I think that was a key moment for me, and also for several of my colleagues. People started timing more during the day and became more aware that the conflict can really come up quickly. For some colleagues, it brought about even more change, but for many it was a helpful visualization — like, "oh yeah, right."

I: Oh yeah, and do you feel that way inside UDP as well?

RC: As a result of the rule change for outside UDP, I think the working method for some colleagues has also changed inside UDP.

I: And for you?

RC: In that sense, I have become more aware — especially with heavies, because they really carry a lot of weight, and their speeds and maneuverability and flexibility are quite different. I have become more conscious when starting and landing with those. But with well-maneuverable mediums and other types, I still tend to push capacity more rather than strictly timing within UDP. Outside UDP it is very clear — it is a rule. Inside UDP it is not a rule, but more of a guideline. And if we were to make it a rule, I'd understand that and be fine with it, but then you're really talking about capacity issues, and you'd have to make different choices. If you want to apply rules within UDP for converging runways, then you simply can't achieve the same capacity. So, if you do that, you basically can't use converging runways anymore. It just does not fit. So instead of using 06 with 09, you'd have to land on 36C and depart from 36L — then you're completely independent. And the same goes for L18C/S24. Instead of departing from 24, you'd have to depart from 18L. Which is actually what we already do outside UDP. And then you have to be able to maintain capacity, so you fall back on other runway configurations — and then we're dealing with environmental and noise concerns. You have to make choices somewhere. If you choose capacity, then you have to make people aware of the potential risks, and the controller must be professionally competent to handle it safely at all times. And if you choose safety, that is fine, but then you have to fly a different runway combination.

I: With less capacity?

RC: Then you'd have to reduce capacity. If you want to combine safety with capacity, then you'd need to fly a different runway combination, or reduce capacity — and that is a very complex issue we always face. Because we're a safety organization, that comes first. But that means we'd have to fly a different runway combination, which we can justify outside UDP because of the conflicts we do not want to risk. But inside UDP, there is really no room for that. So, you have to be aware of how and why you're starting in a certain way, how you handle landings, what space you have if a landing is aborted. You need to be professionally competent for that, and that is why these kinds of trainings are very good, helpful, and interesting.

I: For awareness.

RC: Yes, exactly. Absolutely.

I: And that also varies per controller?

RC: Yes, because it is human work — it varies a lot per controller. Basically, we all use the same rules, and some rules are really strict, like the 3NM 1000ft separation. But as a tower controller, you're allowed to deviate from that. The nice thing is that some rules are really strict — you can't deviate from them — but there is also a part that is a gray area. This is an example of a gray area, and as a controller, you're allowed to act based on your own judgment.

I: For visual separation, can you actually see everything at once?

RC: No, especially with 24 and 18C, you really have to turn and scan. The same goes for 06 and 09. It is not in one field of view. You're constantly switching. You make scanning rounds, looking at the departing aircraft, then at the landing aircraft, and so on. And you do that at every position. They are all timers you keep in your head.

Appendix XV *Interview RC3*

I: Okay, let's begin. Could you briefly introduce yourself and your role?

RC: I am RC3, 45 years old. I have been working at LVNL for almost 23.5 years. I am an air traffic controller and supervisor in the Tower and Approach departments. And since two months ago, I have also started working on the professional competence of supervisors — that is an additional task.

I: Okay, and you also work in the tower?

RC: I work both in the tower and in approach, behind the radar. One day you have a tower shift, the next day an approach shift. And also as a supervisor — one day you're supervising, the next day you're just a controller. So, it varies.

I: Okay, and what are your experiences in operations with converging landings and departures within UDP in good visibility?

RC: Yes, what are my experiences? Yeah, fine — no bad experiences, I'd say. Because you're looking outside. I think the question is mainly about how you handle it when you're in the tower. As long as everyone lands, it goes well, of course.

I: Have you ever had one go around?

RC: Yes, but very rarely. Are you talking about landing on 18C and departing from 24?

I: Yes, among others.

RC: I think I have maybe had that once in real life. In the simulator, of course, you've had it more often, but in real life, very rarely.

I: And how do you handle it when one does go around?

RC: Well, I have noticed that I am timing more and more nowadays. Technically, we do not have to time during the day in good visibility — you can just give traffic info and go. I do not really do that anymore. I used to just keep going, but now I notice that even during the day I time more — especially with heavies. If a heavy is landing and a heavy is departing, or even a medium, I often just wait.

I: What do you mean by "timing"?

RC: If an aircraft is at 2 miles final on 18 Center, the take-off roll must have started. That is the rule outside UDP or in reduced visibility — under 5 km and 2000 feet. But even in good visibility, I notice I do it more often, just to reduce the chance of a conflict.

I: Okay, and suppose the aircraft passes the 2-mile mark — you've had this in training — and it is about here, do you then abort the take-off?

RC: No, I do not. I just watch very closely. I still let it go. Sometimes you clear an aircraft for take-off, but it does not start rolling right away. Sometimes they wait 10–20 seconds. Then the inbound is really in the red zone. But if the weather is good, I do not abort. I just watch very closely and think ahead about what I will do if something happens.

I: What do you focus on when you're "watching closely"?

RC: I mainly watch to make sure the landing is actually going to land. That is what I focus on most.

I: And suppose the approaching aircraft does go around — how do you handle that? Do you steer it or let it go?

RC: That really depends on the situation. It depends a lot on where the aircraft is. You might think, “Oh, steer that way,” but actually, if it is rolling, it is better to steer this way, so you pass behind it. But that is just what I am thinking now — it is really situation-dependent. Maybe the aircraft goes around early and climbs quickly — then you can stop it from climbing. You can also manage it with altitude. But I think you’d steer.

I: And you mentioned you’re timing — did you do that before the new measures?

RC: When do you say the measures came?

I: 2022.

RC: Oh, then I think I did it less before that. I think I have started doing it more in recent years. So that would be around that time. I think it is more about increased awareness.

