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Learning from near-misses

A study on the influence of biases on the learning of Air Traffic Control the Netherlands

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Abstract

This thesis contributes to the debate on organizational learning by addressing the topic near-misses as learning triggers. Within the aviation sector, learning from incidents, and more specifically near-misses, is an essential mechanism for safety improvements. At Schiphol Airport, however, recent studies have demonstrated that this learning is lacking and runway incursions remain a regular occurrence. This thesis explores if and why Air Traffic Control the Netherlands (LVNL) does not learn from all runway incursions. Based on the literature review, a distinction is made between lessons distilled (lessons noticed by an organization) and lessons implemented (lessons acted upon). Moreover, building on the work of Madsen, Dillon, and Tinsley (2016), three barriers are identified as potential explanatory mechanisms: outcome bias, hindsight bias, and association. The constructed framework is applied to eight runway incursions at Schiphol Airport within the timeframe 2004-2015. By conducting qualitative document analysis, 31 lessons have been detected for LVNL. The analysis of the case studies shows that learning does not occur after all incidents, but mostly from category A and D incidents. Biases provide a possible explanation for the variation in learning.

Keywords: bias, near-miss, organizational learning, runway incursion.

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List of Abbreviations

AAS	Amsterdam Airport Schiphol
AMS	Amsterdam Airport Schiphol (IATA Airport Code)
ATCO	Air Traffic Control
DSB	Dutch Safety Board Onderzoeksraad voor Veiligheid
EFS	Electronic Flight Strips
FAA	Federal Agency of Aviation
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IenW	Ministry of Infrastructure and Water Management Ministerie van Infrastructuur en Waterstaat
LVNL	Air Traffic Control the Netherlands Luchtverkeersleiding Nederland
OI	Operational Incident
OROFOL	One Runway, One Frequency, One Language
PD	Pilot Deviation
RI	Runway Incursion
RISC	Runway Incursion Severity Classification Calculator
RST	Runway Safety Team
RWY	Runway
VNV	Dutch Airline Pilots Association Vereniging Nederlandse Verkeersvliegers
V/PD	Vehicle/pedestrian deviation

1 Introduction

"Big mistake only just prevented: Transavia-Boeing almost takes-off from taxiway" (NHnieuws.nl 2019).

"Aircrafts collide during taxiing at Schiphol Airport" (NRC.nl 2019)

"Severe incident: Boeing 737 and Airbus 330 land dangerously close at Schiphol Airport" (AD.nl 2019).

"Dutch Safety Board: airplane was only just able to take-off at Schiphol Airport" (AD.nl 2018).

The aforementioned newspaper headlines represent a mere fraction of aviation-related incidents that have taken place at the Netherlands' main airport, Amsterdam Airport Schiphol (AAS), over the last 15 years. Within the aviation sector, learning from incidents, and more specifically, near-misses is an essential mechanism for safety improvements (Drupsteen and Wybo 2014). Near-misses constitute a subset of incidents, which under different circumstances could have resulted in a different outcome, i.e. an accident. The benefit of a near-miss, rather than an accident, as the mechanism for learning, is that near-misses provide a unique situation where the flaws of a system become apparent, without negative consequences (e.g. loss and damage) associated with accidents (Madsen, Dillon and Tinsley 2016).

At Schiphol Airport, however, recent studies have demonstrated that near-misses, and specifically runway incursions (RI), remain a regular occurrence despite prevailing opportunities to learn, Incidents happen roughly every one in 10.000 take-offs and landings at AAS, in comparison to one in every 35.000-130.000 at other similar-sized airports (Dutch Safety Board 2017). The main example of such a study is the report published by the Dutch Safety Board[1] (DSB) in 2017, "Veiligheid vliegverkeer luchthaven Schiphol". In this report, the research institute signals that changes need to be implemented to enhance safety levels at the Airport. Concerns have additionally been expressed by the supervisory authorities of the airport, as well as within the Dutch policy-circles regarding the safety of Schiphol Airport.

[1] The Dutch Safety Board is an independent and permanent research institute charged with conducting investigations in nearly all sectors in the Netherlands (DSB 2019), including the aviation sector.

1.1 Problem statement

Whereas Schiphol is not currently deemed an “unsafe” airport by the Dutch Safety Board, the report serves as a warning. The airport needs to take into consideration its desire to grow air traffic beyond the existing maximum of 500.000 flights annually, after 2020, and the increasing complexity of airport infrastructure associated with growth (DSB 2017; Tweede Kamer 2018). Within the existing safety management practices, Schiphol Airport can not likely guarantee sufficient levels of safety in the near future.

Schiphol should draw lessons from prior incidents and accidents to improve safety continuously. Technically, this is possible. Prior research has demonstrated that incidents provide ample opportunities for organizations to learn (see e.g. Deverell 2009). Moreover, the aviation sector is organized to support this, and Schiphol Airport knows many systems and mechanisms to support this, such as Safety Management Systems, reporting systems, and internal and external incident investigations. Notwithstanding, in a follow-up report, the Dutch Safety Board claims that despite the additional warning, few lessons have been learned (DSB 2018, 1). Since the publication of the initial report in 2017, previous findings seem to continue to play a role in more recent incidents.

The question that arises from this is why Schiphol does not learn from all incidents, despite the prevailing opportunities. This research will explore this question focusing on runway incursions. The necessity to learn from all incidents for a safer aviation industry is recognized by the researcher, yet the choice was made to focus specifically on runway incursions, as RI’s are seen as one of the most serious threats in aviation (International Air Transport Association 2019). According to the International Civil Aviation Organization (ICAO), a runway incursion is: ‘any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designed for the landing and take-off of aircraft’ (2007, 1-1). RI’s may entail significant impact, both in terms of damage and causalities.

Within scholarship, possible explanations are presented for the limited learning at Schiphol Airport. For example, Dillon and Tinsley (2008) and Dillon, Tinsley, and Cronin (2012) claim that organizations can learn from some incidents. Specifically, within the aviation sector, Madsen, Dillon, and Tinsley (2016) have found evidence that learning occurs when there is an association with danger (1054). The ICAO has identified four categories (A, B, C, and D) to classify runway incursions. This is done based on severity and associated risk/danger. According to this classification, the risk is highest in a category A incident and lowest in a category D incident. It is possible that there exists a relationship between the category in which incidents fall and organizational learning. Additionally, biases are put forward as explanatory mechanisms for the variation in learning. More specifically, Dillon and Tinsley (2008), discuss *outcome bias*, a positive outcome omits the need for learning, *hindsight bias*, the overestimation of one's ability to foresee an outcome and *association*, where the outcome of a prior event enhances the idea that learning is necessary.

1.2 Research question

This thesis explores near-misses as triggers for organizational learning. More specifically, this study examines the relationship between the severity of runway incursions – represented by the runway incursion incident categories - and organizational learning. The research question is as follows:

> *"How do incident categories influence organizational learning in the case of runway incursions in Dutch civil aviation?"*.

As seen prior, this thesis focuses on runway incursions because they are considered a huge threat to aviation. According to the Runway Safety Accident Analysis Report (2015), 22 percent of all aircraft accidents between 2010-2014 were runway incursions (IATA, 3). To further limit the scope of this thesis, it will focus on the learning of Air Traffic Control the Netherlands.

To answer this question, this thesis tests if it is true that LVNL does not learn from all runway incursions, by analyzing eight case studies. More than testing to see whether it is true, this thesis attempts to uncover why LVNL does not learn.

1.3 Academic and societal relevance

This thesis contributes to the academic debate on organizational learning by addressing the phenomenon of near-misses as learning triggers. There have been prior studies into learning from near-misses, but these studies generally focus on the circumstances where learning can take place. This thesis seeks to make a first step to fill in the gap on barriers that prevent learning within organizations, focusing on the explanatory mechanisms. Additional relevance of this study for scholarship is that until today relatively few qualitative studies have been conducted, in comparison to quantitative studies. This thesis brings practical insights into the field of crisis management and organizational learning by conducting empirical research.

Additionally, this thesis holds practical and societal relevance. When organizations want to learn from incidents, they must have an understanding of under which circumstances learning takes place. More so, when an organization understands when and why they do not learn, it can improve the effectiveness of the existing safety management practices. For example, it may have practical implications for how the Dutch Safety Board and LNVL approach their investigations of runway incursions, and how learning is encouraged within LVNL. In the context of this study, a consequence of improved safety management practices is that civil aviation becomes safer, which is of great value to society. Finally, similar barriers to learning may be present in other sectors, by which the results of this study can be of benefit to these sectors.

1.4 Reading guide

To answer the main research question of this study, this thesis consists of several chapters. First, Chapter 2 constitutes a review of the existing scholarship, focusing on organizational learning and barriers for learning. The chapter also presents the conceptual framework, through which the case studies will be analyzed. Next, Chapter 3 entails an explanation of the qualitative research design employed for this study, as well as the operationalization of the main concepts. In Chapter 4, the methodology, qualitative document analysis, and the codebook are explained in greater detail. Chapters 5 and 6 present the results and analysis of the case studies. Finally, Chapter 7 provides an answer to the main research question, as well as a discussion of the limitations and contributions of this thesis.

2 Conceptual framework and literature review

This chapter presents the results from the literature review on organizational learning, specifically within the aviation industry. The literature review places this thesis within the broader body of knowledge. Moreover, the conceptual framework is presented, through which the case studies will be analyzed. This chapter commences by defining organizational learning. Second, learning is discussed concerning accidents most generally, and runway incursions most specifically. Lastly, this chapter discusses why learning can be challenging for organizations.

2.1 What is organizational learning

Organizational learning can be understood as 'a learning process within organizations that involves the interaction of multiple levels of analysis' (Popova-Nowak and Cseh 2015, 300). Learning can take place on individual, group, organizational and inter-organizational levels. Thus, the collective of, and interactions between the various learning processes can be understood as organizational learning. However, the definition by Popova-Nowak and Cseh is not largely agreed upon within scholarship but rather the concept is subject to extensive debate.

According to Deverell (2009), scholars find "learning" hard to define, isolate and measure. Agryrs and Schon (1978) first defined organizational learning as 'a process of detection and correction of error' (as cited by Wang 2007, 3). Agryrs and Schon attest that a change in effectiveness needs to be witnessed to be able to say that learning has occurred.

Later, Huber (1991) identifies four integral components related to organization learning: acquisition, information distribution, interpretation and organizational memory (88). According to this scholar, learning takes place when 'acquired knowledge is recognized as potentially useful' (89).

In his study on learning from crises, Deverell (2009) draws on a definition of Argote (1999) and Schwab (2007). Deverell argues that 'organizational learning occurs when experience systematically alters behavior or knowledge' (180). Deverell further makes a distinction between first and second level learning. First, he defines *lessons distilled* as 'lessons noticed by organizational members but not subsequently acted upon'; and second, *lessons implemented*, are defined as 'lessons observed by organizational members and subsequently acted upon and corrected' (183).

Organizational learning is a useful concept, despite issues of ontology, methodology and normative problems within academia (Dekker and Hansen 2004, 212). The aforementioned definitions have similar characteristics. What the definitions have in common, is that there is more than one "phase" in learning. Broadly, this can be divided into 1) the acquirement of knowledge and 2) the processing/implementation hereof. The key takeaway is that a change needs to occur within an organization. Scholars have distinctly linked this change to effectiveness, behavior or knowledge. This thesis will draw on Deverell's (2009) definition of organizational learning due to Deverell's clear distinction between the various phases of learning.

2.2 Why organizations learn

Section 2.1 illustrates what organizational learning is and how it can be achieved. Yet, it does not address why organizations want or need to learn. The focus of learning can be twofold: prevention or response. Prevention is aimed at avoiding a similar event in the future, by pinpointing and addressing the cause and underlying mechanisms. Response oriented learning aims to 'minimize consequences' by 'enhancing crisis management capabilities' (Deverell 2009, 182).

Within the aviation industry, the focus is on prevention. More specifically, the industry attempts to reduce the number of occurrences[2] (Wiegmann and Schappel 2003) by exploring "what went wrong" in accidents and incidents (Hauschild and Sullivan 2002). This is not unsuccessful, as accident rates have dropped significantly (Janic 2000).

Whereas large-scale accidents do not occur frequently in the aviation industry, their effects can be huge (Wang 2007). Hence, aviation accidents can be classified as low probability/high consequence events (Luxhoj and Coit 2006). Despite this low probability, the desire and need to learn remains.

According to Janic (2000), there are several characteristics of why risk in the aviation industry is distinct from other sectors. These pertain to 1) the nature of flying and 2) spatiality (Janic 2000, 44). First, flying is inherently risky. Second, as a result of large distances traveled by airplane, an accident can occur at any place and time. This can affect many people, not only those inside the aircraft. Aviation accidents and incidents can lead to loss or harm of persons, and high monetary costs, amongst others (Homsma et al. 2007). For example, Wiegmann and Shappell (2003) suggest that when organizations fail to prevent or mitigate future accidents, a decrease of public confidence and an increase of the public's distrust in the industry may be

[2] Occurrences refer to the sum of accidents and incidents (ICAO 2013, 1).

the result (10). The high levels of risk demonstrate the need to learn within the aviation industry.

2.3 When do organizations learn

Organizations can learn at any time and occasion in day to day operations. Nevertheless, some scholars argue that learning needs to be stimulated (e.g. Vaughan 1996; Cooke and Rohleder 2006). Stimulation requires three elements: structures that support learning, a culture where learning is stimulated, and an event to trigger learning.

The first element refers to formal arrangements such as procedures and systems (Drupsteen-Sint 2014, 24). Within the aviation sector, all accidents and incidents are to be reported. Many voluntary and involuntary mechanisms exist for detection, reporting and data collection. The sector is also subject to a wide variety of regulations (Haunschild and Sullivan 2002), directives and guidelines by organizations such as the Federal Agency of Aviation (FAA), ICAO, International Air Transport Association (IATA) and EUROCONTROL.

Second, in addition to formal arrangements, a condition for learning is the availability of a culture where learning is stimulated. According to Drupsteen-Sint (2014), this refers to 'the organizational and managerial environment in which individuals operate' (24). Without a favorable environment where learning is stimulated by management, learning is not likely to occur.

Third, there are several moments in which learning is more likely to take place. This is what Drupsteen and Wybo (2014) refer to as "learning from experience". According to these scholars, for learning to take place 'relevant events are identified and analyzed' (1). This may vary from crises and accidents to (serious) incidents. These triggering events will be explored in greater detail in Sections 2.3.1 through 2.3.4.

2.3.1 Learning from crises

Adopting Boin and 't Hart's definition, a crisis is defined as 'a situation that subjects a community of people, such as an organization or a state, to a serious threat to its fundamental norms, values, and structures' (2006, 42). Inherent to a crisis is a certain level of threat, uncertainty, and urgency. A crisis may be the result of an incident that is not contained.

Especially relevant to organizational learning is uncertainty. According to Wang (2007), the higher the level of uncertainty, the greater the need for learning. Additionally, Wang (2007) argues that the uniqueness of a crisis allows it to be seen as a valuable 'learning opportunity' which can 'lead to increased organizational adaptation' (2). Thus, because uncertainty is higher in a crisis than during latent failure or normal day-to-day business, it is more necessary and probable that organizations learn (Homsma et al. 2007; Wang 2007).

2.3.2 Learning from accidents

Adopting the ICAO definition, aviation accidents are defined as 'an occurrence associated with the operation of an aircraft, resulting in fatality or serious injury to persons and/or damage or structural failure sustained to the aircraft' (ICAO 2013, 1-1).

According to Madsen, Dillon, and Tinsley (2016), accidents 'trigger organizations to investigate, learn and implement changes, consistent with organizational science literature' (1054). The aim of learning is often the identification of causes (Drupsteen and Wybo 2014), to prevent future accidents from happening.

Whereas accidents provide a good opportunity for organizational learning, it can be challenging because accidents do not occur regularly in civil aviation (Donahue and Tuohy 2019). The accidents that do occur, commonly take place because organizations did not learn, missed, or ignored warning signals (Turner 1976; Cooke and Rohleder 2006). For this reason, Wang (2007) concludes that 'significant learning efforts are necessary to reduce or mitigate these effects' (1). Organizational learning does not necessarily need to follow from accidents, it may also follow from incidents.

2.3.3 Learning from incidents and near-misses

As aviation accidents do not occur frequently, the aviation industry focuses strongly on learning from incidents. Again adopting the ICAO definition, aviation incidents are defined as 'an occurrence, other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operation' (ICAO 2013, 1-1).

Near-misses constitute a subcategory of incidents. A near-miss is what ICAO designates a "serious incident", namely 'an incident involving circumstances indicating that an accident nearly occurred' (ICAO 2013, 1-2). A slightly different set of circumstances could have resulted in loss or injury. Thus, the difference between an accident and a near-miss lies only in the outcome.

