THE DUTCH SAFETY BOARD

Take-off from Taxiway

Amsterdam Airport Schiphol

TAKE-OFF FROM TAXIWAY

Amsterdam Airport Schiphol
10 February 2010

The Hague, December 2011

THE DUTCH SAFETY BOARD

The aim in the Netherlands is to reduce the risk of accidents and incidents as much as possible. If accidents or near-accidents nevertheless occur, a thorough investigation into the causes of the problem, irrespective of who is to blame for it, may help to prevent similar problems from occurring in the future. It is important to ensure that the investigation is carried out independently from the parties involved. This is why the Dutch Safety Board itself selects the issues it wishes to investigate, mindful of citizens' position of dependence with respect to public authorities and businesses. In some cases, the Dutch Safety Board is required by law to conduct an investigation.

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General secretary:	M. Visser		
Project Leader:	A. Samplonius		
Visiting address:	Anna van Saksenlaan 50 2593 HT The Hague, The Netherlands	Correspondence address:	PO Box 95404 2509 CK The Hague
Telephone:	+31 (0)70 333 7000	Fax:	+31 (0)70 333 7077
Internet:	www.safetyboard.nl		

This report is published in Dutch and English. In the event of any difference in interpretation the Dutch text must be regarded as binding.

TABLE OF CONTENTS

CONSIDERATION

Reason for the investigation
On 10 February 2010, a KLM Boeing 737 took off from a taxiway instead of a runway at Amsterdam Airport Schiphol. The Dutch Safety Board conducted an investigation into this serious incident on account of the high safety risks involved in taking off from or landing on a taxiway which involves an aircraft at high speeds; there could be other objects such as other aircraft or vehicles on the taxiway, which other users would not be expecting. If the aircraft that is taking off or landing collides with one of these objects, the consequences could be extremely serious. The Dutch Safety Board has therefore conducted an investigation to determine how this situation could have arisen, and which measures should be taken in order to prevent a similar incident from recurring in future.

Relevant facts
The serious incident took place at around 20.30 hours in the evening. It was dark at the time, with occasional light snowfall. The Boeing 737, with aircraft registration PH-BDP, was flown by a pilot in command and a first officer. Prior to take-off, the aircraft had been de-iced on an apron designed for de-icing purposes. The pilot in command and first officer then received the instruction to taxi to the runway for departure via taxiway Alfa against prescribed direction of travel. The aircraft had been scheduled to take off from runway 36C. Two taxiways are located adjacent to the take-off runway: Alfa and Bravo, with taxiway Alfa located furthest to the east.

The aircraft initially was on its way to the beginning of the runway. During taxiing, air traffic control suggested the crew – if prepared – took a shorter route to the take-off runway via entry W8. The flight deck crew accepted the shorter route. Upon approaching taxiway Bravo, which the aircraft still had to cross, however, the crew made an error. They assumed that the taxiway was the runway, turned the aircraft onto the taxiway and then took off. Initially, air traffic control failed to realise what had happened. When the runway controller realised what had happened, he decided not to abort the take-off as the aircraft had gained too much speed and there was no risk of collision. Although no one sustained injury during the serious incident and there was no damage to the aircraft, a highly dangerous situation had arisen.

The serious incident occurred due to the flight deck crew's lack of awareness of the aircraft's position in the manoeuvring area of the airport. The following factors played a role in the above:

- The flight deck crew's workload had increased after they had accepted the shorter route. As a result the crew had to enter changes in the flight management computer and had less time to visually check the aircraft's position at the airport from the cockpit.
- The crew were not using a ground movement chart as they felt they were sufficiently familiar with their home base, Schiphol;
- The pilot in command was distracted by communications between the air traffic controller and a Boeing 747 taxiing in front of the aircraft that had taken a wrong route.

Air traffic control failed to prevent the serious incident from occurring for the following reasons:

- The air traffic controller was forced to shift his attention to another aircraft and assumed that the PH-BDP crew would follow his instructions correctly.
- After having received take-off clearance, the aircraft was no longer monitored until an air traffic control officer in the air traffic control Tower saw it take off from the taxiway.

The section below elaborates on the underlying causes of the serious incident in further detail.

Infrastructure design
Amsterdam Airport Schiphol has a relatively complex taxiway system. It is thus crucial that pilots keep track of their position while taxiing. In principle, this will involve the use of a ground movement chart. In practice, pilots who are familiar with an airport do not use a ground movement chart despite the fact that they are required to do so. As this incident shows, this carries significant risks. With the crew navigating without a ground movement chart and suddenly forced to follow an unfamiliar route, a situation arose in which the aircraft took off from the taxiway.