I: One of the measures is that the aircraft has 10 seconds to start rolling after take-off clearance, and that is now in the AIP and SID charts.

RC: Not every airline follows that, but… yeah, okay. I was not really aware of that specific rule change. But yeah, I have been timing more in recent years, so it might line up with that. I think it is more about increased awareness.

I: And part of those measures is that the aircraft has 10 seconds to start rolling after take-off clearance — is that monitored?

RC: Yes, of course. You want them to start rolling. If they do not, you’re kind of on edge. But like I said, in good visibility, I do not abort the take-off.

I: And do you notice any difference between the moment of take-off clearance and when they actually start rolling?

RC: Between airlines?

I: Yes, or has it improved in general?

RC: Has it improved? I am not really aware of that. My feeling is that it hasn’t improved much. I have been doing this for 23 years, so I know — when you say “cleared for take-off,” they do not always start rolling right away. Airlines like Delta do — Americans hear “cleared for take-off” and they are already pushing the throttle. But KLM always takes a bit longer. And KLM uses leased aircraft with foreign crews, and they also take longer. Has it improved? I can’t really say it has.

I: So it really depends on the airline?

RC: Yes, definitely.

I: So, home carriers take longer than other carriers?

RC: It is not necessarily about home carriers — I mentioned KLM, but it is not like foreign airlines always roll immediately. Some might even be faster than KLM. But Delta — the Americans — they really stand out. You say, “cleared for take-off” and boom, they go. Maybe that is because of regulations in the U.S. that they have to follow, and they apply them here too. But they really stand out to me.

I: Okay, and what factors do you consider when giving take-off clearance to a departing aircraft when there is an approaching aircraft on final?

RC: Yeah, I consider quite a few factors — it really has to be good visibility. If I find the visibility questionable, then I will time it. I will not take the risk.

I: Like with heavies or smaller aircraft?

RC: Yes, if heavies are involved, I will definitely time it. With mediums, you can steer more easily — they are more flexible, can turn faster, can give you a good rate of climb more quickly. But with heavies, I will definitely time more carefully.

I: And is that also airline-dependent when the aircraft is on final? How do you handle that?

RC: No. Maybe if it is a cargo aircraft — those are usually heavier and larger, so you're extra cautious because they can barely steer. But no, a heavy is a heavy to me.

I: Suppose a medium aircraft from a different airline is on final — do you take that into account less?

RC: No. It also depends a bit on who it is. Generally, you'll do something with the landing aircraft rather than the departing one. You might stop the climb of the departure, but in terms of steering, you're more likely to steer the go-around. That is my feeling — that you steer the go-around rather than the departure. So, in that sense, you could say it matters more what airline is on final — whether you feel you can communicate with them and they will listen. But no, I do not think, "Oh, it is a foreign airline on final, I will wait longer." No.

I: Do you inform pilots that they are using a dependent runway combination?

RC: No, not as a standard. Only when the approaching aircraft is within 2 miles, then I will say "traffic departing from runway 24" — just traffic information. But I do not give that info to every aircraft. Even when I am on arrival and lining up traffic for 18 Center, I do not say "converging" — I do not mention that.

I: Is information about a dependent runway combination shared with departing aircraft?

RC: Well, I assume they know that many runways at Schiphol intersect. I think home carriers are definitely aware of what could be going on. Sometimes I will have an aircraft wait a bit, and if it is going to be a longer wait, I will say "landing traffic on conflicting runway." But I do not say that as a standard. I only inform them when the approaching aircraft is within 2 miles. And even then, if it is two mediums, you do not have to during the day. Just traffic info is enough — you're allowed to depart as long as you give traffic info.

I: Is giving traffic info standard within 2 miles?

RC: Yes.

I: How do you monitor and confirm that an aircraft has landed and there is no longer a risk of a go-around?

RC: How do I monitor and confirm? By looking outside — not at the radar screen. We do have a radar display at our workstation, but no, I look outside. The radar is not always perfectly accurate — it lags a bit, in my opinion. So, I look outside: do I see that it is on the ground? And I know that even if it is on the ground, it could still go around, so I really check: are you down? Are you really down?

I: All wheels actually on the ground?

RC: Exactly. Because in the past, someone saw a touchdown and assumed it had landed, but the aircraft still went around.

I: Are there areas where you do not give take-off clearance, for example, if the approaching aircraft is in the red zone?

RC: No, not intentionally. Sometimes I catch myself thinking, "Oh shoot, I gave take-off clearance and the aircraft is on short final." But no, I do not do that on purpose.

I: So ideally around 2 miles, and once it is touched down?

RC: Yes, once it is landed, I can say "cleared for take-off."

I: Do you also tell pilots they need to start rolling as soon as possible?

RC: Yes, sometimes I ask, "Are you ready to roll on my call?" Then they know, okay, I need to go immediately. If they say no, then I wait.

I: Do they let you know if they take longer than 10 seconds?

RC: No, not really. If they need time, they usually say so in advance when lining up — like "we need 30 seconds on the runway" or something. That does not happen much on the main runway. It is more with smaller traffic from Schiphol East or something — maybe an engine run-up. But then ground already informs you. If they just sit there for a while, they usually do not say anything. Sometimes a pilot will say something, but most of the time they just sit there. I will call them: "rolling?" — "Oh sorry, we're going now." But they do not usually say, "We need 10 more seconds." Very rarely — not standard.

I: Do you notice a difference in the situation now after the measures were introduced compared to before?

RC: I think people are just more aware now. In the past, we were more like cowboys — everything was possible. I think now people stick to the rules more and are more consciously timing. Like, "Why take the risk? Let's just wait 20 seconds longer and be sure the conflict is clear."

I: So, more people are timing?

RC: Yes, I absolutely think so.

I: To what extent do you feel that the original training and the refresher courses help you stay professionally competent in this operation?