Although yielding a different, more positive outcome, incidents demonstrate that under existing circumstances there is the potential for disaster. Moreover, incidents can clarify the origin of the failure. It is important for organizations to identify the origin of a failure – the underlying cause - because other incidents may follow if the cause remains unaddressed (Drupsteen-Sint 2014, 14). When no negative consequences become apparent following an incident, the risky behavior that led to the incident can become normalized over time. When efforts *are* made to learn from incidents, this 'normalization of deviance' (Vaughan 1996) is addressed.

2.3.4 Runway incursions

Runway incursions are seen as one of the greatest safety risks at airports. Not only are one-third of all aviation accidents linked to runway operations (Flight Safety 2011, n.p), also, they can entail huge consequences (Homsma et al. 2007). Reducing runway safety risks remains a top priority for many international and local aviation organizations, e.g. the ICAO, IATA, and LVNL.

Defining a RI

The ICAO (2007) defines a runway incursion as 'any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designed for the landing and take-off of aircraft'. This occurs for example when an aircraft or vehicle enters or crosses a runway (RWY) without (correct) clearance. Runway incursions can be classified by severity level.

The ICAO distinguishes between four different classifications of runway incursions. These classifications are adhered to internationally which facilitates 'global harmonization and effective data sharing' (6-1). *Table 1* explains these categories. There exists an additional category of runway incursions: category E. According to the ICAO (2007), a runway incursion may be classified as category E when 'insufficient information or inconclusive or conflicting evidence precludes a severity assessment' (6-1). Category E incidents will not be discussed in this thesis.

Table 1. Runway incursion severity classification (ICAO 2007).

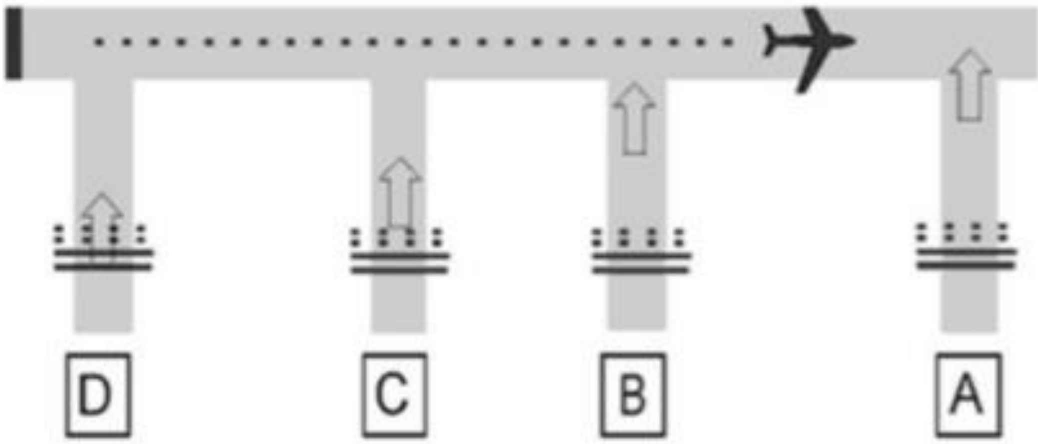
A	A serious incident in which a collision is narrowly avoided.
B	An incident where separation decreased and there is significant potential for collision, which may result in a time-critical corrective/evasive response.
C	An incident characterized by ample time and/or distance to avoid a collision.

D	An incident where a single vehicle, person or aircraft is incorrectly present on the surface designated for take-off and landing but with no immediate safety consequences.
E	Insufficient information or inconclusive or conflicting evidence precludes a severity assessment.

In which category a runway incursion falls, is determined based on several indicators including proximity, factors affecting system performance, and reaction time (ICAO 2007, 6-2). The Runway Incursion Severity Classification Calculator (RISC) is a tool developed to ensure uniform classification.

Classifications as presented in *Table* 1, are awarded to runway incursions to ascribe a certain level of risk. Within these categories, category D incidents are deemed relatively low-risk incidents, and category A incidents entail the greatest risk. The “risk” of a runway incursion is most generally the risk of collision. The risk of collision is generally greater for runway incursions compared to other ground-incidents due to the speed of the aircraft (SKYbrary 2019a). *Figure 1* provides an additional visualization of the severity classification.

Figure 1. Runway incursion severity (Mrazova 2014, 73).



Causes of RI’s

A RI can result from a variety of factors. Wang et. al 2018, divide these factors into six categories. The factors and explanations are presented in *Table 2* below.

Table 2. Factors and explanations (ICAO 2007; Zhang and Luo 2017; Wang et al. 2018).

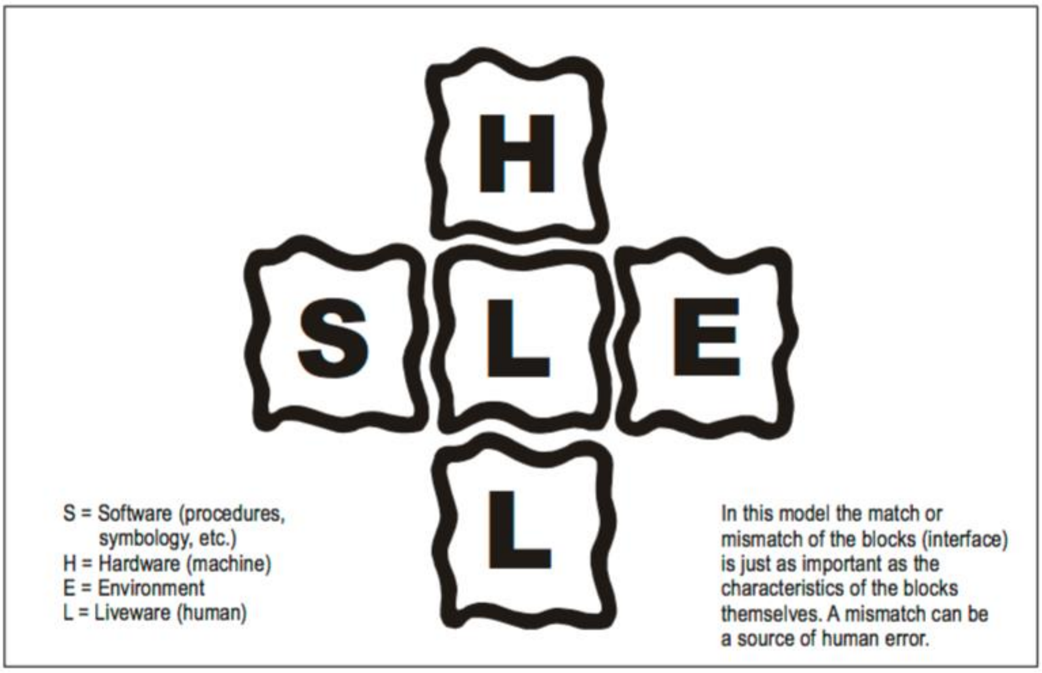
Human	Communication, distraction, situational awareness.
Airport geometry	(Complex) layout of the aerodrome, e.g. high number of crossings.
Technical	Technologies e.g. Runway Incursion Alerting Systems, and other alert systems.
Airport characteristics	Airport size, traffic volume, signage, markings, lights.
Environment	Meteorological conditions, e.g. wind and glare.
Organizational	Supervision, coordination and communication.

Runway incursions can be caused by the interplay of more than one factor. This has to do with the complexity of aviation operations. According to Perrow (1984), in systems with high-risk technologies 'accidents are the result of an interaction of multiple failures' (70). Going in-depth into complex systems is beyond the scope of this thesis. According to Drupsteen-Sint (2014), the essence is to understand that there are many factors, indirect causes and conditions' associated with this complexity (2014).

Another point to consider is that human factors are often part of the cause. According to Helmreich (2000), research by NASA has demonstrated that roughly three-quarters of all accidents in aviation involve human error (781). Helmreich's emphasis on human *involvement* supports the argument that there is commonly not a sole cause (Wiegmann and Shappell 2003).

Within the aviation industry, the ICAO has recommended the use of the SHEL(L) model to analyze aviation accidents. Elwyn Edwards designed the SHELL model specifically for the aviation industry in 1972 (EUROCONTROL 2012). In this model, S stands for software related, H for hardware, E for environment and L for human actions (liveware) (ICAO 2007). There are two letters L because a distinction is made between the 'main actor(s)' and other persons. The core idea is that any occurrence is the interplay of various elements, where the human component plays a key role (Wiegmann and Shappell 2003, 27). In particular, the 'main actor' represented by the central "L". Any change to an element can significantly impact intra-element relationships. *Figure 2* provides a visual representation of the model.

Figure 2. The SHELL model (ICAO 2007, 2-1).



The SHELL model does not enable researchers to isolate one factor as the main cause, nor considers non-human interactions[3]. Nevertheless, it remains a useful tool during safety and incident analysis (EUROCONTROL 2012). The key takeaway is that runway incursion causes should always be considered in relation to other factors. Researchers need to take this into account when studying organizational learning.

The FAA constructed three common scenarios of runway incursions, Taking into account the key role of human factors. The RI scenarios are presented in Table 3 below.

Table 3. Incursion scenarios (FAA 2012).

Air Traffic Control (ATCO)-induced	Operational incident (OI)	Any action by air traffic control which results in a loss of separation between two or more aircrafts/obstacles.
Flight Crew-induced	Pilot deviation (PD)	E.g. Unauthorized crossing/entry of a runway by flight crew.
Vehicle driver-induced	Vehicle/pedestrian deviation (V/PD)	E.g. Unauthorized entrance/entry of airport movement area.

[3] To learn more about complex systems, see Perrow (1984) or Vaughan (1996).

If a vehicle or aircraft receives explicit clearance for runway presence, causal factors for runway incursions lie in the domain of LVNL (OI). If clearance is not granted or misunderstood incorrectly by pilots, a RI is identified as a PD or V/PD (NLR 2018, 85). These scenarios provide an additional means to classify and measure incidents and are commonly referred to in RI investigations.

2.5 Barriers to learning

The approach to aviation safety has 'yielded unprecedented levels of safety' (Wiegmann and Shappell 2003). As of today, aviation is the safest mode of transport when looking at the number of fatalities (Janic 2000; Wiegmann and Shappell 2003), compared to other modes of transport (AGCS 2015).

Although the aviation industry recognizes the potential to learn from accidents and incidents, as explored in Section 2.3, learning does not always occur. There are many potential reasons why organizations do not learn. Schilling and Kluge (2008) provide an extensive overview of all barriers to learning which have been identified by scholarship up until the time of Schillings and Kluge's research. These barriers are structured according to the four stages of learning they have identified: intuition, interpretation, integration, and institutionalization (343). The barriers are divided into subcategories: action-personal, structural-organizational, and societal-environmental.

2.5.1 Learning from runway incursions

The overview by Schillings and Kluge is too broad to explain the variation in learning from runway incursions. Moreover, Madsen, Dillon, and Tinsley write that organizations cannot learn from all incidents. In their study on organizational learning of U.S. airlines, Madsen et al. (2016) demonstrate that airlines learn from accidents and one category of near-misses. This category of near-misses entails the greatest signs of danger (1062). Accordingly, in this thesis, these higher-risk category corresponds with category A RI's.

The explanation that Madsen et al. provide for the lack of organizational learning is because people are susceptible to bias. Bias can be linked to a specific category of barriers to learning by Schillings and Kluge. Namely, the "action-personal" category. According to Schillings and Kluge, action-personal barriers include 'basic psychological phenomena which occur as the individual perceives his or her environment' (344), such as biases and emotions.

These barriers, and more specifically 1) outcome bias, 2) hindsight bias, and 3) association (Dillon and Tinsley 2008) are investigated below.

Outcome bias

First, when a near-miss occurs, two contradicting interpretations may arise: that of success and resilience, or that of failure (March et al. 1991, as cited by Dillon and Tinsley 2008, 3). Thus, one can either identify a near-miss as an occurrence that "went wrong" or "went right". Based on their research, Dillon and Tinsley (2008) find that there is a general tendency to identify near-misses as a success, rather than a failure. A near-miss is only judged based on the outcome; the process is ignored. Consequently, learning is not often deemed necessary.

Dillon and Tinsley (2008) further put forward that the outcome bias can also evoke risky decision-making. Evoking risky decision-making can be explained as a person assuming that for a future occurrence, they can make the same decisions and take the same risks, as it "went right" the previous occasion(s) too. Because the occurrence is a near-*miss*, this type of decision making should not be supported. Risky decision-making is inherent to the "success" labeling that is more likely to take place.

The "success" argument is supported by research conducted by Terum and Svatdal (2019) in their study of risky behavior in traffic. Terum and Svatdal enhance the existing literature with their investigation of the reasoning behind labeling an incident as a "success" or "failure". These scholars establish that individuals rely on either 'social, temporal or counterfactual information for evaluation (672), proposing that counterfactual thinking is the most plausible in this context. Counterfactual is literally: 'contrary to the facts' (Epstude and Roese 2008). In near-misses, counterfactual thinking entails deciding what alternative outcomes are plausible if one variable had been different.

Smith and Elliot (2007) use a different term for what this thesis understands as outcome bias, namely the 'minimization of threat' (350). According to Merriam Webster Dictionary, minimization can be defined as "intentional underestimation". Within a near-miss context, minimization regards the tendency of individuals to give only limited attention to prior incidents and/or accidents (Smith and Elliot 2007). This is a form of "denial" that something potentially harmful has occurred. Minimization of threat differs from Dillon and Tinsley's outcome bias, as it emphasizes intentional action. Dillon and Tinsley do not discuss intentionality.

Based on the aforementioned definitions of outcome bias and similar concepts, this thesis argues that the outcome bias holds a negative relationship with organizational learning from near-misses. Learning is not likely to take place because all near-misses, regardless of the incident category, yield a positive outcome.

Hindsight bias

Second, when a near-miss has occurred, it is relatively easy to identify what went wrong, and how this could have been prevented. Yet, when a critical decision needs to be made, making the correct choice may not be so simple. The signs are not seen beforehand, but are clear in hindsight because then we know what we were looking for. This ‘tendency to overestimate one's ability to have foreseen the outcome' (Encyclopaedia Britannica 2019) is hindsight bias. When an incident or accident has happened, people tend to proclaim to “have known” that this outcome was to be expected (Woods and Cook 1994).

Similarly, hindsight bias is defined by Gilbey and Walmsley (2019) as a situation where ‘following an event, people often claim that it would be all too easy to predict the event in advance’ (2). In reality, one’s own ability to predict is commonly overestimated (7). Because of hindsight bias, only when an *accident* occurs do people realize ‘the warning embedded in near-miss events' (Dillon and Tinsley 2008, 2). In this sense, organizations recognize the necessity for learning when under similar circumstances an accident occurs, rather than a near-miss.

Based on the aforementioned definitions of hindsight bias and similar concepts, this thesis argues that hindsight bias holds a negative relationship with organizational learning from runway incursions. This may apply to all incident categories, as all runway incursions have the potential to result in an accident under other circumstances.

Association

Third and final, in terms of association, Madsen et al. (2016) have established that people need to associate near-misses with a certain risk or danger, and its capacity to lead to a crisis to fully recognize potential for learning from a near-miss. When relating this to aviation specifically, one will be more likely to learn from incidents that ‘at other times had resulted in major accidents' (Madsen et al. 2016).

Similar to the outcome bias, association influences how individuals process information about prior occurrences. Also, these biases potentially influence ‘subsequent decision making’ (Gilbey and Walmsley 2019). Distinctly, association differs from the outcome bias as the focus lies in *association* with accidents. Association can occur with any accident in aviation, regardless of the place or time of occurrence.

Contrary to Madsen et al. (2016), who focus on a positive relationship between association and organizational learning, Smith and Elliot (2007) focus on a negative relationship. According to them: 'the assumption that catastrophic events are unique and constrained in both space and time can hinder the learning process' (532).

Gilbey and Walmsley (2019) define a similar concept: availability bias. They describe this as 'the tendency for judgments to be influenced by how easily an episode or event can be recalled' (2). As dramatic events are often recalled more easily than less dramatic events, an individual may become biased towards a small, atypical sample (3). Again, in this understanding of association by Gilbey and Walmsley, learning is hindered by the infrequent occurrence of accidents, and therefore describes a negative relationship.

Based on the aforementioned definitions of association and similar concepts, this thesis argues that association holds a positive relationship with organizational learning from runway incursions. Specifically, category A (and B) incidents, as these are more likely to be associated with accidents. This thesis does not focus on the specific element of association with accidents, as described by Madsen et al. (2016). Researching this is outside of the scope of this study.

2.6 Conclusions and expectations

This literature review and theoretical framework provide a broad overview of the key concepts, definitions and debates on organizational learning from runway incursions. Existing scholarship has further demonstrated that near-misses can be valuable opportunities for learning, but also that there exist barriers to learning.