RC: Yes, we had a sim exercise once — that was quite a big thing. I think it was about two years ago. We also had a refresher course with a busy exercise. I know we're getting another tower competence day this fall, and I believe that will include a lot of go-arounds. I do not know which runway combination it will be, but I know there will be a lot of go-arounds. I think we also had one two or three years ago. Did it help? Yes, of course — it raises awareness. I always find it hard to take the sim as truly realistic. I mean, I am not shocked when an aircraft goes around in the sim — I just think, "Oh yeah, of course, it is the sim." It is not like I think, "Oh no, they are getting too close." In the sim, if you say, "turn left heading," the aircraft immediately turns left. But in real life, it depends on why the go-around is happening. If something's wrong in the cockpit, they are not going to immediately follow your instructions — they are focused on stabilizing the aircraft. So, I do not find the sim very realistic. It does not feel real to me. But of course, it is useful to train and to see it happen, because in real life, you might not experience it for years.

I: In 2022, you also had a presentation alongside the sim training with these [shows risk analysis chart per runway combination] risk analyses per runway combination. How was that for you?

RC: I do not remember exactly. It is only because you have this sheet that I think, "Oh yeah, we did see that." How was it? I do not remember exactly. I can't name the specifics per runway — like "at 0.8 NM it turns orange" — no. I just stick to the rules I know. Like with 06 landing and 09 departing, I know that at 1 mile final on 06, 09 must have started rolling. That is what I pay attention to. I do not look at that [the risk analysis chart].

I: So, you follow the rules for outside UDP and in reduced visibility?

RC: Pretty much, yes.

I: Would you be able to easily find this [risk analysis per runway combination] again if you wanted to look it up?

RC: No, I would not know where to find it. Is it in our… what is it called… our OPS manual? You do not find it there?

I: No, that is correct.

RC: Not in the AIP either. No, I really would not know where to find it.

I: Would you want to be able to look it up?

RC: Well, maybe. I actually think it is pretty bad that within our organization it is sometimes really hard to look things up. I always think — we can't remember everything, but if you can look it up and know where it is, then you can always check it when you need to. Would I do that? Yes, maybe especially because of this interview — it makes you more aware again. Like, "Oh yeah, I should check what the differences are between the runways." So yes, I'd find it interesting if you could find it somewhere — where the most critical point is. Because I am also a supervisor, and sometimes you're just observing while your colleagues are working. Then you have time to look things up. Like, "Okay, where is the most critical point?" Yes, I think if this exists, you should also know where to find it. You get it once in a course in 2022, and then never again. So now that you're showing me this chart, I think, "Oh yeah, I have seen something like that," but after that — no, not again.

I: Do you also take different wind strengths into account when giving take-off clearance?

RC: Yes and no. If there is calm wind, then you do not really do much. But if there is stronger wind, then you're definitely more aware — the chance of a go-around is simply higher, the chance they will need to steer or something is greater. So yes, you definitely take that into account. Then I will time even more. Even earlier, actually. Look, within UDP we technically do not have to time, but I already do it quite often during the day. And when certain conditions are present — like if there is a heavy involved, or strong crosswinds or whatever — where you know the chance of a go-around is higher, then I will time as well.

I: When do you give landing clearance to the approaching aircraft?

RC: Ideally, when the aircraft is just before 2 miles final. But to be honest, I think I often give it when it is at 2 miles. I can see the aircraft's altitude on the radar, so I know — 200, 100 feet — then I know it is about to land. But I do not see these [risk analysis] distances. I do see a marker that indicates 2 miles.

I: So, you rely on the presentation you had back then?

RC: That, and you do not even really have it in the back of your mind anymore. You just know that within a mile, you're slowly entering the critical zone. The flare — when they are basically hovering just above the runway — that is the moment when the chance of a go-around is highest. That is the hardest part of the landing.

I: When the nose of the aircraft goes up?

RC: Yes.

I: Once it is past that, it is basically landed?

RC: Yes. It comes in, and at the end it lifts the nose — the rear wheels touch down first, and then it fully settles.

I: And why are you more cautious with heavies?

RC: Because heavies are simply less flexible — slower to steer or climb. They are literally larger, heavier aircraft. So, when you give a turn or climb instruction — or a descent, though you would not do that in a go-around — it just takes longer for them to respond. And you also have wake turbulence. If my go-around is a heavy and I turn it to the right, then I know that the outbound aircraft could end up in the wake turbulence of that heavy. Or if the heavy is climbing and the go-around cuts behind it, it could end up in the wake turbulence.
I: Have you ever had a moment where you actually aborted a take-off?

RC: No, not because of a situation like that.

I: Okay, so not with dependent landing and take-off?

RC: No.

I: Would you stop a take-off if, for example, an approaching aircraft is in the red zone?

RC: Yes, that could happen. I can't say for sure that I would stop it — it depends on how I see the approach, what the visibility is like, what the wind and weather conditions are. If I really think, "Oh no," then of course I will do it. It also depends on how far along the take-off is. If it is just started rolling, then you can stop it — that is not too dramatic. But if it is already well into the roll and I cancel the take-off, then you're dealing with hot brakes, reverse thrust, whatever else can happen — that can have a big impact. So no, you do not do that lightly. Then I'd rather look at what options I have in the air. Of course, if I see the inbound coming in with an engine on fire or something extreme, then yes, of course I will stop the other one. But those are extreme cases. On the tower radar screen, you see lines projected ahead of each aircraft — you can see that they do not intersect. They may come closer than intended, but they do not touch.

Appendix XVI *Interview RC4*

I: Could you introduce yourself and briefly explain your role?

RC: Yes, okay. I am RC4. I am a supervisor at Tower and Approach. I have been here for 25 years. I originally started through the training program, went to Rotterdam first with the goal of quickly moving on to Schiphol — which happened. I am usually around. I happen to be on duty today because I also have a secondary task. Many of us have side tasks in addition to our regular air traffic control duties. I am working on the new system — AAA, which is our air traffic control system used in the control room and also in the tower. It is being replaced by ICAS, which you've probably heard of internally. It has become a bit of a headache project. Initially, the idea was to adapt a system used in upper airspace for use at Schiphol or in the Netherlands, but that turned out not to be feasible. So now we've been working for a long time to adapt it so we can use it in practice. That is my side task, and I occasionally have shifts for that. This year not so much due to staff shortages, but I happen to have a few shifts now, which worked out well for this interview. I work both on radar (approach) and in the tower, and this topic is relevant to both.

I: Okay. What are your experiences with dependent landing and take-off?

RC: Well, let's say it depends on your own experience and how you approach the job. In my time, we were trained to maximize throughput — just get everything out as fast as possible. So, if it is within UDP and the conditions are met, you're allowed to initiate take-off even with an aircraft on final that could become a conflict. For example, with L18C/S24, you're allowed to release the departure in good weather and daylight. But you always have in the back of your mind: what if the landing aircraft goes around? I have seen that so many times now that I do not even take the risk anymore — I just time it. Only in extremely busy situations do I push it. Fortunately, those days are mostly behind us. So now I think: why not just time it during the day too? Not necessarily at the two-mile mark, but the training helped with that. You get a sense of where the "red zone" is for each runway combination — where you really shouldn't initiate take-off if the landing aircraft might go around. If you're just before or after that, you might go ahead. If something happens, you can stop the outbound or steer the go-around. But that last option — steering the go-around — was always one of the solutions taught in training and in the sim. That was very enlightening because you really see the difference between runway combinations. One converging landing/take-off pair can be completely different in terms of timing than another. For example, L18C/S24 or 04 departures with 06 landings — or 22 landings with 18L departures — that is a very critical one. I now think: I will just wait through the critical moment. I will skip one and make it up later. That is fine. So, I have started to feel less pressure to push everything through. I try to anticipate and consider which aircraft are involved. Is it some Chinese airline or is it KLM, which lands here three times a day.

I: How do different airlines influence your decisions in dependent landing/take-off?

RC: Because you think: okay, if the aircraft goes around, what do I do? Do I stop the departure or steer the go-around to resolve the conflict? You might think: I'd rather do that with a KLM pilot who flies here three times a day than with some Chinese pilot where you're not sure if they will understand. So, you take fewer risks — or rather more controlled risks — with KLM, which is like family here. You're taught that you can either stop the departure or steer the go-around. But I personally get more and more frustrated that we often rely on steering the go-around as a solution, even though it does not always work in practice. For example, I once had a go-around in a situation that was not even on paper — 18R landing and Tower Center departing from 24. Normally, they'd never conflict. But in this case, I was coordinating both. There was a lot of crosswinds, and Tower Center coordinated with me that they'd fly course 6 with a slower aircraft. I thought: okay, if it lands, no problem. But then it went around. I thought: I will steer it right, as it should. But it didn't — the pilot just said "negative," it is not possible. So, the solution I had in mind didn't work. The only real option was to stop the departure — and even then, you hope they listen. So now I think: is it really wise to rely on that? There is a risk it will not be executed. So, I am more inclined to just wait until the aircraft has landed or at least until it is safe. You've got those color codes — from two miles to touchdown, you're technically allowed to depart, but I personally avoid the red zone. I just wait until it is landed or hold off on the departure.

I: So, you time around the two-mile mark?

RC: Well, not exactly — it depends on which runways are involved. For example, with 18 Center — I think that chart is also with 24 — I'd say this is about two miles. Yes, this is two miles. So, in darkness or low visibility, once the aircraft passes this point, you're no longer allowed to start — or rather, the aircraft may not begin rolling. So it could be that the aircraft is at 2.3 miles and I say, "cleared for take-off," but it does not start rolling. That happens quite often. Then I say, "Okay, cancel take-off clearance, hold position." Pilots do not like that. But I say, "Well, you should've started rolling, because now it is too late." I gave the clearance, so it is on the recording, but if the aircraft has passed by now, then it is no longer allowed — or I no longer want it to go. So, in darkness or poor visibility, you have to wait until the aircraft is at two miles. That is just the rule. But if you're allowed to deviate under other conditions, then technically you can always go. But I think, "This stretch — I'd rather wait." Eventually, you reach a point where you think, "If it goes around now, it is going to be a mess," and you'll have to pull all kinds of tricks to resolve it. So, I'd rather just wait with the departure. And that also depends on the weather. Say it is a day like today — beautiful weather, I haven't worked yet, but I think the wind is okay. If the wind is straight down the runway, not too strong, not too gusty, not too much crosswind, then you're more inclined to think, "The chance of a go-around is minimal." You look outside and think, "Okay." But if there is a lot of crosswind and gusts, then I mentally expand that critical zone. So, where that boundary lies — I can't quantify it in miles. It is more like, "Now I feel okay about it."

I: So, you do not have a specific distance, but roughly two miles?

RC: Yes. In this case, I'd say that even in good visibility and good conditions, I'd still wait out that red zone a bit. I'd look at how it is developing — do I really see the aircraft landing? Then I go. If it is really critical — say it is a heavy aircraft, fully loaded, going far, and the other one is also a heavy, and not KLM — then I usually think, "I will just wait." Because a heavy that is just airborne — you can't really do anything with that. And if it is already rolling, you might not be able to stop it. And if the heavy on approach goes around — you do not want to deal with that either. So, I just make sure that situation can't happen. I time it. But if it is two small aircraft, I think, "Okay, if something happens, I can still steer one or the other." Even then, I often wait out that critical point.

I: So you're more flexible with smaller aircraft?