The mitigation and prevention of runway incursions remain a huge safety concern within aviation. Moreover, because of the contemporariness of the situation at Schiphol airport, it both relevant and interesting to explore if and why LVNL does not learn from all runway incursions. With this approach, this thesis seeks to make a first step to fill in the gap on barriers that prevent learning within organizations. Moreover, this thesis seeks to contribute to the scholarship on organizational learning by conducting qualitative empirical analysis. Thus far, studies on this topic have mostly focused on statistical analysis (Zhang and Luo 2017).

Based on the theoretical framework of this thesis, I expect that biases can explain the variation in learning. The hypothesis for this research is that:

LVNL is more likely to learn from runway incursions classified as category A or B incidents, than from category C or D incidents.

In this sense, the higher the risk, the greater the chance that learning will take place. More specifically, because of association I expect that learning is most common for category A. Biases are challenging to study, generally, as it requires a controlled environment. Within the context of runway incursions this is very time consuming and lies beyond the scope of this thesis. Nevertheless, they will be explored as explanatory mechanisms.

Despite a lower risk of collision for category C and D incidents, statistically, the majority of RI's constitute category C and D incidents (DSB 2017; FAA 2018). Schiphol Airport aims to reduce the absolute number of runway incursions at Schiphol. Therefore, the desired outcome is that LVNL learns from all incidents. The learning that should take place is the adjustment and/or implementation of new measures that reduce the opportunity for a future collision between two aircraft/vehicles.

3 Research design

This chapter presents the research design of this thesis. First, the main concepts "organizational learning" and "runway incursions" are operationalized. Second, this chapter discusses qualitative document analysis as the main research method and the pros and cons of a multiple case study design. Furthermore, the selected time frame and case studies are explained. Finally, the chapter concludes with instruments and motivations for data selection.

3.1 Operationalization

This thesis examines the causality between runway incursion categories and organizational learning. For this reason, the concepts of organizational learning and runway incursions, as discussed to a great extent in the previous chapter, are highly relevant for this thesis.

For this study specifically, organizational learning will be operationalized as the implementation or adjustment of measures and/or other (policy) changes. This operationalization is based on the definition of organizational learning by Deverell (2009) because he clearly distinguishes between two phases of learning: lessons distilled and lessons implemented. The former relates to the availability of knowledge, and the latter is when this knowledge is acted upon. Deverell explains that lessons distilled only constitute part of the learning process. Lessons distilled may contribute to a reduction or mitigation of similar incidents and accidents in the future, but require action. To this end, both phases are fundamental for organizational learning. Learning is thus 'a change in performance' (Madsen et al. 2016, 1057). Specifically, this study focusses on the organizational learning of Luchtverkeersleiding Nederland, as they are primarily responsible for clear and safe runways.

As seen in Section
2.3.4 Runway incursions, a runway incursion is 'any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designed for the landing and take-off of aircraft' (ICAO 2007, 1-1). The concept itself is rather clearly defined, and the definition provides specific characteristics. This facilitates simple identification. The specific runway incursion categories (A, B, C, and D) are not measurable without operationalization. Similar to the concept "runway incursion", internationally recognized guidelines do exist to support this. As seen prior, the RISC calculator has been developed to classify a runway incursion. This tool can be downloaded and therefore employed to classify the runway incursions of interest to this study. For purposes of clarity and workability, additional category names are used throughout this thesis. These

category names are derived from a safety risk severity table presented by the Dutch Safety Board in an incident report (2013). The categories are presented in *Table 4* below.

Table 4. Category names based on safety risk severity table (DSB 2013).

Official classification	**Attributed classification**	**Refers to**
A	Catastrophic incident	A serious incident in which a collision is narrowly avoided.
B	Hazardous incident	An incident where separation decreased and there is significant potential for collision, which may result in a time-critical corrective/evasive response to avoid a collision.
C	Major incident	An incident characterized by ample time and/or distance to avoid a collision.
D	Minor incident	An incident that meets the definition such as the incorrect presence of a *single* vehicle, person or aircraft on the protected surface designated for the landing and take-off of aircraft but with no immediate safety consequences.

3.2 Research design

This study employs a qualitative research methodology, based on a multiple case study design. Qualitative document analysis is conducted to analyze variation in organizational learning across eight runway incursions in the Netherlands.

According to Yin (1994), a case study is 'an empirical inquiry investigating a contemporary phenomenon within its real-life context' (13). In this study, the choice for case study design is driven by the idea that it is a useful method of analysis due to 'the closeness to real-life situations' (Flyvbjerg 2006, 223) as well as the possibility of in-depth analysis (Yin 2003; Crowe et al. 2011).

Although the method has been critiqued quite extensively, case study research is now 'prevalent in virtually every academic field' (Yin 2003, 2). The main limitations of case study research pertain to generalizability or single case studies (Yin 1994). In this study, multiple case studies are analyzed. The researcher can achieve more reliable and generalizable results (Flyvbjerg 2006) by selecting a 'representative sample with a useful variation on dimensions of interest' (Seawright and Gerring 2008, 296). Therefore, categories A through D are all represented in this study. More specifically, two case studies will be analyzed per runway incursion category. In sum, N = 8 for this research. A benefit of Small-N analysis, in comparison to Large-N analysis, is that theories can not only be confirmed, but they can also be placed within context.

The choice for N=2 per category is made because it allows having multiple observations, rather than just one. Chiefly, within-case analysis will be conducted. The aim of analyzing each case distinctly is to gain an in-depth understanding of the case, and a description of the phenomenon under study (Paterson 2012, 971). For each case, it is thus analyzed whether learning takes place for LVNL. According to Mahoney (2000), this stand-alone analysis 'compensates for limitations associated with cross-case methods' (409) such as quantitative analysis.

Nonetheless, within-case analysis allows the researcher to compare results across-cases. More than making inferences about all cases, details and differences can be pointed out and explored (Paterson 2012). Additionally, relationships and connections between cases can be studied at a later stage. For example, whether or not learning takes place after previous (similar) incidents.

Finally, a case study design fits with the deductive approach that is followed. The research follows from the development of a hypothesis based on existing theory. Through comparison of 'the expected findings with the empirical findings deduced from theory, 'it is possible to verify or falsify the theory' (Johansson 2003, 4).

The results of qualitative document analysis are used to test the hypothesis of this research: *LVNL is more likely to learn from runway incursions classified as category A or B incidents, than from category C or D incidents*. The independent variable of this study is then the incident category, and organizational learning is the dependent variable.

3.3 Timeframe

This research examines runway incursions between 2004 and 2016. There are two main reasons for the selection of this specific timeframe. The first relates to the availability of data. The timeframe begins in 2004 as this marks the first year in which the Dutch Safety Board analyzed runway incursions. The DSB was officially founded on February 1, 2005. At the time of writing this thesis, 2016 constitutes the final year from which to induce cases, taking into account a timeframe for learning.

This timeframe for learning is the second reason for the selected timeframe. A timeframe of three years is adopted for this study. Following this, measures and/or other (policy) changes need to be implemented within 3 years after an incident for learning to be attributed to this event.

This three-year timeframe is derived from Madsen, Dillon, and Tinsley (2016). The timeframe is based on previous scholarship (1057) and is applied by these scholars in a similar study on the organizational learning of airlines.

3.4 Case selection

In the Netherlands, *all* aviation incidents have to be reported. Furthermore, the Dutch Safety Board has an obligation to analyze all incidents. The most important incidents are investigated by the DSB to determine their potential causes (Rijksoverheid 2019). This obligation to report near-misses yields an exhaustive list of runway incursions in the Netherlands, which can be utilized for this study. The full extent of runway incursions at Schiphol Airport for the chosen timeframe is presented in *Figure 3* below.

Figure 3. Runway incursions at Schiphol Airport annually between 2004-2016.

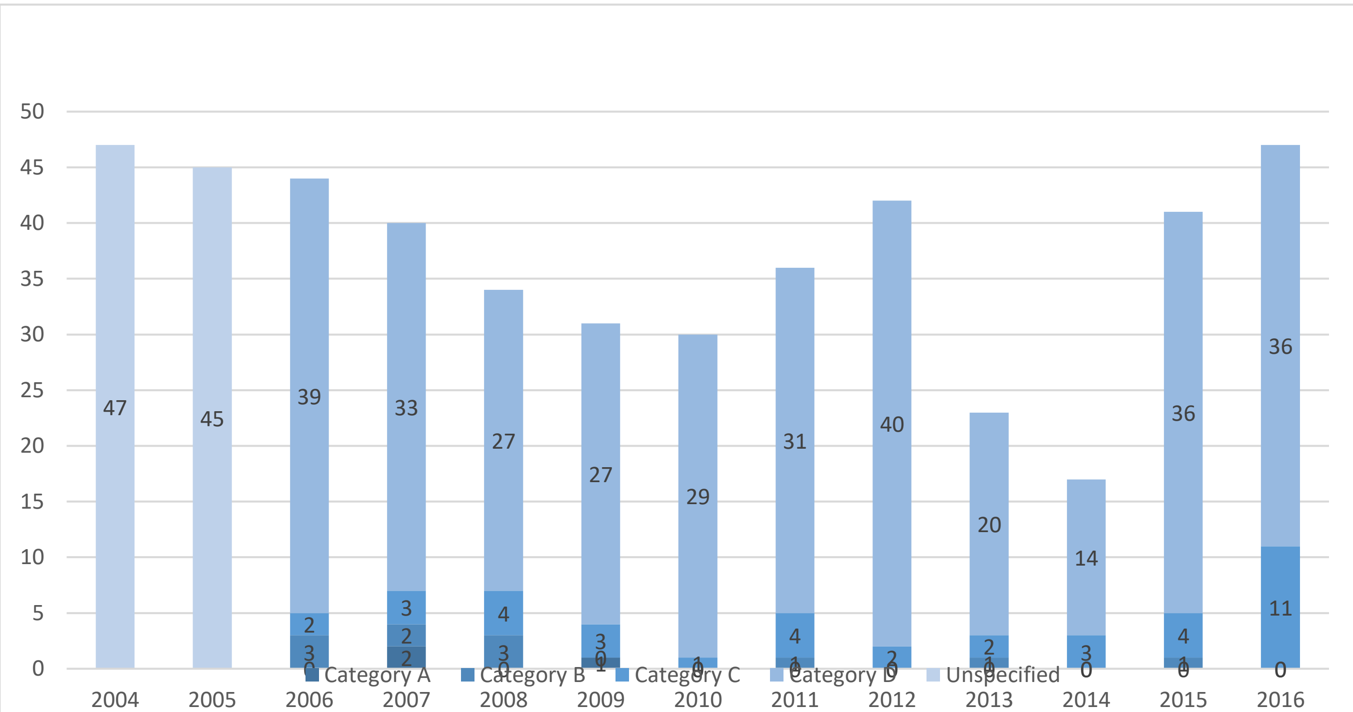


Figure 3 illustrates that multiple incidents occur yearly, with an average of 35 incidents per year. Because no two incidents are identical, different lessons may be learned.

This thesis examines organizational learning in eight case studies. As seen prior, runway incursions can be classified into four main categories (see *Table* 1). For each runway incursion category, two case studies are selected. Three selection criteria guide the case selection. The primary selection criterion is the availability of data in the form of publicly available research reports of the Dutch Safety Board. These reports are crucial as they will play a prominent role in this study. The purpose of these research reports is explained in greater detail in Section **Error! Reference source not found.**. From the 22 runway incursions investigated by the Dutch Safety Board, 17 research reports were readily available.

The second criterion is the timeframe for learning as described in Section 3.3

Timeframe. In choosing case studies *within* the respective categories, at least a three-year period separates the occurrence of the first and second runway incursion[4]. This three-year period is necessary to guarantee sufficient time for intra-crisis learning. Although cases are initially analyzed as stand-alone cases, the timeframe for learning facilitates cross-case comparison, as learning is ascribed to only one case study.

Finally, taking into account the aforementioned, no two similar scenarios are chosen. This way, the cases can 'represent the full variation of the population' (Seawright and Gerring 2008; Flyvbjerg 2006). Selecting diverse cases allows for comparison between cases based on their diverse characteristics. This representativeness is further 'essential for good external validity' (Wikfeldt 1993, 7). The selected cases are as follows:

Table 5. Case study overview.

Classification	Year	Case nr.	Brief description of incident
A	2004	A1	Unauthorized taxiing onto runway in use for landing.
	2009	A2	Take-off with clearance, towing combination present on RWY.
B	2005	B1	Takeoff with clearance, bird control present on RWY.
	2007	B2	Entrance of protected area of active RWY.
C	2009	C1	Taxiing onto RWY in use for landing.
	2014	C2	Initiation of takeoff with clearance, bird control present on RWY.

[4] An exception is made for category B. Due to the relatively low occurrence of category A and B incidents, there was no second incident that matched all criteria.

D	2004	D1	Crossing active RWY without clearance.
	2015	D2	Takeoff from unavailable RWY.

A more detailed overview of the case studies can be found in *Appendix A: Case studies*.

Several limitations should be taken into consideration. A general critique regarding case selection concerns the selection criteria. A researcher may choose between randomization and purposive selection (Seawright and Gerring 2008). As seen prior, purposive selection has been chosen over randomization for this study. Whereas both approaches have their limitations, purposive selection can make an important contribution to the reliability and generalizability of research (Steenhuis and de Bruijn 2006; Seawright and Gerring 2008;). By explaining - in great detail - the case selection procedure, validity is enhanced.

A limitation related specifically to diverse case selection concerns the variation between cases. This approach may be problematic when there 'are more high cases than low cases' (Seawright and Gerring 2008, 301), or an imbalance in cases. This is addressed by employing specific selection criteria. For this study, the selection of two case studies per RI category, as well as distinct scenarios within the categories, enhance the representativeness and generalizability of the sample (Flyvbjerg 2006, 229). This approach does not only counter such shortcomings, but it also increases the strength of the claims to be made (Seawright and Gerring 2008).

The aforementioned demonstrates that the generalizability of this study is enhanced through the purposive selection and the specific selection criteria employed. In qualitative research, generalizability commonly refers to analytical generalization (Yin 1994; Steenhuis and de Bruijn 2006) rather than that of conclusions. For this to be possible, the cases 'need to be similar in some respects to a larger population' (Gerring 2004, 248), for example, time, people, or other social contexts (Leung 2015). To determine whether or not something is generalizable, it needs to be made clear whether or not the theory holds. For this research, following the deductive approach (see Section 3.2, p. 25), and theory verification (or falsification), 'the domain within which the theory is valid can be defined' (Johansson 2003, 9).

3.5 Sources

For this research, primary sources that are made publicly available constitute the main data sources. Examples include incident and research reports, safety analyses and annual or monitoring reports. The majority of the sources are published by Luchtverkeersleiding Nederland, the Ministry of Infrastructure and Water Management (IenW), Schiphol Airport (Group) and the Dutch Safety Board.

A possible limitation is that not all information regarding implemented changes is made publicly available. Nevertheless, due to the public accountability of Schiphol and its close cooperation with the state, the Ministry of IenW specifically, this thesis expects that the most relevant data is made available to the public. A fortitude of this accountability is the high credibility of the sources.

Nevertheless, credibility and validity issues remain a potential limitation for this study. To deal with these issues, triangulation of both data and methods will be applied where possible. Data triangulation can be explained as ‘the collection of data from a variety of sources to increase a study’s credibility’ (Rothbauer 2008; Bryman 2011). By using various sources to underpin a claim, it becomes more credible (Bowen 2009). Similarly, method triangulation involves ‘the use of more methods for gathering data, providing a more complete set of findings’.

Finally, a language barrier is not an issue for this study. As the author of this thesis speaks Dutch, the sources can be gathered and coded in their original language, when necessary.

3.6 Data collection

The process of data collection is similar for all case studies. Primarily, the case-specific research reports of the Dutch Safety Board are collected, as well as the annual reports for Luchtverkeersleiding Nederland, and Schiphol for the years 2004-2016. This data is obtained by searching the respective websites and/or their databases. The exception here is the annual reports by Luchtverkeersleiding Nederland, which are provided to the researcher at the discretion of LVNL.

Depending on the completeness of the reports by the Dutch Safety Board, Luchtverkeersleiding Nederland, and Schiphol, additional data collection may be necessary. Data collection is then guided by the content of the research report corresponding to the case study. The research reports by the Dutch Safety Board provide the lessons distilled.

To obtain the relevant data in addition to the prior mentioned reports, both the search engine of Google and those of the key organizations (LVNL, DSB, Schiphol, IenW) are employed. Searches are performed for “Schiphol”, and/or “Luchtverkeersleiding” or “LVNL” in combination with words referring to the specific recommendations. These searches may be supplemented by the year of occurrence or time frame for learning.