RC: Yes, just because you have more confidence that if you need to steer them, you can. They are much more maneuverable than a big heavy from some airline that only comes here once every five years. That is a whole different story compared to someone who comes here three times a day. They know how Schiphol operates. What we do here is not standard everywhere. And where it is standard, they often have procedures that prevent conflicts. I think pilots assume it is always timed. But we say, "If the weather is good, you do not have to — you can just go." Like with converging landings — 06 landing and 36R at the same time. That is head-on. Some pilots have been flying to Schiphol for years and assume it is all coordinated — like a mirror system. They think, "If both go around, they will always miss each other." But that is not the case. In the tower, we have a counter that tracks the radar plots of aircraft on each runway. It calculates the distance from the intersection — DFI (Distance From Intersection). It regularly happens that both aircraft are at the exact same distance from the intersection just before landing. So, if they both go around, they will arrive at the same point at the same time. Then you know: if they both go around, I will have to give one of them a very short turn to avoid a conflict. And that usually works. But when you explain this to foreign pilots, they are like, "Huh?" That is just part of the job. It is a calculated risk. There are safety cases that say the risk is so extremely small that we're allowed to continue this operation. But pilots often assume it is all coordinated. The answer is: not really. Schiphol pilots know this, but someone from China Southern or Airbus Cargo — who knows?

I: Is it communicated to pilots that dependent landing and take-off operations are in use?

RC: For inbound aircraft, no. For outbound aircraft, it is on the ATIS. Do you know what ATIS is? It is a radio frequency that continuously broadcasts the current weather, and sometimes operational information is added — like if a certain runway exit is unavailable, it'll be mentioned on the ATIS. So, they've already heard it, along with the weather — "Okay, I need to take that into account." Inbounds do not hear it, but outbounds do hear on the ATIS that converging landings are taking place with departures. I think that came from a safety case — that the departing aircraft should at least be aware that something might happen with the departure if there is a go-around on the other runway. But I do not think many pilots really realize what that means. It is on there, so they could know — but whether they actually do in practice? I do not think so.

I: So, the departing aircraft does not really know?

RC: No, well — actually, that is not entirely true. They do hear it once they are with the tower. So, in principle, you're allowed to depart independently — up to two miles. But if the inbound is within two miles, then you have to inform them. So, if I decide to give take-off clearance while the inbound is within two miles, I have to inform them: "traffic information, traffic departing 24," and they will say "roger."

I: And that is also within UDP?

RC: Yes, yes — because outside UDP, it is not allowed at all. So, then you have to time it anyway, and there is no need to inform them because it is already safe. But if you're stretching the limits because the weather is good, then you tell the aircraft on final: "for information, traffic departing runway 24." So, if they are landing on 18 Center, they should know: "Okay, there is a chance that if I go around, I might encounter traffic departing from 24." And they might already see that in the distance. But I do not think they pay much attention to it — they are busy with the landing. And when I say that to, let's say, more exotic carriers, I rarely get a "roger" or any acknowledgment. I think they are like, "What is this guy saying?" But I have said it — it is in the procedure. If you're within that margin, you have to inform the inbound. So, it is part of the job. But again, what effect it has — I would not bet on them understanding what I mean.
So yes, those are some of the conditions — weather, visibility, and informing the inbound. Usually, when they check in, I say, "You're number 3, traffic departing 24," and that is it. I am not even sure yet if I will actually start while they are within two miles, but if it is busy, I think, "Let me just say it now." Otherwise, if I suddenly decide to start, I'd have to quickly tell them — and they do not want to hear that at the last moment of their landing. That is just a distraction.

I: So, before the two-mile mark?

RC: Yes. As soon as aircraft check in on the tower frequency — when I am working in the tower — radar hands them over to the tower around 10 miles out. So, they check in around 10 miles. They are number 2, 3, 4 — whatever. I do not know yet when I will start or where they will be, but I have already told them. So, I have checked that box, just in case I need it.

I: And how can you recognize that a go-around is about to happen? Can you see it in advance?

RC: Well, in principle, you have to see it — that is why you're in the tower. You can usually see it outside first. You can also see it on radar, especially in low visibility when you're allowed to rely on radar. We also have a go-around detection system now — it is been around for a few years. It is called GARDS. It uses a formula: if the radar detects that the aircraft is climbing again and the speed does not decrease after the landing phase, it gives you a warning. First, you get a visual alert, and if the aircraft actually goes around, you also get an audio warning — you'll hear "go around" through the speaker at your workstation, along with the runway involved, like "go around 18C." So even if you didn't see it yourself because you were busy with something else, you're still alerted and prompted to act.

I: And GARDS is available for every runway?

RC: Yes. Recently — I am not sure if it is fully implemented yet because a system release failed and was delayed — but the idea is that we'll get that warning at all positions. Previously, only the runway controller working that specific runway would get the warning. But it might also be relevant for another runway controller. For example, at Tower Center, there is usually one controller handling both departure and arrival runways. Sometimes it is split between two people. There is always someone at Tower West who handles the Polderbaan. But if you're using a northern configuration — say, landing on 36C and 36R, and Tower West is handling departures from 36L — if an aircraft goes around on 36C, it could conflict with a departure from 36L. Not immediately, because both initially go straight, but many departures turn right shortly after, so they could meet. Tower West never used to hear that an aircraft went around on 36C. Normally, I'd have to coordinate that manually — I'd call over the intercom and say, "Heads up, I have got a go-around on 36C." But that is not the first thing I do — I am usually busy with other things, so a few seconds pass. That might be too late for Tower West to stop a departure. If the aircraft is already accelerating, it is too late. But if they also get the alert, they might not have even cleared for take-off yet and could decide to wait until the situation is resolved. That helps avoid radar conflicts too. So yes, we have an audio warning, and it starts with a visual alert on your radar — both on the ground radar (which shows a map of Schiphol with taxiways and runways) and the air radar (which shows what is happening in the air). You'll see something on both, and you'll hear something. So even if you do not see it yourself — which you should — you're still triggered to act. This system came from a safety recommendation. We've had quite a few incidents in the past, including some serious ones, where the go-around was not recognized on time and the solution was not ideal. So, safety investigations led to this system being implemented. It is helpful to have system support so you're not 100% reliant on visual observation — because that is never perfect. Sometimes you're looking somewhere else and you miss it.