Upon acquiring more knowledge of the recommendations and measures in the research process, the data collection process may be repeated to ensure that all relevant data has been acquired. This is necessary to ensure that all aspects of the topic are represented fairly (Bowen 2009).

According to Bowen (2009), for this type of research, quality and content should be leading, rather than the number of sources (33). For this reason, no limitation has been set as to the number of documents to be collected per incident. More importantly, sources need to be evaluated on accuracy, completeness, credibility, and purpose (33) to establish their relevance for this research.

As a timeframe for learning of three years has been adopted, the lessons implemented ought to fall within this timeframe. For this reason, chiefly, only documents will be gathered that are published within three years of the occurrence of the RI. Yet, no relevant documents may be published within this timeframe.

A lack of documents within the given timeframe does not mean a lack of data. The annual reports of LVNL and Schiphol ensure sufficient data. More importantly, a lack of documents within the given timeframe does not mean that no learning has taken place. In the absence of documents within the timeframe, documents will be used that fall outside of this timeframe. To ensure that the learning does take place within the provided timeframe, the document will need to refer specifically to a year in which the changes were made. If learning is delayed, this will be noted. However, considering the complexity of learning, learning cannot always be attributed to a specific incident. The research strategy employed to answer the research question is presented in the next chapter, Chapter 4: Methodology.

4 Methodology

This chapter provides greater insight into the main research method employed for this thesis. More specifically, it clarifies how document analysis will facilitate the analysis of the case studies. Moreover, the codebook will be explained, as well as the codification process and data analysis.

4.1 Document analysis

Document analysis will be employed as the primary method to answer the research question of this thesis: "*How do incident categories influence organizational learning in the case of runway incursions in Dutch civil aviation?".* Similar to content analysis, document analysis is a systematic research technique for the evaluation of sources (Krippendorff 2004; Bowen 2009). Any type of written text, either analog or digital, can be analyzed. A requirement is that the content has come into existence without the involvement of the researcher. The selected documents depend on the study (Gross 2018). Possibilities include letters and memoranda, background papers, manuals and various public records (Bowen 2009, 27-28).

Document analysis draws heavily on the related qualitative research methods thematic analysis and content analysis. Similar to content analysis, document analysis employs codification as a research method. In content analysis and document analysis alike, codes constitute 'labels for assigning units of meaning' (DeCuir-Grunby et al. 2011, 137). Distinct from content analysis, codification serves a different purpose for document analysis. Content analysis seeks to quantify data or extract excerpts, and to use them directly in a research report. Document analysis employs codification for the 'identification of meaningful and relevant passages of text or other data' (Bowen 2009, 32). In this sense, it is a means to a different end. Moreover, in document analysis, codes and categories are constructed based on themes, following basic principles of thematic analysis (Bowen 2009).

There are several advantages inherent to document analysis. These include the efficiency of the method and availability and stability of documents (Gross 2018).

In spite of these advantages, there are also disadvantages, or 'potential flaws' (Bowen 2009, 32). These are biased selectivity (Yin 1994; Flyvbjerg 2006; Bowen 2009) and reliability issues (Flyvbjerg 2006). When biased selectivity is understood as 'incomplete document collection' (Yin 1994) the data collection procedure outlined in Section 4.2 (p. **Error! Bookmark not defined.**) seeks to overcome this. Nevertheless, it is relevant to note that lessons distilled are derived from a single source, namely the Dutch Safety Board. Whereas this may point towards biased selectivity, it is likely that, based on their expertise, the Dutch Safety Board presents the most "important" lessons. In this sense, the possibility of the existence of multiple, co-existing routes for learning – such as the LVNL internally – is not disregarded.

It is important to note that a reliability check should be conducted to check the reliability of the coding (Krippendorff 2004). Reliability checks entail the cross-examination of a sample of the coded work to ensure the objectivity of the researcher (Macnamara 2005). A reliability check was not possible within the scope of this study. Reliability can additionally be interpreted as 'the replicability of the processes and results' (Leung 2015). The detailed information provided in this thesis on the employed research method and procedures, as well as the strict adherence hereto, a repetition of this (or a similar) study will likely lead to similar results.

In this study, document analysis is employed to identify the lessons distilled and lessons implemented. Lessons distilled are identified based on the analysis of the Dutch Safety Board of "what went wrong" and specific recommendations presented in the research reports of the respective runway incursions. Whether lessons are implemented is determined based on the evidence presented in the research report or other relevant sources. For lessons implemented, commonly, there is an explicit reference to the implementation, research into, or adjustment of a measure. Codification of these lessons distilled and implemented is done is according to the codebook that is explained in greater detail in Section 4.3.

4.2 Codebook

As discussed by DeCuir-Gunby et al. (2011), a codebook is essential as it 'provides a formalized operationalization of the codes' (138). This section provides insight into the codebook that is utilized for this study. The choices made concerning the coding categories are explained and justified.

4.2.1 Codebook format

A total of 23 variables will be used for codification to extract relevant data from each source. The respective codes "A-D" and "1-19" are assigned to the variables. These codes are used solely to simplify the coding procedure. As codification is done manually, these codes do not serve an additional purpose.

The variables are divided into themes and subthemes. More precisely, the themes "General information", "Incident characteristics", "Recommendations", "Measures" and

“Reasons for not implementing”. A description is also provided. The researcher can determine what is coded based on this description, in combination with indicators and coding rules (if applicable).

4.2.2 Variables

The variables for this codebook were constructed before data analysis. More specifically, the variables are derived from the literature review and conceptual framework. For example, the subthemes in “Recommendations” and “Measures” are derived from the causal factors described in Chapter 2. From this list, “Environment” is left out as this is beyond the scope of this research. A study can attain higher levels of objectivity by following the deductive approach (Bowen 2009; DeCuir-Gunby et al. 2011). During the research process, minor changes are sometimes made to subtheme names, to better correspond with the context. Variables are constructed in such a way that data can always be coded within the existing codes.

Variables A-D are article-specific variables. These variables provide background information about the source itself. The variable “Date” is used to register the publication date of each source. The variable “Author” is used to identify the organization from where the source was retrieved. The variable “Audience” is used to identify the target audience. It is relevant to know the target audience of a source, as the content is often created to address a specific audience. This needs to be taken into account when assessing the credibility and reliability of a source. The variable “document type” is used to identify the type of source that is used.

Variables 1-19 are content-specific variables, providing information about the content of the document. The first theme “Incident characteristics”, variables 1-7, entail relevant details about the incident. Examples are the date and location of the incident, the vehicles that are involved, and the incident category. These variables collectively describe the incident. Furthermore, the variables provide the context within which learning takes place for that specific case.

The second theme “Recommendations”, variables 8-12, regard the lessons distilled. Here, the variable “Campaign” is used to identify measures that regard the provision of information to stakeholders, be it through campaigns or other means of information sharing such as news bulletins or updated maps. The variable “Infrastructure” is used to identify measures that regard the adjustment of the layout of the airport for the benefit of LVNL. This can relate to both airport geometry and airport characteristics. The variable can also refer to a restructuring of the work environment. The variable "Technical" is used to identify measures that entail adjustment or adoption of any technological means by, or for the benefit of LVNL. The variable "Organizational" is used to identify measures that concern the adjustment or adoption of (new) procedures or processes either by or for the benefit of LVNL. Lastly, the variable "Cooperation" is used to identify measures that regard stimulating or enhancing cooperation between various stakeholders, regarding safety topics of concern to LVNL.

The third theme "Measures", variables 13-17, is very similar to the theme "Recommendations". Whereas the two themes are made up of the same subthemes, "Measures" refers to measures implemented or actions undertaken by LVNL, or lessons implemented, rather than lessons distilled. The corresponding descriptions of the variables are the same nevertheless. These similarities facilitate the easier finding of the corresponding lessons implemented and further enhance consistent codification.

The final theme "Reasons for not implementing", variables 18 and 19, can provide meaningful insights when analyzing when, or why organizations do not learn. The variable "Necessity" is used to identify justifications where LVNL claims that learning is not necessary. The variable "Feasibility" is used to identify justifications where LVNL claims that learning is not possible. An overview of all variables, their descriptions and indicators can be found in the codebook in *Appendix B*: *Codebook.*

4.2.3 Coding rules

The descriptions and indicators in the codebook corresponding to the variables contribute to consistent coding. Coding rules can be established to guide the researcher in difficult, or less clear situations. To ensure consistent codification, the following coding rules apply to this study:

1) Variables are coded as often as they apply. For example, if multiple recommendations or measures fall within the same category, these are all coded.
2) When a code consists of several sections, or if supplemental information is provided in a different section of the source, it receives the additional marking ↺.
3) When a code is repeated in similar, or the same terminology later on in the source, it receives the additional marking **RE** to signal that it does not need to be taken into account again.

Additional, variable-specific coding rules have been added in the codebook.

4.3 Data analysis

All data is collected following the data collection procedure described in Section 4.2 and subsequently coded according to the codebook. The unit of analysis for this research is sentences. The researcher can take into account the different objectives of the documents by coding texts on the sentence level, thereby better grasping the meaning of the texts. Examples of codification can be found in *Appendix C: Coding examples*.

Following codification, all coded data is entered into a coding sheet. The coding sheet comprises of all codes and their corresponding variables retrieved from the codebook, sorted by theme and subtheme. Per source, all the corresponding data is entered. This coding sheet does not only provide a good overview of the retrieved data; it allows for easier analysis.

As seen prior, coding serves as a means to uncover relevant and meaningful information. Therefore, this interpretive approach requires the extracted information to be explored in detail and linked. In this research, recommendations and measures need to be linked manually, to be able to determine whether lessons are solely distilled, or also implemented.

Thus, the final step that has to be taken is to link the data retrieved from the various sources. Therefore, the data of the different coding sheets are combined into one document. This document consists of several columns which provide insight into:

- **The type of recommendation**: campaign, infrastructural, technical, organizational. cooperation.
- **The specific recommendation**
- **The implementation status:** implemented, delayed implementation, planned, under consideration, justification[5].
- **The measure taken:** either an explanation or justification for the measure(s) that are (not) taken.

The data is linked manually and then entered into the designated columns. Each case (A1 through D2) is listed separately. The final results are discussed in the following chapter, Chapter 5: Results. Moreover, an overview of the results is presented in *Appendix D: Results.*

[5] Definition of statuses can be found in Appendix D.

5 Results

In this chapter, the findings of the conducted document analysis are presented. The presentation of findings enables evaluation of the influence of RI categories on learning in the next chapter. This research expects that LVNL is more likely to learn from runway incursions classified as category A and B incidents than category C and D incidents. As the perceived risk is greater for category A and B incidents, learning should be stimulated.

5.1 Results per case

To analyze the learning from the various categories of incidents, each runway incursion is addressed separately. The focus lies on learning that has taken place within the timeframe. A detailed overview of the results of the document analysis is found in *Appendix D*.

5.1.1 Case A1: Boeing 757-2Q8

In response to the runway incursion on 19 December 2004, the Dutch Safety Board made seven recommendations to LVNL. The recommendations made by the DSB in their investigation report regard infrastructural, technical and organizational factors. Of the recommendations, two corresponding measures were implemented within the timeframe.

A pilot deviation caused the runway incursion. The flight crew of the Boeing 757 took a wrong turn at an intersection while taxiing to the Zwanenburgbaan. Consequently, the Boeing entered runway 36R[6]. The first recommendation made by the DSB was to adjust the entrance to runway 36R/18L via E4. In response to this recommendation, Schiphol adjusted the layout of intersection E4 within two years after the incident, 'allowing for better oversight and emphasis on leaving taxiway Bravo' (DSB 2010a).

Second, the DSB recommended addressing complex taxiways and traffic situations on aerodrome charts. In 2005, LVNL launched a campaign to 'make pilots aware of specific risk areas' (LVNL 2006). To comply with the full extent of the recommendation, hotspots were subsequently published on aerodrome charts (LVNL 2019a). The aerodrome chart alterations took place between 2004-2010. Unfortunately, the exact year is unknown.

Additionally, LVNL has responded to two recommendations with justifications as to why measures were not implemented. For one, regarding the intervention by supervisors, LVNL responded to this recommendation by arguing that it is not the task of a supervisor to

[6] For more insight into airport layout and runway intersections see *Figure A-6* and *A-7* in *Appendix E: Airport layout.*

intervene. Rather, LVNL testified that supervisors are in charge of managing operational processes in the control tower (DSB 2010a).

Second, LVNL did not implement measures corresponding to a recommendation regarding the obstruction of sight of runway controllers in the control tower. The DSB established that visual barriers limited the ability of the runway controller to prevent the RI. According to LVNL, 'window obscuring is not considered a real problem' (DSB 2010a).

5.1.2 Case A2: Cessna Citation II

In response to the runway incursions on 29 December 2009, the Dutch Safety Board made three recommendations to LVNL. The recommendations made by the DSB in their investigation report regard infrastructural, technical and organizational factors. Of the recommendations, two corresponding measures were implemented within the set timeframe.

Case A2 involved two towing combinations and one aircraft. The incident is classified as an operational incident. LVNL overlooked the second towing combination crossing runway 04/22 when clearing the Cessna Citation II for landing. The towing vehicles were en route to Schiphol Oost. A first measure implemented for LVNL regards the location of runway and reachability of hangars at Schiphol Oost. Due to the location of runway 22 and the existing infrastructure of Schiphol Airport, runway 04/22 needs to be crossed to reach the hangars. Following the incident, intersection G3 towards Oostbaan was closed permanently. This aimed to reduce the frequency of clearance being provided to towing vehicles on an active runway.

Second and last, LVNL implemented a measure to deal with the incorrect following of procedures for double runway presence. The Dutch Safety Board found that these procedures are sometimes subject to different interpretations. For this reason, LVNL developed the program "Duidelijkheid in Veiligheid" in 2011 (LVNL 2012). This program ran until 2016 and focused on ensuring closer alignment of designed operational procedures and actual practice (LVNL 2019c).

5.1.3 Case B1: Boeing MD-11

In response to the runway incursion on 28 May 2005, the Dutch Safety Board made three recommendations to LVNL. The recommendations made by the DSB in their investigation report regard technical and organizational factors. No measures were implemented in response to this runway incursion.

Case B1 involved one aircraft and a bird control vehicle. LVNL granted takeoff clearance to the Boeing MD-11 from runway 06/24, while a bird control vehicle was still on the runway. This runway incursion is classified as an operational incident. The recommendations by the DSB were directed towards gaining more insight into the location of vehicles.

Whereas no measures were implemented in this regard, LVNL does justify not acting upon one recommendation by the DSB. This recommendation regards the intervention by supervisors. Again, as in case A1, LVNL testified that supervisors are in charge of managing operational processes, rather than intervening in the work of air traffic control employees.

5.1.4 Case B2: Boeing 737

In response to the runway incursion on 28 May 2007, the Dutch Safety Board made three recommendations to LVNL. The recommendations made by the DSB in their investigation report relate to campaigns and infrastructural factors. No measures were implemented in response to this runway incursion.

This runway incursion occurred because the crew of the Boeing 737 misinterpreted ATCO instructions to leave the runway at the end. Consequently, the Boeing 737 entered runway 36R. RI B2 is, therefore, the result of a pilot deviation. The recommendations by the DSB aimed to reduce the number of incorrect crossings at the end of the runway, at the runway end lights.

Additionally, LVNL justifies not acting upon one recommendation by the DSB. Namely, to implement a physical barrier at the end of runway 06/24. According to LVNL, a physical barrier should not be implemented because it is common for traffic destined for Schiphol-Oost to taxi over these runway end lights (DSB 2010d, 5).

5.1.5 Case C1: Cessna 510

In response to the runway incursion on 10 September 2009, the Dutch Safety Board made two recommendations to LVNL. The recommendations made by the DSB in their investigation report relate to campaigns and infrastructural factors. No measures were implemented in response to this runway incursion.

Case C1 involved two aircraft and was the result of a pilot deviation. The crew of the Cessna 510 misinterpreted ATCO instructions and taxied onto runway 04/22. The recommendations made by the DSB were aimed at preventing such incorrect entrance from happening.

Whereas no measures were implemented in this regard, LVNL does provide a general justification for not acting upon the measure "to ensure compliance with ICAO-standard radio terminology". According to LVNL, air traffic control may deviate from this terminology when deemed necessary, for example, to enhance the clarity of instructions (DSB 2017, 14).

5.1.6 Case C2: Boeing 737

In response to the runway incursion on 12 January 2014, the Dutch Safety Board made seven recommendations to LVNL. The recommendations made by the DSB in their investigation report regard technical and organizational factors, as well as cooperation between sectors. Of these seven recommendations, four measures were implemented within the timeframe for learning.

Air traffic control granted a Boeing 737 takeoff clearance from runway 06/24 while a bird control vehicle was still on the runway, to whom he had granted clearance earlier. Because air traffic control granted this clearance, runway incursion C2 is classified as an operational incident. The first recommendation by the DSB was to change the driving direction of bird control vehicles *towards* departing and landing aircraft. This measure aims to increase situational awareness of pilots and drivers and was implemented in 2015.