I: And is it clearly visible when an approach is stable?

RC: No, not necessarily. You can have situations where there is an increased risk of a go-around. In those cases, it is definitely not smart to initiate a departure. At Schiphol, we have to maintain high throughput — as many landings per hour as possible. So, the arrival controller on radar is tasked with sequencing aircraft as closely as possible, just within the limits. If you space them out more, you'll have fewer landings per hour. So, for each pair of aircraft, there is a minimum separation. If a large aircraft is followed by a smaller one, you need more distance due to wake turbulence. If it is two small aircraft, they can be closer. But you can't go below the minimum, because the first aircraft needs time to vacate the runway before the second lands.
Sometimes you slightly exceed that minimum. That is not immediately a reason to break off the approach, but you'll have the first aircraft brake harder, and the arrival controller will inform the tower: "Heads up, it is going to be tight." Then the tower knows to pay attention and might tell the first aircraft to vacate as quickly as possible. But if it is clear that the timing will not work and a go-around is likely, then I will not initiate a departure. I will just wait until the aircraft has landed. In normal situations, you might stretch the limits a bit, but if the approach looks unstable — too high, too fast, poor weather, or too close behind the previous aircraft — then the chance of a go-around is higher, and you take that into account. But you do not get a warning for that. The only warning comes when the aircraft actually goes around — not before.

I: And in the operations manual, it says you monitor landings — what do you monitor for?

RC: Just by looking outside to see if the aircraft actually lands. You can see it clearly — you see the speed decreasing. In extreme cases — and those are usually the ones that cause problems — you might think, "Oh, it landed," but it turns out to be more of a touch-and-go. Just because the wheels touch the ground does not mean it will not go around. Sometimes the pilot decides at the very last moment to go around because the approach was not stable. They might hit the go-around button just before touchdown. The engines need time to spool up, so the aircraft is still descending while preparing to climb. So even if it touches the runway, it might still go around. You have to really see that it is landed — the speed drops, and it vacates the runway. I can't fully describe what I see — it is something you learn from experience. You recognize a proper landing. Anything before that could still turn into a go-around.
For example, I was once at Tower West with a British Airways aircraft. I wanted to steer it right after a go-around from 18R, as per procedure. But they only turn once they are flying normally again. First, they stabilize the aircraft. In this case, the pilot didn't turn. I told him to, but he didn't. It turned out to be a rough landing — more like a touch-and-go — and they later reported they weren't satisfied with it. That situation developed in just a few seconds.

I: Was that within UDP?

RC: Yes, it was during the day, so it was allowed. But you could feel it coming — there was a lot of crosswind, and several aircraft had already gone around that hour because of the weather. Those are all red flags. On a day when everything is smooth — "cleared to land, cleared to land" — you take more margin. But where exactly that margin lies — 0.4, 0.6 miles — I couldn't say. It is more of a feeling.

I: So, it is based on intuition?

RC: Yes, exactly.

I: How do you know when the approaching aircraft is at 2 miles? Can you see that?

RC: Yes, you can. You have your radar display, and you can see where the runway is. In front of the runway, there is a line — that is 10 miles out. And then there are tick marks every 2 miles, like distance markers. So if the aircraft is here, it is at 4 miles. Besides that, there is also a label attached to the radar plot that shows the distance from touchdown.

I: Is that label specific to each aircraft?

RC: Yes. On your radar, you see all these plots showing where each aircraft is, and each has a label. The label shows the callsign, the speed, the altitude — all the relevant information. [Shows an example radar screen] This is the radar we use here in the east. These lines you see — this is 10 miles. The black area in between is the runway. Then you have tick marks — 2, 4, 6, 8, 10 miles. You have something similar in the tower. These are the runways in use now — 18R, 18C. It is a bit cluttered here with other things you do not see in the tower, but you see aircraft plots with labels. The label shows the callsign — EasyJet, United, KLM, whatever — the current altitude, aircraft type, and speed. So, you have a lot of information, and from that, you can tell. You can't see from outside how fast an aircraft is coming at you, but you can see it on the label. If it is still doing 200 knots, that is way too fast to land normally. Then you know it is an unstable approach. They are working hard to reduce speed in time. If they can't, it ends in an unstable approach, and they will have to go around. So, if they are still high or too fast, you know they are going to struggle to stabilize — and if they do not, they will go around. So, you take more margin when things do not look steady.

I: So, you take the speed of the approaching aircraft into account?

RC: Yes, because that is one of the indicators of a stable approach. You know roughly what speed each aircraft type should be flying. That also depends on the wind. If there is no wind, it is a fixed value. But with a strong headwind, you subtract that — with a tailwind, they will go faster. So, if they are going fast, it might be due to wind, not because they haven't reduced speed. Over time, you get a feel for what is normal. If they are too fast, it might still end well, but there is a higher chance of an unstable approach and a go-around. So, you take more margin when things are not nominal.

I: And you mentioned a go-around button in the cockpit — is that a physical button pilots can press?

RC: Yes, I believe so. I am not a pilot, but they have a go-around button that sets the correct power setting — full power for a go-around. I do not know if it also adjusts flap settings or other things, but it gives go-around power. And we were talking about how you know an aircraft is going around — they are supposed to report it. But in serious incidents, like with L18C/S24, the pilot reported the go-around quite late. I understand that — their first priority is to keep the aircraft flying. We always say: *aviate, navigate, communicate*. First fly, then navigate, then talk to ATC. So, you shouldn't rely on the pilot to tell you — but it can be a helpful backup if they do.

I: Do you get a notification when the pilot presses the go-around button?

RC: No, no. And I do not think it is even required to press that button — I believe you can do everything manually. It is all handled technically within the aircraft. But in practice, it is the same: full throttle and make sure you're flying again. At that point, they've already reduced power as much as possible and are in landing configuration, so yeah.

I: When is the latest moment you can give take-off clearance? Is that when the arriving aircraft has landed?
RC: Yes — well, no — it depends. If conditions are not favorable, you're not allowed to give take-off clearance once the inbound is in that critical zone. You can only give clearance again once you've confirmed the landing is complete. So, you look outside or at the ground radar and see that the aircraft has actually landed. If we're in low visibility — BZO, with fog — and we can't see anything outside, then we're 100% dependent on radar. On the ground radar, you see a plot with a white arrow in front of it. As long as the aircraft is moving above a certain speed, the arrow is

visible. Once the speed drops below a threshold, the arrow disappears — that is how you know it has landed. Then you can give take-off clearance. But you hope the aircraft actually starts rolling, because if it does not and the next inbound enters the critical zone, you'll have to cancel the take-off. In BZO, the spacing on finals is also greater, which gives you a bit more room. But if you have three aircraft lined up to depart and three inbound to land, you need to use every gap. If one does not go, you lose a slot and have to wait for the next landing — that is 1.5 minutes lost. So yes, that is one way to determine when to give clearance.

I: And in good visibility, within UDP?

RC: Then you just look outside. You see the aircraft has really landed, and then you give take-off clearance. Sometimes it is tight, and you think, "This is too close," so you skip a take-off slot. The aircraft has to go immediately. That is why it is on the ATIS — so pilots know in advance that when they get take-off clearance, they need to go right away. I think it is also in the AIP — the document with all procedures — that they are expected to start rolling within a certain number of seconds. But sometimes it is like, "Oh, cleared for take-off — okay, let's get ready," and by then the window has passed. Then I have to cancel the clearance. Instead of 10 departures in a time slot, you only get 9. That can't happen too often, or you lose capacity. So, we expect them to be lined up and ready to go. If they still have to line up, some take 20 seconds, others 30 or 40 — then it is no longer possible to time it properly. They should already be on the runway, waiting for clearance, and then go immediately.

I: That rule was also part of the safety measures — that they have 10 seconds to start rolling after clearance. Do you feel things have improved since those safety measures?

RC: I do not know. You'd have to compare the last few years to before. I can't say. It still happens that they just sit there. I do not know how well that is communicated to everyone. Honestly, I do not think it is a huge problem, but it still happens occasionally — you think, "Go now, or it is too late." Sometimes I cancel the clearance and wait for the landing to finish before trying again.

I: When do you cancel a take-off?

RC: Honestly, in good conditions — when you're allowed to stretch the limits — I rarely say, "You can't go anymore." But in poor visibility or outside UDP, you think, "Okay, now he has to go." If he does not, you stop him — it just will not fit anymore. I also look at the runway combination. For example, L18C/S24 or 09/06 — those have more room because the intersection is farther away. But with 22 landing and 18L departing, I never push it. I do not even try to time it. If the go-around happens there, you can't do anything. If the aircraft is already rolling and the other goes around, you can't steer them apart. So I never want to end up in a situation where a go-around meets a departure — there is nothing you can do. I always time those, and I hope everyone else does too. If you tell a pilot, "Sorry, your chance is gone" — not in those words, of course — and they respond, "Why?" then you already know: they weren't paying attention to what was expected.

I: Do you notice a difference in reaction time between different airlines, home carriers and others?

RC: Strangely enough, there are quite a few KLM and especially Transavia flights where they do not start rolling when I expect or want them to. If I had to make a top 3, it would be Transavia, KLM, and then some unknown third. You could say that is logical because they are the ones flying here the most, so maybe it is just proportional. But other carriers usually start rolling faster than Transavia or KLM. Especially exotic carriers — you just know. Sometimes, because you know they will not roll immediately after "cleared for take-off," you give the clearance a bit earlier, thinking, "If they wait 10 seconds, I have accounted for that." With Delta Airlines, for example — the Americans tend to go immediately. So, with them, I wait 10 seconds before giving clearance, otherwise they will go too early, which you also do not want. Americans are just used to it — in the U.S., they have a lot of converging runways. Sometimes a landing runway crosses a departure runway, so every landing has to go behind a departure. That is hard to time if they do not go immediately. So, they are trained from the start to go on the call — shoot and go.

I: Back to Schiphol — regarding L18C/S24, you said you steer the go-around in one direction and not the other?

RC: Yes, if the aircraft starts within that critical zone, you must already have a solution in mind — that is drilled into you during training. What if the landing goes around? Will I stop the departure or steer the go-around? There comes a point where you can't stop the departure anymore. Only in the very early stage, when it just starts rolling, can you still say "abort," but you do not want to do that. It surprises the pilot, and while they will usually comply, they might already be going too fast. There is V1 — the decision speed. Once they reach V1, they are not allowed to stop anymore. It is calculated: if they are going that fast, there is not enough runway left to stop safely. Even if an engine catches fire, they must take off. So, if I want to stop them, I have to do it well before V1. If I wait too long, they will brake hard, maybe blow a tire, and then the runway is blocked. All the aircraft behind them can't depart — it is a mess. So, I only stop them if they are still slow or haven't started moving. Otherwise, I steer the go-around — assuming they can steer. But sometimes they do not want to. They will go straight first, stabilize, and only then turn.

I: Could you deviate from the go-around procedures?

RC: Yes, you do that sometimes. The standard go-around procedure for almost all runways — except 18R — is straight ahead and climb to 2000 or 3000 feet. That is the most comfortable for the pilot. Here at Schiphol, that is usually fine — there are no mountains. But if the go-around happens and you want them to turn left or right, you're still sending them toward the departing aircraft from 24. That turn takes a while. Steering them behind the departure is always better than trying to go in front. That is been tried before — didn't go well. So, it is better to steer them behind, no matter the combination. Even with 06 landing and 09 departing, you want to turn them away quickly — ideally northbound — so they always pass behind. That gives the best chance of success.

I: And just to clarify — within UDP and in good visibility, do you still abort the take-off if the aircraft is in the red zone?