Second, LVNL implemented an official procedure for runway-occupied strips in 2014 (DSB 2016) At the time of the incident, air traffic control was not required to use the runway-occupied strips. This measure was expanded upon in 2018, four years after the incident. Preparations were started in 2016 to digitalize these strips: Electronic Flight Strips (EFS). The implementation of EFS is classified as "delayed implementation" due to the lengthy implementation procedure. EFS are a useful next step. They add to serenity of tower because physical passing of papers etc. is no longer required (LVNL 2019b).

Third, with these runway-occupied-strips, air traffic control can, in addition to seeing that a runway is occupied, see by how many aircraft or vehicles. This through placing of two (or more) strips in the runway bay (LVNL 2017). By implementing this measure, LVNL addressed the recommendation to adapt the runway occupied signaling system to register multiple subjects.

The fourth measure that LVNL implemented within the timeframe relates to cooperation. The DSB found that parties do not sufficiently cooperate to address safety concerns. In 2008, LVNL, together with other parties initiated the Schiphol for Safety program. This program stimulates a proactive safety culture (AAS 2019).

Additionally, LVNL has responded to two recommendations with justifications as to why measures are not implemented. First, regarding the effectiveness of the signaling function of the runway occupied signaling system. According to LVNL, ‘there has for a long time been a discussion regarding the effectivity and usability of the system’ (DSB 2016, 21). Based on the December 2019 data, no decision has been made regarding the signaling system.

Second and final, the DSB and sector parties plead for the implementation of OROFOL (One Runway, One Frequency, One Language). OROFOL entails a shift where bird control operates on the “main” runway radio frequency, together with pilots and air traffic control. One of the benefits mentioned by pilots is that OROFOL can enhance situational awareness for flyers, for example when bird control communicates that he has unexpectedly stopped on the runway (DSB 2016). Accordingly, communication between bird control and the Airside Operations Manager would have to take place in English rather than Dutch, which is the current status quo. Justifications by LNVL regard the unfavorable necessity to change related procedures, and overcrowding of the already crowded main frequency (DSB 2016).

5.1.7 Case D1: Boeing 767

In response to the runway incursion on 23 September 2004, the Dutch Safety Board made four recommendations to LVNL. The recommendations made by the DSB in their investigation report relate to campaigns as well as infrastructural and organizational factors. Of the recommendations, one corresponding measure was implemented within the set timeframe.

This runway incursion occurred because a Boeing 767 crossed active runway 04/22 without clearance. Because the crew misinterpreted ATCO instructions, case D1 is classified as a pilot deviation. The incident involved only one aircraft. The only measure that LVNL implemented is an awareness campaign. LVNL launched a radio-telephony awareness campaign in 2005 (LVNL 2006), in response to case D1. This awareness-campaigns sought to stimulate compliance with ICAO-standard radio terminology for taxi instructions.

LVNL did not provide justifications for not learning.

5.1.8 Case D2: Airbus A320

In response to the runway incursion on 13 June 2015, the Dutch Safety Board made two recommendations to LVNL. The recommendations made by the DSB in their investigation report refer to organizational factors. One measure was implemented within the timeframe.

Runway incursion D2 is classified as an operational incident. LVNL granted takeoff clearance to the Airbus A320, from runway 18L/36C which the Airside Operations Manager had not made available to air traffic control (DSB 2015a). The incident involved only one aircraft. The recommendation by the DSB relates directly to the complex procedure at AAS, where control and responsibility of runways continuously shifts between LVNL and AAS, depending on the runway status. Since 2016, all runway crossings are coordinated by LVNL, regardless of the status of a runway (LVNL 2017).

5.2 Trends

From the Dutch Safety Board incident reports, 31 recommendations for LVNL were gathered. Section 5.1 displays that from these 31 recommendations, 10 corresponding measures were implemented within the three-year timeframe for learning.

For six recommendations, measures were implemented outside of this timeframe. Learning can thus not be ascribed to the specific case study.

In response to another six recommendations, LVNL justified not learning. Of the remaining nine recommendations, two measures are planned or under consideration. The rest is not implemented.

Table 6 below presents the division of recommendations for runway incursion categories A-D, as well as a total sum of measures identified per category.

Table 6. Division of recommendations per category, for incursion categories A-D.

Recommendation	A	B	C	D	Total
Campaign	0	2	1	1	**4**
Infrastructure	4	1	1	1	**7**
Technical	2	2	2	0	**6**
Organizational	4	1	3	4	**12**
Cooperation	0	0	2	0	**2**
Total	**10**	**6**	**9**	**6**	**31**

The majority, namely 39 percent of all recommendations fall within the organizational category, referring to both organizational processes and procedures.

5.3 Conclusions

The results indicate that LVNL does not learn from all recommendations made by the Dutch Safety Board. LVNL learning from 10 out of 31 lessons.

To say that LVNL has learned from an incident, we need to look at the definition of organizational learning. In Section 3.1, organizational learning is operationalized as "the implementation or adjustment of measures, and/or other (policy) changes". Following this definition, learning takes place when there is a change in behavior. Organizational learning is operationalized on the general, incident level. In five out of eight cases, *at least* one lesson is implemented. For these five cases, a change in behavior has thus occurred. More specifically, LVNL has learned from five of the eight runway incursions studied in this research namely: AI, A2, C1, D1, and D2.

Overall, it is evident that learning differs greatly among the case studies. Despite that this study expected that learning would take place from category A or B incidents, this was not entirely the case. Learning did take place in the two category A cases, but no measures were implemented following the category B cases. Contrary to the hypothesis learning did take place following both category D cases and one category C case.

What is learned also varies per incident. The lessons distilled constitute a different combination of recommendations for each runway incursion within the five categories: campaign, infrastructure, technical, organizational and cooperation. Commonly, the recommendations are divided into two or three different categories. Only for case D2 are the recommendations solely "organizational". With 12 out of 31 recommendations, the majority of all recommendations fall within the organizational category. Lessons distilled regarding organizational factors were recommended in six out of eight case studies. Similarly, recommendations regarding infrastructural factors are common in the case studies. Lessons distilled regarding infrastructure are present in five out of eight case studies. Both organizational and infrastructure recommendations are present in categories A, B, C, and D. Based on these results, there are no significant differences between what is learned from incidents in category A, B, C and D. This variation in learning will be analyzed and discussed in the following chapter, Chapter 6.

6 Discussion

In this chapter, the results of the conducted research are analyzed and discussed. Again, this study hypothesizes that LVNL is more likely to learn from category A or B incidents, than category C or D incidents. The findings of the study indicate that LVNL learns from some incidents, but not all. Within the sample, learning always takes place following category A and D incidents, but not from category B and C incidents. Therefore, only part of the hypothesis holds: learning from incidents in category A - the category with the highest associated risk - is likely.

The relation between the severity of the incident and the extent of learning cannot be confirmed based on the results presented in Chapter 5. Closer examination of the cases is required to make substantiated inferences about runway incursions as learning triggers. Hence, all runway incursions are critically examined, to identify what lessons are not learned. Potential explanations will be provided for the variation in learning.

6.1 How much is learned

The previous chapter demonstrates that there exist no significant differences within categories between *what* is learned, in terms of types of lessons. Therefore, the content of the recommendations cannot sufficiently explain the difference in learning between categories A-D in this study.

A more thorough examination of the cases presents evidence of a difference between *how much* is learned. *Table 7* provides an overview of the lessons distilled and implemented for each case study, and per category.

Table 7. Lessons distilled and implemented per case, derived from Appendix D.

Case	Distilled	Implemented	Percentage	No learning	Whereof justification
Category A	**10**	**4**	**40%**	**6**	**2**
A1	7	2	29%	5	2
A2	3	2	67%	1	0
Category B	**6**	**0**	**0**	**6**	**2**
B1	3	0	0	3	1
B2	3	0	0	3	1
Category C	**9**	**4**	**44%**	**5**	**2**

C1	2	0	0	2	(1 general)
C2	7	4	57%	3	2
Category D	**6**	**2**	**33%**	**4**	**0**
D1	4	1	25%	3	0
D2	2	1	50%	1	0

As seen prior, no learning follows from cases B1, B2, and C1. When ascribing learning based on individual lessons distilled, rather than the case as a whole, learning furthermore does not take place following all recommendations in cases A1, A2, C2, and D1. Learning on an entity level is highest for A2 (67 percent) and C2 (57 percent).

Overall, category A is good for learning in 40 percent of the recommendations, LVNL does not learn from any recommendation in category B incidents, 44 percent of the recommendations in category C, and 33 percent of the recommendations in category D.

6.2 When learning does not take place

To explain the difference in learning across-cases, it is relevant to analyze in what instances LVNL does not learn. Therefore, in this section, each case study is examined. As Chapter 5 presented when LVNL learned or justified their choices for not learning, this section focusses specifically on when LVNL did not learn.

6.2.1 Case A1: Boeing 757-2Q8, 2004

There are three recommendations after which LVNL did not learn, nor provide a justification. First, the recommendation to enhance the effectiveness of markings and signage, as this ‘contributes to successful monitoring by air traffic control’ (DSB 2010a). The Dutch Safety Board deemed the lack of clarity of entrance E4 to the Aalsmeerbaan the most prominent cause of incident A1. Adjusting the markings and signage can enhance clarity for aircraft. Measures were implemented outside of the timeframe. Only six years later, in 2010 and 2011, AAS installed additional ground markings and signage in the (AAS 2011; AAS 2012) to enhance the clarity of the aerodrome.

Second, LVNL did not learn from the recommendation to reduce the workload for ground controllers. The DSB makes the same recommendation in another incident within this sample. This is explained in case D1 (Section 6.2.7)[7].

Third, no data was found regarding the use of the designated taxi routing names. LVNL may have disregarded this recommendation, as it was not made by the Dutch Safety Board or the LVNL's investigative board, rather Cabo Verde Airlines (DSB 2010a).

6.2.2 Case A2: Cessna Citation II, 2009

There is one recommendation after which LVNL did not learn, nor provide a justification. Measures were implemented outside of the timeframe. Namely, LVNL did not learn following the recommendation to address the inability of air traffic control to verify vehicle locations at all times. In this incident, the air traffic controller could not visualize a bird control vehicle. According to the report, 'when the controller lost sight of the vehicle at the end of the runway' the occupation sign was switched off (DSB 2010c, 1). This measure focusses on increasing the visibility of ground vehicles, such as bird control and towing vehicles. Within the sample, it is the second time that LVNL does not learn from this recommendation.

Nine years later, in 2018, Schiphol airport and its partners are considering the implementation of navigation and surveillance systems in ground vehicles (ISMS 2019). Before a measure can be implemented, studies need to be conducted regarding the effectiveness of the measure under review. This recommendation receives the status "Under consideration" in this study as it is not implemented as of December 2019.

6.2.3 Case B1: Boeing MD-11, 2005

There are two recommendations after which LVNL did not learn, nor provide a justification. In both cases, the DSB makes the same recommendation in a later incident within this sample. The recommendations refer to the inability to verify vehicle locations explained in case A2, (Section 6.2.2), and the ineffectiveness of the runway occupied signaling systems in case C2, (Section 6.2.6).

[7] Because lessons are ideally only ascribed to one incident, the results of the study (for this recommendation) are only presented in the last incident, case D1, to prevent contamination of results.

6.2.4 Case B2: Boeing 737, 2007

There are two recommendations after which LVNL did not learn, nor provide a justification. First, LVNL did not address the different experiences of air traffic control and pilots regarding the crossing of runway end lights (DSB 2010d). At Schiphol Airport, it is not uncommon to cross the runway end lights at RWY 06/24. However, not all pilots flying on Schiphol Airport are familiar with this procedure. In this instance, learning took place outside of the timeframe for learning. Namely, in 2016 pattern B marking is applied at the runway thresholds S7/S8/E6/V4. Pattern B marking is used to demarcate a holding position near a runway. It is hoped that this marking prevents double occupation of runways (DSB 2017), as aircraft have to stop at pattern B marking and wait for ATC clearance to cross (SKYbrary 2019b).

Second, the recommendation to ensure compliance with ICAO-standard radio terminology. The DSB makes the same recommendation in a later incident within this sample. This is explained in case C1 (Section 6.2.5).

6.2.5 Case C1: Cessna 510, 2009

There is one recommendation after which LVNL did not learn, nor provide a justification. Measures were implemented outside of the timeframe. Namely, the recommendation to implement a permanent in-use stop-bar for entrance G1 at runway 04/22 (DSB 2010e). According to the DSB (2017, 188), some corresponding measures were implemented at a later time. More specifically, LVNL launched an awareness campaign concerning entrance G1. Also, runway guard lights are installed at G1 to enhance the visibility of the holding position at G1 (DSB 2017). Based on data from the Knowledge and Development Centre (2010), AAS was to install the runway guard lights in 2014, five years after the incident.

6.2.6 Case C2: Boeing 737, 2014

There is one recommendation after which LVNL did not learn, nor provide a justification. Namely, the recommendation to enhance the position of the Runway Safety Team (RST). The RST is an advisory body within the Schiphol Safety Platform (SSP) charged with reducing the number of runway incursions (LVNL 2019a). The Dutch Safety Board concluded that the existing authority of the RST is too limited, and therefore doing injustice to the aim of the RST (DSB 2016). Their position can be enhanced by enforcing more decision making power. According to the Dutch Safety Board, at two airports similar to Schiphol, namely London and Frankfurt, the respective Runway Safety Teams do have a strengthened position, which is seen as value-added (DSB 2017). A review of data demonstrates that Schiphol airport placed the strengthening of the position of the RST on the agenda in 2018 (AAS 2018). It is not known if and when this will be implemented.

6.2.7 Case D1: Boeing 767, 2004

There are three recommendations after which LVNL did not learn, nor provide a justification. In two instances, measures were implemented outside of the timeframe. First, the revision of taxiway names. In case D1, the taxiway names were confusing regarding "G5". Considering that G5 is the name of two taxiways and three holding points near Oostbaan (DSB 2010f), it is understandable that the Boeing 767 misinterpreted the instruction to taxi to taxiway G5, instead of holding point G5. According to the ISMS (2019), the goal of this measure is to 'improve consistency and reduce the likelihood of errors, due to similar or confusing naming conventions (n.p)'. This should be implemented in 2020. This recommendation receives the status "Planned" in this study as it is not implemented as of December 2019, but is expected to be soon.

Second, LVNL did not address the inability of ground controllers to monitor all movements of aircraft. The monitoring of aircraft means following the aircraft while taxiing, for example to the assigned gate or runway. According to the DSB (2010a), it is not uncommon for ground controllers to be unable to monitor all aircraft while taxiing, due to the high numbers of aircraft under their control daily. In spite of this, the current monitoring capacity is deemed insufficient. LVNL added a third ground controller in 2016 (DSB 2017), to keep up with growing traffic levels. The addition of a third controller indicates that between the publication of the case A1 report and the addition of the third controller, LVNL added a second controller to the permanent capacity of air traffic control. As traffic levels at AAS are expected to grow in the near future, Schiphol Airport and its partners are planning to implement "follow-the-green" (lights) in 2026. These lights are intended to guide aircraft along their assigned taxi routes (NLR 2018), further reducing the necessity of ground controllers to monitor the movement of aircraft.

Additionally, for one recommendation, the DSB makes the same recommendations in a later incident within this sample. Namely, to transfer traffic to the frequency of the runway controller, when crossing an active runway. This is explained in case D2 (Section 5.1.8).

6.2.8 Case D2: Airbus A320, 2015

There is one recommendation after which LVNL did not learn, nor provide a justification. Namely, the recommendation to record all conversations in the control tower (DSB 2015b). No data was found regarding this recommendation.

6.2.9 Findings

From the closer review of the cases, two main conclusions can be drawn:

1) When looking at the categories as a whole, it becomes clear that most recommendations are made by the Dutch Safety Board for category A. Learning is relatively low.
2) In many instances, rather than not learning, lessons are implemented at a later time, outside of the timeframe related to that particular incident.

These findings will be explored in Section 6.3.

6.3 What can explain the findings

First, the results show that LVNL learns from both incidents in category A. The expectation was that the necessity to learn from incidents in runway incursion category A may be inherent to this particular type of incident. According to the ICAO severity classification scheme, category A incidents entail the highest level of risk compared to B, C, and D. Because this risk is the highest, learning may be deemed of higher necessity than for the other categories.

Additionally, when looking at the individual recommendation level, Category A is good for 10 out of 31 recommendations (see *Table 7).* Section 6.2.8 demonstrates that relatively little is learned from the sum of recommendations in category A, albeit being this largest group of recommendations. Namely, only 40 percent of the recommendations.