RC: Yes, if the aircraft goes around. But if it is just in the red zone and still looks good, I let it go. Aborting a take-off is a big move, especially if nothing bad has happened yet. In principle, 99 out of 100 aircraft land — probably even more. Statistically, the chance of a go-around is 1 in 1000, not counting bad weather. On a stormy day, you'll get a lot of go-arounds, and that skews the stats. But on a normal day with normal wind and a dry runway, almost all aircraft land. So even if it is in the red zone, I am almost certain it'll land. If it does go around, then I will take action and steer it behind the departure.

I: So, you basically allow departures in most cases, but you take into account—

RC: I do not aim to allow everything. I aim for everything outside the red zone. If I think the landing looks good, then I will go ahead and start. Sometimes, depending on how it looks — for example, if the aircraft is heavy or just turning onto the runway — I might say "cleared for take-off" early. If it ends up going around, but hasn't started rolling yet, I can still stop it. The truly critical moment is very short — the moment the aircraft starts rolling and the inbound initiates a missed approach. Statistically, that is rare. But if the inbound is in the red zone, I will not give take-off clearance. I will wait until it is past and the landing looks good. If I give clearance just before the red zone and the aircraft is slow to roll, it might end up rolling while the inbound is in the red — which is what we want to avoid. In normal operations, you might think, "It'll be fine." But if I think the chance of a go-around is higher than usual — even if that is still less than 1% — I will say "cancel take-off clearance" because the aircraft is barely rolling. So, you can always prevent a truly bad situation. It is better to prevent it upfront than to apply emergency measures during a go-around or rolling departure. I only stop them if they are within two miles in poor conditions — then I am not allowed to let them go, so I stop them. If they haven't started rolling, there is no issue — they just wait for the next turn.

I: Have you ever experienced a situation where the inbound went around while the departure had already started rolling?

RC: Honestly, I can't really remember. Maybe once, when I could still easily stop the departure. I have had cases where the aircraft had just lifted off and the inbound went around — but by then, the critical moment had passed. You might still give the departing aircraft a heading instruction to avoid the go-around path, but the collision risk is already gone. They might meet again later in the air, not dangerously close, but within separation limits. Then I might tell the departing aircraft to fly straight ahead to avoid the area the go-around will enter. So yes, it happens. But I have never personally had a really critical situation. I have seen it happen while working elsewhere. For example, once I was at Tower West, and 18C had a go-around while 24 was already rolling. They tried to steer the go-around right, but I saw it happening — it was a Jumbo. Trying to steer that is already difficult. The departure went straight, and the go-around didn't turn. I have never had to deal with it myself, but I have seen it. And of course, we all learn from the shared safety cases.

I: When did that happen?

RC: Years ago.

I: Before the safety measures?

RC: Yes, definitely before. I am not sure which measures you mean exactly.

I: A 10-second rule was introduced — aircraft must start rolling within 10 seconds of receiving take-off clearance. This was added to the AIP and SID charts to improve pilot awareness.

RC: Yes, that one. And the traffic information we give to inbound aircraft — that was always there. But for outbound aircraft, it is now clearer that there is a chance of a go-around. That is been in place for a few years now — maybe two? I haven't experienced anything major since then. But I am not here every day. If something serious happens, you hear about it — in the hallways, in reports, or in safety bulletins. The last time something really went wrong was quite a while ago. I think that incident led to the introduction of these measures.

I: That was in 2018.

RC: 2018 already? Feels more recent to me.

I: To what extent do you feel the original training and refresher courses help you stay professionally competent in this operation?

I: So overall, you found the training effective?

RC: Yes, definitely. The training was always good. We covered this whole topic once during a refresher course — the annual refresher training — and I thought it was very well done. You start with some theory, including those visual charts. What I really appreciated was that they first showed an example of a situation that didn't go well — the one that started it all. That really confronts you with the seriousness of the situation. The downside of this job is that things almost always go well, which can make you complacent. That is why it is important to keep repeating these things — it keeps you sharp. Those charts exist for all runway combinations — this one is for L18C/S24, but there are others. You could clearly see that the critical zones differ per combination. In practice, I might think "two miles," but two miles is not always the same depending on the combination. And yes, people joke — "One time it is an F-16, the next it is a Cessna" — but in principle, the performance is comparable enough that the color-coded chart is actually quite accurate. It was really helpful to see which combinations allow more room and which ones do not. Then you go into the simulator, and it is good to see how you actually respond. But again — everything always works in the sim. If you tell a sim pilot "turn right immediately," they turn within a second. But if you say that to an Airbus Cargo pilot, it takes longer. So, you get this false sense of confidence — "If there is a go-around, I will just steer them." But in real life, I do not have that confidence. I always have a bit of hesitation. I might have a good plan, but I can't guarantee it will be executed. That is why I prefer to stay out of the red zone, even in good visibility. I'd rather avoid the situation altogether than rely on a plan that might not work. At the same time, there is always tension with capacity. You can't always say, "I will just wait until two miles." If there are 30 aircraft waiting, the pressure builds to start one. So yes, in principle you're allowed to go, but if it is in the red zone, I usually wait. Maybe I lose 10 or 20 seconds — I will make that up later. I think most of my colleagues feel the same. I rarely hear anyone say, "I will just clear for take-off because I can and see what happens." Thankfully, no one has that mindset anymore.

I: Did you used to do things differently?

RC: Yes, I think so. Back then, there were quite a few people who would just say “cleared for take-off” and see what happened. The weather was good, and if the aircraft went around, they’d deal with it. That was allowed under the rules. But now, I think most people avoid the red zone — especially depending on the aircraft type. If it is a heavy, my red zone is much larger than what is shown on the chart. I will wait until it is landed. But you can’t do that for every landing, so you still use part of that zone.

I: Would you be able to find that risk analysis again if you wanted to?

RC: Let’s just say — I should be able to. After some digging, I’d probably find it. We have a document web where all kinds of announcements and training bulletins are stored — even old ones. I think I have them saved on my computer somewhere. But in principle, everyone should still have access to them.