On the one hand, this finding can be explained by the failure of LVNL to recognize the necessity to learn. The research shows that the necessity to learn from incidents in category A is recognized by the Dutch Safety Board, as they provide many lessons distilled. This necessity is not matched by the actions of LVNL. Only a few lessons are implemented on their behalf. More specifically, six lessons distilled are not implemented. The limited lessons implemented can indicate that LVNL does not recognize the necessity to learn to the same extent as the DSB. For example, it may be the case LVNL has decided that it is not necessary to implement measures under the current circumstances. According to *Table 7*, from these six instances, LVNL justifies for not learning twice.

More specifically in case A1 regarding window obscuring:

> 'In view of the Corporate Quality & Safety/Incident Investigation department of LVNL it is not considered as a real problem, however, it may occasionally obscure whatever is behind it (DSB 2010a, 5).'

In case A1 regarding tower supervision:

> 'The tower supervisor is an on duty air traffic controller with additional authority to supervise. Generally, he is an experienced controller. It is not a requirement for him to be present in the tower control room at all times. LVNL indicates the supervisor manages the operational process and it is not the task of the supervisor to act as a safety net in the first place. (DSB 2010a, 4-5).'

Both examples provide evidence of justifications where "Necessity" is the main explanatory mechanism. Specifically, these sections are underlined.

On the other hand, there could be an alternative explanation for the relatively low learning on the recommendations level in category A. For example, it may be the case that it is not possible to implement measures under the current circumstances. In all instances, an alternative explanation, such as those described in Section 6.5 may apply. Within the incident reports, no explicit evidence is found hereof.

In sum, LVNL's learning from incidents in category A can be explained by the severity classification (i.e. incident category). The relatively little learning on recommendations level can be the result of both necessity and alternative explanations. It is important to note that this explanation does not have to be limited to category A, and rather may apply to learning as a whole.

Second, the review of the cases made apparent that in many instances, lessons are implemented more than three years after the incident, which is the timeframe for learning in this thesis. In this study, learning outside of the timeframe occurs when the status is either "Delayed" or "Planned" (see *Appendix D*). Measures "Planned" constitute a distinct category from "Delayed" to indicate that measures have not been implemented as of December 2019, but will be implemented soon according to plan. Both the status "Delayed" and "Planned" indicate that lessons are (almost certainly) implemented outside of the timeframe. According to section 6.2, delayed learning happens seven times within the cases selected for this study, across all RI categories.

There are two explanations for delayed learning[8]. On the one hand, it can mean that learning takes longer than the timeframe selected in this study. For example, when it takes

[8] Delayed here refers to learning at a later time, rather than the specific category "Delayed".

LVNL four years to implement changes, rather than the three years that have been assumed as the timeframe for learning. In this sense, learning still takes place in direct response to the case under review. Strictly speaking, the implementation then does not fall within the timeframe, thus no learning takes place. In this study learning within the timeframe is expressed through the status “Implemented”. An example of this first version of delayed learning is found in case C2, regarding the implementation of Electronic Flight Strips. The incident took place in 2014, preparations for EFS began in 2016, and the implementation took place in 2019. The time of the implementation was influenced by a lengthy implementation procedure, testing and its dependence on the restructuring of the control-tower, which took place in 2018/2019 (LVNL 2019d).

On the other hand, delayed learning can mean that learning takes place at any later moment in time. It does not say anything about whether or not LVNL investigated the recommendation following the initial incident. When LVNL learns at a later time, this may still correlate with the initial recommendation. Conversely, learning can no longer be ascribed to the case under review, unless proven otherwise, as presented above. For example, the learning that takes place may be the result of other occurrences or inputs at a later time. The measure corresponding to the initial recommendation is then implemented outside of the initial timeframe for learning. An example of this second version of delayed learning is found in case DI, regarding the reduction of workload of ground controllers. The incident took place in 2004, LVNL added a second ground controller only after 2010. Case D1 may have influenced this learning, but learning cannot be ascribed to case D1.

Moreover, cross-case analysis demonstrates that several recommendations are found multiple times throughout the case studies. More specifically, according to section 6.2, recommendations are repeated in a later incident five times within the cases selected for this study, across all RI categories. It is highly likely that when reviewing *all* incident reports, the actual numbers are much higher. For example, the recommendation regarding the strengthened position of the RST in case C2. In the corresponding incident report, the DSB states that it had made the same recommendation in 2013, after an incident outside of this study (DSB 2016, 29).

This finding supports the argument that multiple incidents are necessary for LVNL to learn. On all five occasions, LVNL did not implement any measures the first time the recommendation was made. Thus, LVNL has not learned.

Within the cases used for this study, only once is there evidence that learning took place after the DSB made a recommendation a second time. This regards the recommendation that is initially made in case D1 (2004) to ‘transfer traffic to the runway controller frequency to obtain clearance for crossing an active runway’. LVNL did not learn from this lesson distilled within the timeframe for learning. In case D2 (2015), the DSB made the same recommendation. Within a year, LVNL adjusted the procedure accordingly (LVNL 2017). Aside from the cases within this study, there is evidence that the existing procedure has long been an issue. In 2012, nine category D runway incursions took place on one day, after nine aircraft departed from an unavailable runway (DSB 2015a). The Dutch Safety Board made similar recommendations following these incidents.

More often, LVNL did not implement any measures after the first incident, nor the second incident. An example hereof is the recommendation initially made in case B1 (2005) to ‘address the ineffectiveness of the signaling function of the runway occupied system’. LVNL did not learn, nor provide a justification. The same recommendation was made following case C2 (2014). This time, LVNL provided a justification for not learning. Namely, that no solution was found for the problem, and that there had long been a discussion within LVNL regarding ‘the effectiveness and usability of the system’ (DSB 2016, 21). Again, no lessons implemented were found corresponding the second time the DSB made the recommendation. In this sense, no learning takes place at all. Because LVNL did not address the lesson distilled initially, irrespective of the nature of the justification, a new incident could take place. If the same recommendation is made again after 2014, LVNL may learn.

In sum, when the same recommendation is made multiple times, LVNL has likely not learned the first time[9]. The frequent occurrence of delayed learning of LVNL can be explained partly by longer implementation processes, and/or the fact that learning requires multiple events. Because evidence of delayed learning and repetition of recommendations is found across all categories, it is not likely that the RI category influences this finding.

6.4 How does this relate to biases

Although biases are difficult to study, this research expects that outcome bias, hindsight bias, and association are explanatory mechanisms for learning from near-misses. Although the hypothesis for this research does not hold entirely, biases can nevertheless explains several elements.

[9] It is important to consider that lessons implemented do not always have the desired effect (DSB 2017, 106). If this happens, new incidents can occur, regardless of LVNL’s efforts.

First, this thesis understands the outcome bias as 'the idea that learning is not necessary because a near-miss is a success, rather than a failure' (Dillon and Tinsley 2008). The outcome bias holds a negative relationship with learning, meaning that learning does not take place because of the outcome bias. This can apply to runway incursions within all categories because runway incursions all yield a positive outcome.

In this respect, this thesis argues that the lessons that are not implemented can be explained by the outcome bias. This applies to cases B1, B2, and C1, but also individual recommendations. According to the outcome bias, LVNL evaluated the incident solely based on the outcome. In all cases, the outcome of the runway incursion was positive, because collision was prevented and no individuals were harmed. The process by which the runway incursion took place is then not subjected to closer examination or evaluation, and learning is not considered a necessity.

As seen prior, there are six instances within this study where LVNL provided a justification for not implementing any measures, in cases A1, B1, B2, and C2. For the two justifications in case C2 "feasibility" was coded, indicating that LVNL argued that under current circumstances, they cannot implement the measure. These examples should thus be omitted for this section. All remaining justifications fall within RI categories A and B. These justifications can support the argument for outcome bias. The two justifications for case A1 are reviewed prior, in section 6.3. Additionally, in case B1 regarding tower supervision, the justification is as follows:

> 'The tower supervisor is an on duty air traffic controller with additional authority to supervise. Generally, he is an experienced controller. It is not a requirement for him to be present in the tower control room at all times. LVNL indicates the supervisor manages the operational process and it is not the task of the supervisor to act as a safety net in the first place.' (DSB 2010c, 2)

In case B2 regarding to physical barriers at the end of Kaagbaan:

> 'It is not unusual for traffic landing on runway 06 destined for Schiphol-Oost to be given the instruction to taxi over the runway end lights.' (DSB 2010b, 5)

All four examples provide evidence of justifications where "Necessity" is the main explanatory mechanism. Specifically, these sections are underlined. The justifications demonstrate that LVNL does not see the necessity to adjust existing procedures and systems. For example, in the B2 justification, according to LVNL it is "not unusual to do so". In spite of it being common practice, it does not necessarily mean that this is not a potential trigger for a future incident or accident. Despite the warnings by the DSB that what is being recommended is an issue or potential trigger for a future incident or accident, LVNL looks only at the positive outcome of the incident. Based on the evidence in this study, outcome bias is applicable to all RI categories.

Second, this thesis understands hindsight bias is the 'tendency to overestimate one's ability to foresee the outcome of an incident (Encyclopaedia Britannica 2019)'. The present warning signs that indicate that an incident or accident can occur in the future are only recognized in hindsight. The accident element, which is stressed by Dillon and Tinsley as a prerequisite to recognizing the warning embedded in near-misses does not apply to this study, because accidents are not a subject of study. Focusing on the realization of warning embedded in prior near-misses captures the essence of the concept. Hindsight bias holds a negative relationship with organizational learning. This can be applicable to runway incursions within all categories.

In this respect, this thesis argues that delayed learning observed across the case studies can be explained by hindsight bias. Specifically, the second explanation of delayed learning, where learning takes place outside of the timeframe for learning. This applies to recommendations within cases A1, A2, B2, C1, C2, and D1.

In the case of hindsight bias, it is the realization, in hindsight, that the organization missed a warning. For this study, this is best explained by the repetition of recommendations across-cases. Specifically, the recommendation on the responsibility for clearing aircraft and vehicles to cross active runways in cases D1 and D2 provides a good example. In this example, case D1 presents multiple warning signs for potential new occurrences, represented by the DSB's specific lessons distilled. These lessons are noticed, but not acted upon. The occurrence of incident D2, many years later, demonstrated that warning signs were ignored. Upon the realization of failure to learn, this is subsequently acted upon.

In this sense, learning takes place at a later time. It is possible that this explanation also applies to delayed learning where no repetition of recommendations was found within the study's cases. However, it is more difficult to substantiate this based on the evidence presented in this study. Nevertheless, it is likely that, similarly, other occurrences triggered learning for LVNL. Based on the evidence presented in this study, this is commonly after another runway incursion takes place, independent of the RI incident category.

Finally, this thesis understands association as 'the need to associate near-misses with a certain risk or danger, to fully recognize a near-misses' potential for learning (Madsen et al. 2016)'. Hindsight bias may seem similar to association in the sense that for both biases, Dillon and Tinsley found that earlier occurrences lead to learning. This study demonstrates that for association, learning relates to the type of event (i.e. catastrophic incident) rather than prior occurrences. Association holds a positive relationship with organizational learning. The literature review expects that association is most likely in category A (and B) incidents.

When linking association with the results of this study, the learning of LVNL that followed from incidents in category A can be explained by association. In catastrophic incidents, the separation between aircraft (or aircraft and vehicle) is minimal (see *Figure 1*). The risk for collision is thus relatively high in such situations. Because of the association with high risk or other serious events that led to less favorable outcomes, it is more likely that LVNL learns from these incidents. This thesis argues that the same holds for the relatively high number of recommendations for category A (as discussed in Section 6.3). Because the Dutch Safety Board recognizes the necessity to learn, they explore causes and mechanisms thoroughly, likely leading to the generation of relatively many lessons distilled.

6.5 Alternative explanations

In addition to biases, there are several alternative explanations for the difference in learning from incidents of LVNL. Three possible explanations are provided in this section. It should be noted that other explanations than those provided are plausible.

For some recommendations, LVNL recognizes the necessity or value-added, but they are unable to implement the changes within the timeframe. This can be the result of several things. For one, capacity wise it is impossible to implement all necessary and desired changes or adjustments within the same period. As a result, some changes are attributed a higher priority than others, and may, therefore, be addressed relatively sooner. This prioritization is not limited to measures in this study, but also applies to other developments at the airport. It is possible that rather than dismissing a recommendation, LVNL implements measures at a later time following this “priority list”.

In 2018, the Integral Safety Management System of Schiphol (ISMS) presented a roadmap on its website which visualizes what measures have been taken collectively, are taken and will be in the future. A status is appointed: under study, in progress, or implemented, as well as implementation dates (ISMS 2019). This roadmap does not provide concrete evidence for LVNL’s employment of such modus operand. Nevertheless, it demonstrates a result-oriented approach to safety improvements (LVNL 2018) at AAS, whereby choices are made regarding priority of implementation, in support of this argument.

An example hereof is LVNL’s actions to address the visual barriers in the control tower, as recommended in case A1. LVNL did not consider window obscuring as something to be addressed immediately by LVNL after the incident in 2004. When LVNL renovated the tower in 2018/2019, LVNL adjusted the layout of the tower, and placed cameras to increase visibility (2019b). Now, air traffic controllers can sit closest to the window providing the best views of their work area (LVNL 2018). This demonstrates that, while LVNL did not see the immediate urgency at the time, recommendations can be addressed later nonetheless.

Second, in many, if not all, developments in the domain of airfield operations, multiple stakeholders are involved. In spite of changes being made by or for the benefit of LVNL, LVNL is not the only actor that influences these decisions.

The most important sector parties at Schiphol Airport are the Schiphol group, LVNL, and the airlines. KLM (Royal Dutch Airlines) is often denoted as a distinct stakeholder, as they are the home-carrier, and together with her SkyTeam partners, is responsible for roughly 70 percent of all air movements (DSB 2017). Other important parties include the Human Environment and Transport Inspectorate (ILT), the “Omgevingsraad Schiphol”, the Ministry of IenW and several other ministries (DSB 2017, 153). All the aforementioned stakeholders have their concerns and interests, which can complicate the process of organizational learning for LVNL.

An example hereof is OROFOL, the One Runway, One Frequency, One Language principle. The DSB recommended the implementation hereof in response to case C2. The stakeholders here are identified as AAS, LVNL, airlines (represented by pilots) and the Dutch Airline Pilots Association (Vereniging Nederlandse Verkeersvliegers – VNV) (DSB 2017). Additionally, bird control is influenced by the decisions. In Section 5.1.6, LVNL has provided a justification to the Dutch Safety Board as to why the OROFOL principle has not been implemented at Schiphol. This justification constituted of several arguments made by LVNL and other stakeholders. However, at a meeting of the RST it appeared that the airlines and the VNV favored the implementation of the OROFOL principle (DSB 2017, 25). As of December 2019, the OROFOL principle has not been implemented at Schiphol airport, despite frequent discussions held in the RST, on the topic (DSB 2017). As explained in greater detail in Section 5.1.6, LVNL’s main justifications include the necessity to switch to English and change related procedures. This example demonstrates that LVNL’s learning process can be discontinuous, especially when other stakeholders are involved.

Third and final, other external factors, such as the state of the economy influence organizational learning of LVNL. The economic and financial crisis of 2008 significantly impacted the operations of Schiphol Airport. The number of air transport movements dropped worldwide as a result of this global crisis (AAS 2011, 238). For Schiphol Airport this meant an overall reduction of flights, significantly affecting both the number of passengers and the amount of cargo transported to and from the airport (AAS 2009). These economic developments in turn greatly impacted Schiphol Airport's developments. Many plans were delayed or canceled because the stakeholders did not recognize the necessity and/or there was a lack of resources.

Moreover, in their annual report, Schiphol denotes developments in the domain of politics, economy, laws and regulations, the environment, and the aviation market as other external factors (AAS 2009, 74). This research expects that the influence of the external factors is greatest on infrastructural and technical developments because the associated costs (and stakes) are usually significantly higher compared to for example campaigns.

In the report "Veiligheid Vliegverkeer Schiphol (2017)" the Dutch Safety Board provides an example of such delayed implementation. The realization of taxiway Tango near RWY 06/24 was planned for 2008/2009 but was realized only in 2014 (DSB 2017, 100). According to the Dutch Safety Board, this delay resulted from 'the economic crisis and a lack of urgency felt by the KLM' (DSB 2017, 100). The report proved that the number of runway incursions at this location decreased significantly, following the implementation (DSB 2017). This demonstrates that learning can be hindered by external factors.

6.6 Final remarks

This research shows that LVNL *can* learn from runway incursions, and that association with danger likely stimulates learning. Taking into account the current circumstances in aviation safety in the Netherlands, it is desirable that LVNL learns from *all* runway incursions, and incidents more generally. This research further demonstrates that the positive outcome of a runway incursion influences whether or not LVNL learns, but also that LVNL frequently recognizes the necessity to learn at a later time. Many incidents at Schiphol Airport may be prevented when learning is improved. LVNL must look at how their learning structures can be altered to draw lessons from all incidents, to ensure safer aviation and a safer society.

7 Conclusion

The aim of this thesis was to explore if and why organizations do not learn from all incidents. Existing scholarship has demonstrated that incidents or more specifically, near-misses such as runway incursions, consist of a good opportunity for organizations to learn, as the only difference with accidents lies in the outcome. However, prior research has demonstrated that learning does not follow from all near-misses in aviation. This thesis seeks to identify how runway incursion classification categories influence organizational learning, by focusing on Air Traffic Control the Netherlands (LVNL). Eight runway incursions in the timeframe 2004-2015 are analyzed to answer the research question for this thesis "*How do incident categories influence organizational learning in the case of runway incursions in Dutch civil aviation?".* The hypothesis was that "LVNL is more likely to learn from runway incursions classified as category A or B incidents, than from category C or D incidents. This study expected that biases are the explanatory mechanisms for (not) learning.

7.1 Possible explanation of results

The results of the study show that in the case of Air Traffic Control the Netherlands, learning does not follow from all runway incursions. This is in line with the results of prior research by the Dutch Safety Board concerning safety at Amsterdam Airport Schiphol. Moreover, the results demonstrate that learning takes place mostly from runway incursions within categories A and D. Therefore, only part of the hypothesis holds, namely that learning is likely from incidents classified as a category A incident.

To answer the research question, incident categories can be said to influence organizational learning from runway incursions. This is mostly true for learning from incidents in category A. As discussed in Chapter 6, learning from incidents in category A can be explained by association with higher levels of risk. In addition to this, learning from incidents in categories B, C, and D can be explained by the influence of prior occurrences, from which similar lessons have become apparent. Although the link is not very strong in this thesis, the finding is consistent with hindsight bias. Additionally, the instances where LVNL did not learn can be explained by outcome bias. There were sufficient examples where this is true to assume that in other cases it would hold as well. When we employ other case studies we will likely get results that confirm the theory; thereby reinforcing the strength of the theory's validity.

A possible explanation for why only part of the hypothesis holds might be found in the results of learning from category D incidents. Although hindsight bias can explain learning from category D incidents, based on association bias, it is not likely that learning is more likely for incidents in category D, than B or C. Therefore, it is possible that this is sample bias. The study would need to be repeated with a greater sample to test whether or not this is true.

7.2 Added value

Thus far, organizational learning from incidents has received a lot of attention within existing scholarship. However, there is still a gap in the literature about the potential for learning from near-misses. The literature review of this study has demonstrated that scholars have identified many potential barriers to learning, as the overview by Schillings and Kluge makes clear. This thesis attempted to contribute to the debate on near-misses as learning triggers by exploring specific barriers to learning from aviation incidents.

Another contribution of the thesis is the conduct of qualitative document analysis on the lessons implemented and lessons distilled. By employing qualitative document analysis, and analyzing multiple case studies, this study contributes to the empirical data on organizational learning from runway incursions, and near-misses more generally. The development of a clear theoretical framework and conceptual framework has generated relevant results and can be applied in other contexts.

7.3 Limitations of research

Despite the value-added of this thesis, the study has two main limitations that should be mentioned. First, the number of case studies. The framework has been applied to eight case studies in total. Although this relatively Small-N has positive consequences for the internal validity, the external validity is negatively affected. Consequently, the results, specifically the biases as explanatory mechanisms, cannot be said to hold for all other contexts. Fortunately, the conceptual framework and the variables for the document analysis are not context-specific, and can therefore, be applied to other cases. The number of case studies impacted the outcome of the study, in the sense that the sample size does not account for potential sample biases. An example is that learning took place after both category D incidents, which was unexpected. Nonetheless, relevant conclusions could be drawn.

Second, the availability of data was a limitation of this research. The data that was collected constituted publicly available data. The results of the study may be negatively influenced by this availability because occasionally, minor details, such as exact implementation dates, were difficult to verify. Albeit it is understandable that LVNL, Schiphol

Airport, and other stakeholders did not publish *all* information on carried out, potential and planned measures, because it constitutes a large quantity of data. Notwithstanding, the researcher is confident that the most relevant data was indeed made publicly available, and was findable to a sufficient extent to draw conclusions.

7.4 Avenues for future research

A relevant avenue for future research is to conduct the same study with different or more case studies. Here, only runway incursions at Schiphol airport have been examined. The study can be expanded to other, comparable airports. For example, it would be interesting to explore the learning from near-misses in the case of München airport, or New York JFK. At these airports, the number of runway incursions significantly lower than in the Netherlands. Expanding the study to other contexts, and testing whether the conclusions of this study hold in these contexts can increase external validity, and value added, of the research. Likewise, a repetition of the study with a larger sample can increase internal validity of the research. The analysis of a greater number of case studies, additionally, allows the testing of the falsified aspect of the hypothesis, namely that learning is more likely from category B than D incidents. It can then be confirmed whether this holds, or if it can be explained as sample bias.

Also, this thesis has demonstrated that cognitive biases can be used to explain variation in learning from runway incursions. This study expects that learning increases when people are aware of their vulnerability to biases, or it is known how to alter this behavior. For future research, it would therefore, be interesting to explore if, and how, cognitive biases can be influenced.

7.5 Recommendations

This study has demonstrated that there exists a potential for LVNL to learn from all incidents, but that bias influences LVNL's learning abilities. To ensure the future safety of Schiphol Airport it is important that LVNL and its partners find a way to deal with these biases, and learn from runway incursions more effectively. This requires both elements of learning, namely lessons distilled and lessons implemented. This thesis advises LVNL to make efforts to change the organizational culture to one where learning is triggered not only when incidents involve high levels of risk, but all levels of risk. The case studies for this research illustrate that the value of lessons from runway incursions in a lower category should not be underestimated.

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9 Appendices

Appendix A: Case studies

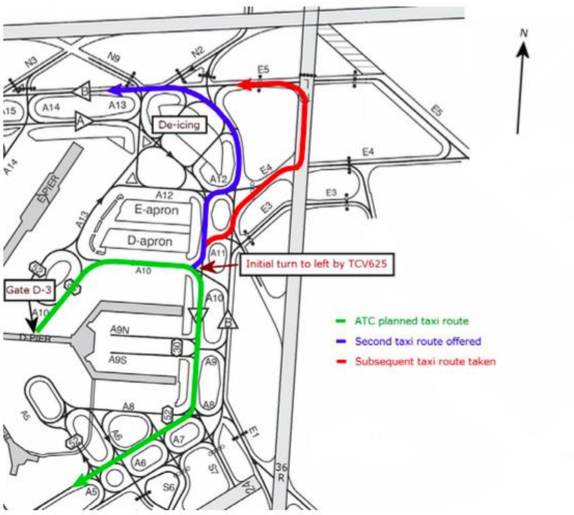
All runway incursions utilized as case studies are explained in greater detail in this appendix. Insight is provided into the situation, main causes and severity classification. The case studies are presented per severity category.

Category A

Case A1: Boeing 737, 2004

On 29 January 2004, a runway incursion took place at Schiphol Airport. While taxiing to runway 36C for takeoff, a Boeing 757 mistakenly entered active runway 36R (DSB 2010a, 2) at E4. This was caused by taking a wrong turn at an intersection. An approaching Boeing 737 was ordered by Air Traffic Control to perform a go-around. The runway incursion has been evaluated as a category A incident by LVNL according to the report of the Dutch Safety Board. It is further classified as a pilot deviation.

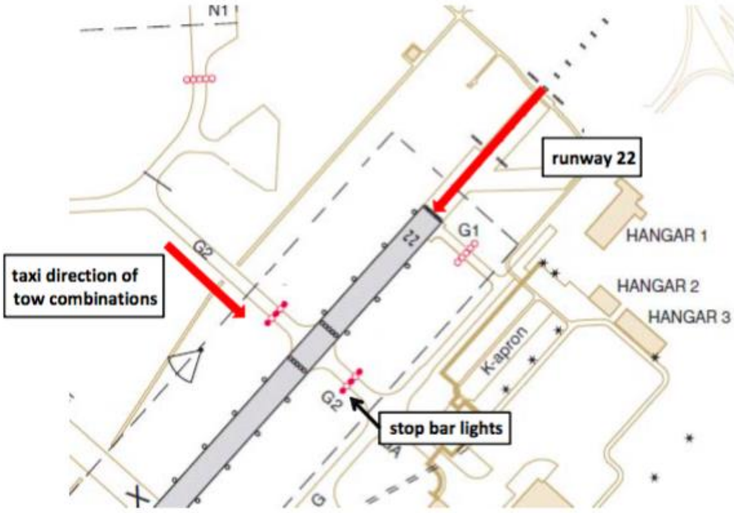
Figure A-1. Planned and actual routs of the Boeing 737 (DSB 2010a).



Case A2: Cessna Citation II, 2009

On 29 January 2009, a Cessna Citation II was involved in a runway incursion at Schiphol Airport. In the incident, two other vehicles were involved: towing combinations with an Airbus A330 (call sign BDD) and a towing combination with an Airbus A330 (call sign AOA). The towing combinations subsequently requested air traffic control for clearance to cross runway 04/22 at G2, which they were granted. At the time landing clearance was provided to the landing aircraft, the second towing vehicle had not yet vacated the runway. The approaching aircraft registered the towing combination and initiated a go-around. Due to the minimal distance between aircraft and towing vehicle, as well as the nature of the corrective action – which took place without interference by air traffic control – this incident can be categorized as a type A incident.

Figure A-2. Visual representation of the close proximity between aircraft and location of crossing towing vehicle (G2) (DSB 2010b).



Category B

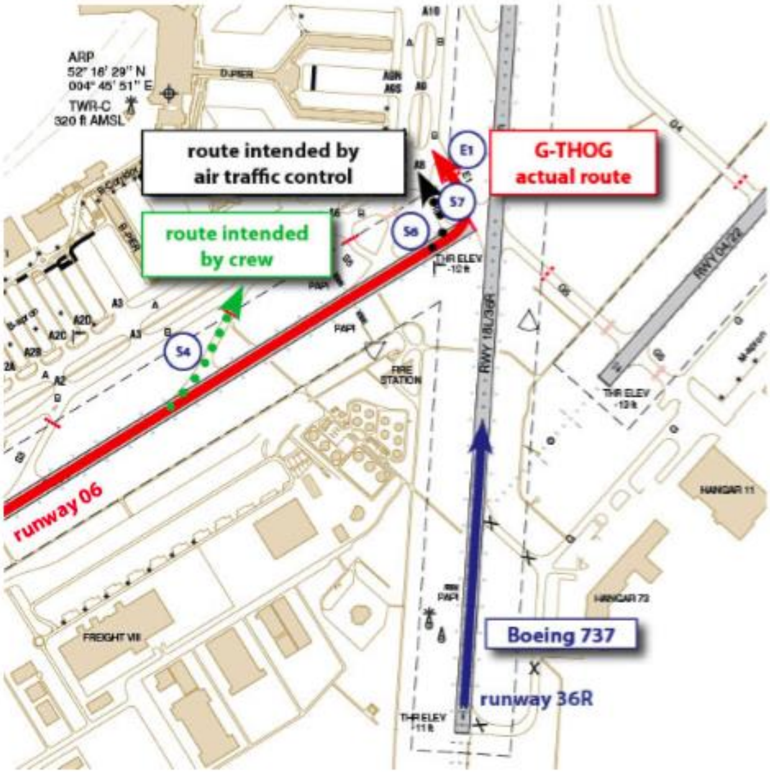
Case B1: Boeing MD-11, 2005

On 28 May 2005, a category B runway incursion took place at Schiphol Airport (DSB 2010c, 4). This involved a Boeing MD-11 and a bird control vehicle. The bird control vehicle had stopped to clear remains off the end of runway 24. Bird control was vacating the runway at the end when the MD-11 passed overhead (2). As both aircraft and bird control vehicle had gained clearance from air traffic control, this incident is classified as a pilot deviation.

Case B2: Boeing 737, 2007

On 8 July 2007 a Boeing 737 with registration G-THOG was involved in a runway incursion at Schiphol Airport. This incident was the result of a pilot deviation. After landing on runway 06/24, the aircraft was requested by air traffic control to leave the runway at the end. These instructions were taken literally when rather than taxiing the exit, the aircraft passed the end of the runway. As a result of this misinterpretation, the Boeing 737 G-THOG entered protected area of the instrument landing system of runway 36R at S7. The necessity to perform a go-around illustrates the potential for collision. Because the aircraft was located ‘close to or on the runway threshold’ (DSB 2010d, 4) it is classified as type B incident, rather than type A or C (See *Figure 1*).

Figure A-3. Intended and actual route of the Boeing 737 (DSB 2010d).



Category C

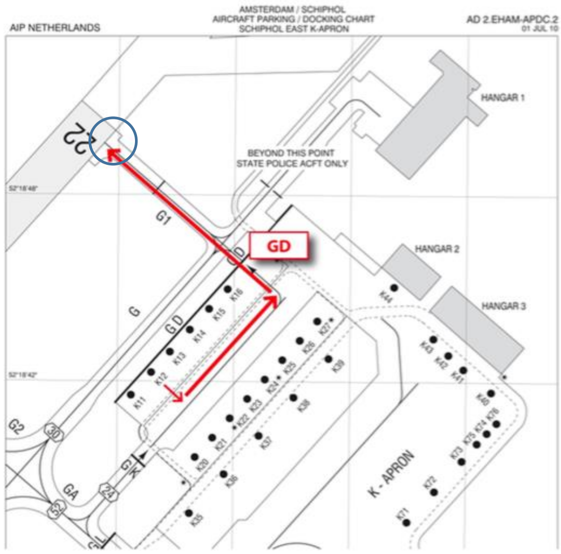
Case C1: Boeing 737, 2014

On 12 January 2014 a runway incursion took place between a bird control vehicle and a Boeing 737 at Schiphol Airport. After waiting for a Boeing 747 cargo aircraft to cross the runway, LVNL granted takeoff clearance to the Boeing 737 from runway 24. However, it had forgotten that a bird control vehicle was still on the runway between S1 and S2, whom had received clearance earlier. LVNL classified the incident as category C (DSB 2016, 14). The incident is further classified as an operational incident.

Case C2: Cessna 510, 2009

On 1 September 2009, a runway incursion took place at Schiphol Airport when a Cessna 510 was taxiing to runway 22 via G1 for takeoff. At this time, the runway was in use for landing aircraft. The crew of the Cessna 510 misinterpreted the instructions of air traffic control ‘to continue to runway 22’ (DSB 2010e) and started to line up. This is understood as a pilot deviation. As there was sufficient time, as well as distance between the landing aircraft and the Cessna 510, this incident is classified as a category C incident.

Figure A-4. Location of the Cessna 510 (DSB 2010e).

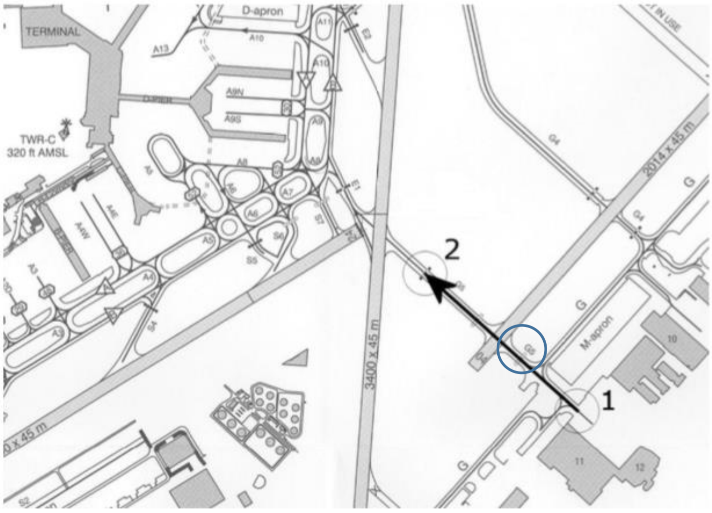


Category D

Case D1: Boeing 767, 2004

On 23 September 2004 a category D runway incursion took place at Schiphol Airport. A Boeing 767 crossed active runway 04/22. The crew of the Boeing had assumed that crossing clearance was granted. However, clearance had been granted to taxi to holding point G5 (See blue circle in *Figure A-6*). Due to this misunderstanding of clearance, the incident is classified as a pilot deviation. As the runway was clear of departing and landing aircraft, there was no risk of collision (DSB 2010f, 1).

Figure A-5. Actual and intended holding position of the Boeing 767 (DSB 2010f).



Case D2: Airbus A320, 2015

On 13 June 2015, a runway incursion occurred with an Airbus A320 at Schiphol Airport. The Airbus took off from runway 18L/36R as ordered by LVNL. After granting takeoff clearance to the Airbus, LVNL realized that the runway was not yet made available by the Airside Operations Manager for use (DSB 2015a). However, as there was no risk of collision, LVNL decided not to abort takeoff. Based on characteristics of the event, as well as guidelines by ICAO - most specifically 'one aircraft only'- this incident can be categorized as type D. It is an operational incident.

Appendix B: Codebook

In this appendix, the codebook as described in Chapter 4 is presented.

Table A-1. Codebook.

Code	Themes and subthemes	Description	Indicators (if applicable) *Coding rules in italics*
	General information		
A	Date	Refers to the publication date of the document.	Date (DDMMYY)
B	Author	Refers to the author of the article. More specifically, the overarching organization, rather than the author of the document.	E.g. Dutch Safety Board (DSB), LVNL, Schiphol
C	Audience	Refers to the target audience of the document.	E.g. Internal, External; Specific actors
D	Document type	Refers to the kind of document.	E.g. Annual report, Research report, Strategic Plan
	Incident characteristics		
1	Date of occurrence	Refers to the date of occurrence of the runway incursion (RI).	Date (DDMMYY)
2	Location of occurrence	Refers both to the airport as well as the specific location on the aerodrome.	Amsterdam Airport Schiphol (AMS), Runway (RWY) nr.
3	Actor A	Refers to the primary vehicle involved in the RI.	Airplane, Bird control vehicle, Tug combination, Other
4	Actor B	Refers to any subsequent vehicles involved in the RI.	Airplane, Bird control vehicle, Tug combination, Other
5	Incident type	Refers to the level of severity, allocated to the RI based on the official ICAO classification.	Catastrophic incident (A), Hazardous incident (B), Major incident (C), Minor incident (D)
6	Scenario	Refers to the situation that best describes the human factor in the incident.	ATCO-induced, Flight crew-induced, Vehicle driver-induced
7	Preventative measures	Refers to whether or not preventative measures have been taken by LVNL to prevent an accident from happening, at the time of occurrence.	Yes, No, Uncertain
	Recommendations		
8	Campaign	Concerns any measure that regards the provision of information to stakeholders, be it through campaigns or other means of information sharing.	E.g. awareness campaigns, info bulletins.

9	Infrastructural	Concerns any measure that regards any change to airport geometry or characteristics, either by or for the benefit of LVNL. Also refers to a re-structuring of the work environment.	
10	Technical	Concerns any measure that regards the adjustment or adoption of any technological means for the benefit of LVNL.	*In the case that the origin of a problem lies with infrastructure, but it is to be addressed by technologies, then Technical is chosen.*
11	Organizational	Concerns any measure that regards the adjustment or the adoption of procedures or processes.	*In the case that the origin of a problem lies with procedures, rather than the (in)existence of technologies, then Organizational is chosen.*
12	Cooperation	Concerns any measure that regards stimulating or enhancing cooperation between various stakeholders.	E.g. workgroups
	Measures		
13	Campaign	Concerns any measure that regards the provision of information to stakeholders, be it through campaigns or other means of information sharing.	
14	Infrastructural	Concerns any measure that regards any change to airport geometry or characteristics, either by or for the benefit of LVNL. Also refers to a re-structuring of the work environment.	
15	Technical	Concerns any measure that regards the adjustment or adoption of any technological means for the benefit of LVNL.	*In the case that the origin of a problem lies with infrastructure, but it is to be addressed by technologies, then Technical is chosen. .*
16	Organizational	Concerns any measure that regards the adjustment or the adoption of procedures or processes.	*In the case that the origin of a problem lies with procedures, rather than the (in)existence of technologies, then Organizational is chosen.*
17	Cooperation	Concerns any measure that regards stimulating or enhancing cooperation between various stakeholders.	E.g. workgroups
	Reasons for not implementing		
18	Necessity	Concerns any argument that indicates that under current	

		circumstances measures are not necessary.	
19	Feasibility	Concerns any argument that indicates that under current circumstances measures are not possible.	E.g. time, resource, or capacity constraints; physical limitations of the aerodrome. *In the case that the argument infers that no feasible solution has* yet *been achieved, this category is also chosen.*

Appendix C: Coding examples

This appendix provides additional insight into the coding process by providing examples of codification. Additionally, the translation to concise recommendations and measures as found in *Appendix D: Results* have been added following each example.

2. Location

When taxiing out to runway 36C the flight crew of a Boeing 757, inadvertently entered the active runway 36R that was being used for landing.

➔ AMS; RWY 36R

7. Preventative measures

After permission had been granted to AOA to cross the runway, the tower assistant looked on the radar screen and saw G-BIS straight in front of runway 22 on the screen (..). The tower assistant immediately sent a transmission over the radio stating that AOA had to stop. At moment, the crew of G-JBIS initiated a go-around *(Case A2, p. 2)*

➔ Yes

8. Campaign

The terminology used by the runway controller following the landing on runway 06 to instruct the crew to taxi on to the end of the runway does not correspond to the standard terminology specified in ICAO document 4444. The controller could hardly imagine that his statement would be misinterpreted by the crew, because usually no pilot passes the end of runway 06 *(Case B2, p. 5)* (..) The instruction to leave the runway was not unequivocal *(p. 6)*.

➔ Ensure compliance with ICAO-standard radio terminology for taxi instructions.

It has been laid down internationally that permission to taxi to a holding point for departure is granted by using the standard phraseology: (..). The ground controller did not apply the standard terminology *(Case C1, p. 4)*.

➔ Ensure compliance with ICAO-standard radio terminology for taxi instructions.

10. Technical

The controller stated that the runway occupation indication was set to “occupied” on her equipment in the tower when the vehicle entered the runway. This indication shows a flashing light for the runway 06/24. The controller turned off the light when she lost sight of the vehicle at the end of the runway (*Case B1, p. 1*) (..) The process of verification of the vehicle position did not work *(p. 4).*

➔ Address inability of air traffic control to verify vehicle locations at all times.

10. Technical

The controller stated that the runway occupation indication was set to "occupied" on her equipment in the tower when the vehicle entered the runway. This indication shows a flashing light for the runway 06/24. The controller turned off the light when she lost sight of the vehicle at the end of the runway (*Case B1, p. 1*) (..) And the use of the flashing runway signal by the controller did not work *(p. 4).*

➔ Address the ineffectiveness of the signaling function of runway occupied signaling system.

14. Infrastructural

Schiphol and its partners are revising the names of specific taxiways. We will implement a revised nomenclature of the taxiway system to improve consistency. This will reduce the likelihood of errors and misunderstandings due to similar/confused naming conventions. Implementation date is 1 October 2020 *(NLR 2019, n.p.)*

➔ Revision of taxiway names, aiming to improve consistency and reduce likelihood of errors due to similar/confusing naming conventions, to be implemented in 2020.

17. Cooperation

Our goal for 2020 is to develop Schiphol into a High Reliability Organization (HRO) with a proactive safety culture. In 2016, we started the program Schiphol for Safety (S4S). We measure our progress based on Hudson's Health, Safety and Environment (HSE)-culture ladder *(Schiphol 2019, p. 78) (transl.).*

➔ Started the program Schiphol for Safety (S4S) in 2016, to further develop a proactive safety culture.

18. Necessity

LVNL indicates the supervisor manages the operational process and it is not the task of the supervisor to act as a safety net in the first place (*Case B1, p. 2*)

➔ Supervisors should not act as a safety net, rather they manage the operational process in the control tower.

Appendix D: Results

This appendix holds a systematic overview of the results of the document analysis. In *Table A-2*, the recommendations (lessons distilled) are presented per case. Subsequently, the status of implementation of the specific recommendations is described. The statuses are as follows:

- **Implemented**: Corresponding measure is implemented within the set timeframe.
- **Delayed implementation:** Corresponding measure is implemented outside of the set timeframe. Learning cannot be allocated to the specific RI, unless otherwise specified.
- **Planned**: Corresponding measure is in planning, however has not yet been implemented as of December 2019.
- **Under consideration**: LVNL is conducting research into the implementation of a corresponding measure.
- **Justification**: No corresponding measure is implemented. An explanation is therefore provided.
- **--**: No data has been found. Most likely, this means that no (noteworthy) action has been undertaken.

At times, multiple statuses apply. These are all noted. Lastly, the evidence or justification is provided, whereby becomes clear specifically what has been implemented.

Table A-2. Overview of results of document analysis.

Category	Recommendation	Status	Explanation of measure
A1: Boeing 757-2Q8, 2004			
Infra	Adjust entrance to runway 36R/18L via E4 so that aircraft taxiing north along taxiway Bravo have less easy access.	Implemented	E4 is changed by bend in entry. Allows better views, and emphasizes leaving taxiway Bravo (DSB 2010a).
Infra	Remove visual barriers in the control tower to enable better views of intersection E4 for the runway controller.	Justification (Necessity); delayed implementation	-Window obscuring is not considered a real problem by LVNL (DSB 2010a). -Various cameras were installed in 2012 and 2018 to increase visibility from the tower (LVNL 2013; LVNL 2019b). -Alterations to workspace took place in 2018/2019 (LVNL 2019b), whereby the air traffic controllers can

			now sit closest to the window providing the best views of their work area (LVNL 2018).
Infra	Increase effectiveness of markings and signs on taxiways, entries and runways as this contributes to successful monitoring by air traffic control.	Delayed implementation	Installation of additional ground markings and signage near take-off and landing runways (LVNL 2019a). This took place in the years 2010 and 2011 (AAS 2011; AAS 2012).
Tech	Address complex taxiways and traffic situations on aerodrome chart.	Implemented	-In 2005, a campaign was launched to make pilots aware of specific risk areas (LVNL 2006). -Publication of hotspots on the airport map material officially used by pilots (LVNL 2019a). Implemented between 2004-2010; exact year unknown.
Org	Enforce use of designated taxiing routing names by air traffic control.	-	-
Org	Ensure the presences of a supervisor in the tower who does not have additional duties.	Justification (necessity)	Supervisors should not act as a safety net, rather they manage the operational process in the control tower (DSB 2010a).
Org	Reduce workload of ground controller to improve capacity for monitoring to prevent runway incursions.	-	*See explanation in case D1.*
A2: Cessna Citation II, 2009			
Infra	Address frequent crossing of runway 04/22, which is inevitable due to location of hangars behind runway. a) Inability to taxi to Schiphol-East without crossing the runway. b) Enhance awareness.	Implemented	a) Permanent closure of G3 towards Oostbaan to prevent clearance being provided to towing vehicles on an active runway. An aerodrome chart d. 17-10-2013 (See *Figure A-7*) suggests that G3 was closed prior; an exact date cannot be found.

Tech	Address inability of air traffic control to verify vehicle locations at all times[10].	Under consideration	Implementation of navigation- and surveillance systems in ground vehicles is under consideration in 2018 (ISMS 2019).
Org	Address incorrect following of procedures for double occupation of runways.	Implemented	Procedures are sometimes subject to different interpretations. The program "Duidelijkheid in Veiligheid" is developed by and for LVNL in 2011 (LVNL 2012).
B1: Boeing MD-11, 2005			
Tech	Address the ineffectiveness of the signaling function of runway occupied signaling system.	-	*See explanation in case C2.*
Tech	Address inability of air traffic control to verify vehicle locations at all times.	-	*See explanation in case A2.*
Org	Ensure the presences of a supervisor in the tower who does not have additional duties[11].	Justification (necessity)	Supervisors should not act as a safety net, rather they manage the operational process in the control tower (DSB 2010c).
B2: Boeing 737, 2007			
Camp	Ensure compliance with ICAO-standard radio terminology for taxi instructions.	-	*See explanation in case C1.*
Camp	Take into account different experiences of air traffic control and pilots regarding the crossing of runway end lights.	Delayed implementation	In 2016, pattern B marking is applied at the runway thresholds S7/S8/E6 and V4 to prevent double occupation (DSB 2017).
Infra	Implement a physical barrier to prevent aircraft from passing the end of runway 06/24.	Justification (Necessity)	It is not unusual for traffic landing on runway 06 destined to Schiphol-Oost to be given the instruction to taxi over runway end lights (DSB 2010b, 5).

[10] Same recommendation was made in case B1 (2005).
[11] Same recommendation was made in case A1 (2004); same justification was provided by LVNL.

C1: Cessna 510, 2009			
Camp	Ensure compliance with ICAO-standard radio terminology for taxi instructions[12].	- (Necessity)	General justification by LVNL: to enhance clarity of instructions, or because of time pressure, air traffic control may deviate from ICAO-standard terminology (DSB 2017, 14).
Infra	Implement a permanent in-use stop-bar for entrance G1 at runway 04/22.	Delayed implementation	-Awareness campaign launched for G1 (DSB 2017) -Installation of runway guard lights to enhance visibility of holding position at G1 (DSB 2017). To be implemented around 2014 following the developments at Paris' Charles de Gaulle airport (Knowledge and Development Centre 2010).
C2: Boeing 737, 2014			
Tech	Address the ineffectiveness of the signaling function of runway occupied signaling system.[13]	Justification (Feasibility)	There has been a discussion within LVNL for a longer time regarding the effectivity and usability of this system (DSB 2016, 21).
Tech	The runway occupied signaling system should be able to provide insight into number of objects on the runway.	Implemented	*Addressed by implementation of runway-occupied-strips.*
Org	Implement OROFOL principle. This requires that: a) Communication takes place in English, rather than Dutch. b) Bird control operates on main runway frequency, rather than directly with Assistant 2.	Justification (Feasibility)	a) In 2003, a project was started by LVNL and AAS to enhance English communication skills (DSB 2016) b) Conclusions of research conducted in 2014 were that the disadvantages outweigh the advantages (DSB 2016).
Org	Enforce use of runway-occupied-strips that can signal double occupation (to be used in combination with flight strips) by air traffic control.	Implemented; delayed implementation	-In 2014, a procedure was implemented enforcing the use of runway-occupied-strips (DSB 2016). -In 2014, an additional procedure was introduced for the recommended usage of strips for crossing during short activities on the runway (DSB 2016).

[12] Same recommendation was made in case B2 (2007) and D1 (2004).
[13] Same recommendation was made in case B1 (2005).

			- Electronic Flight Strips (EPS) were introduced in 2018 (LVNL 2019b). Preparations began in 2016.
Org	Increase visualization for aircraft and bird control by carrying out runway inspections in the opposite direction of landing/departing traffic.	Implemented	Since 2015, bird control carries out inspections of the runway in the opposite direction of aircraft (DSB 2016).
Coop	Increase cooperation of parties at AAS in order to facilitate addressing safety concerns to a sufficient extent.	Implemented	In 2016 started with program Schiphol for Safety (S4S) to further develop a proactive safety culture (AAS 2019).
Coop	The RST should attain a special position and greater authority within the SPS.	Delayed implementation	According to the Bedrijfshandboek Schiphol (AAS 2018), strengthening of the SPS is a point of attention for that year.
D1: Boeing 767, 2004			
Camp	Ensure compliance with ICAO-standard radio terminology for taxi instructions.	Implemented	In 2005, a radio-telephony 'awareness' campaign was launched (LVNL 2006).
Infra	Address confusion caused by multiple interpretations of Golf 5 near RWY 04/22 (name of two taxiways and three holding positions near runway).	Planned	Revision of taxiway names, aiming to improve consistency and reduce likelihood of errors due to similar/confusing naming conventions (ISMS 2019), to be implemented in 2020.
Org	For crossing an active runway, traffic should always be transferred to the runway controller frequency to obtain clearance.	-	*See explanation in case D2.*
Org	Reduce workload of ground controller to improve capacity for monitoring, in order to prevent runway incursions[14].	Delayed implementation; Planned	-A second ground controller was added to permanent capacity of air traffic control between 2010 and 2016. -A third ground controller was added to permanent (day) capacity of air traffic control in 2016 (DSB 2017). -Taking into consideration desire of AAS to grow in the future, follow-the-green (lights) will likely be

[14] Same recommendation was made in case A1 (same year).

			implemented in 2026 to guide aircraft along assigned taxi routes (ISMS 2019).
D2: Airbus A320, 2015			
Org	Adjust the procedure 'requests and return of runways' according to EU and ICAO recommendations to transfer all crossing traffic to ground control. (DSB 2015b).	Implemented	Since 2016, all runway crossings are coordinated by LVNL regardless of the status of the runway (LVNL 2017).
Org	Implement ICAO recommendation to record all conversations in the control tower (DSB 2015b).	-	-

Appendix E: Airport layout

Figures A-6 and A-7 provide insight into the complex layout of Amsterdam Airport Schiphol.

Figure A-6. Positions of runways at Schiphol Airport (Schiphol24 2019).

Figure A-7. Runway intersections at Schiphol Airport (E-AIP 2013).