The infrastructure, including the lighting, meets all ICAO standards. However, some entries and exits are not equipped with green centreline taxi lights. This also applied to entry W8. Although the absence of centreline taxi lights is not in breach of ICAO requirements, it did play a role in the crew's decision to follow the incorrect route. The thin layer of snow on the entry route also played a role in this regard. Moreover the runway lights were inconspicuous at the location where the navigation error occurred whereas the taxiway lights were clearly visible.

Despite Amsterdam Airport Schiphol's compliance with ICAO requirements, this incident underlines the need for additional measures. The airport is responsible for making the necessary infrastructural changes and improvements to supplement the existing ICAO requirements. However, the airport does not see any need to do so. The Transport, Public Works and Water Management Inspectorate (IVW) has also stated that it does not see any need to impose additional requirements.

Use of the infrastructure
Not only is the design of the infrastructure important, so too is its use. Neither Amsterdam Airport Schiphol nor air traffic control have analysed the risks associated with the use of taxiways. The decision to taxi to runway 36C via taxiway Alfa means that the pilot must taxi against the prescribed direction of travel, and by definition will have to cross taxiway Bravo. The investigation shows that the crew could not have made a mistake if they had taxied via taxiway Bravo.

According to procedure, an aircraft may be transferred from the ground controller to the runway controller if there is no longer any room for error on which taxi route the aircraft should follow. In practice, however, the transfer takes place as soon as the risk of an aircraft following the incorrect route (thus conflicting with other traffic) is so minimal that the aircraft can be transferred to the runway controller. For that reason the aircraft had already been transferred to the runway controller when it was on taxiway Alfa. However, any divergence from prescribed taxiing routes requiring the aircraft to first cross a taxiway on its way to the take-off runway – as was the case with the PH-BDP – increases the likelihood of making an error on which taxi route the aircraft should follow. In this case, the crew did make such an error, which the runway controller subsequently failed to notice on time.

At Amsterdam Airport Schiphol, opposite directions of travel apply to taxiways Alfa and Bravo in order to ensure that traffic can be safely and efficiently directed to and from the take-off and landing runways. These taxi routes are featured on the aeronautical ground movement charts and must be adhered to by all pilots. However, air traffic control is entitled to deviate from these compulsory taxi routes. Particularly in such situations, the Dutch Safety Board expects air traffic control to carefully monitor the aircraft's position and supervise the crew by issuing what are termed as positive instructions aimed at guiding the crew around a manoeuvring area, step by step.

Take-off clearance had been issued to the aircraft before it had crossed taxiway Bravo. The air traffic controller then assumed his instructions would be heeded but did not continually monitor whether this was actually the case. As a result, he failed to notice on time that the PH-BDP had turned onto taxiway Bravo and was in the process of lining up. As the PH-BDP had already been issued take-off clearance, it was actually able to depart. If a positive instruction to first cross taxiway Bravo and subsequently taxi to the take-off runway via entry W8 had been given the crew's error may possibly have been prevented.

Safety versus punctuality
Pilots and air traffic controllers are aware of the risks involved in a taxiway take-off and will always try to avoid these. However, they also endeavour to operate as efficiently as possible. The procedure of offering and accepting a shorter route is part of such operational practice. The parties involved must weigh up the options and may obviously never sacrifice safety in an effort to be punctual.

As the investigation shows, this incident was caused by the decision to follow a shorter route, based on a suggestion by air traffic control aimed at stimulating the flow of traffic. Punctuality was also important to the pilots. All flight plans indicate how much each minute of delay will cost.

Measures taken in response to the serious incident
A number of measures have already been taken in response to the serious incident in order to ensure that similar incidents do not occur in future. These measures are described below.

KLM has taken two measures in response to the incident. Firstly, the airline has introduced threat and error management. According to this procedure, pilots in the cockpit must jointly decide on their course of action and identify the various threats affecting the flight. The procedure was included in the flight manual on 1 July 2010, and has since been featured in pilot simulator training. Secondly, the manual for all aircraft types now features a 'take-off runway verification procedure'. According to this procedure, pilots must verify that the entry and take-off runway are correct before they can be entered. Finally, the airline decided to install an on-board system that sounds a warning when an aircrafts still on a taxiway taxies too quickly. However, this system is not yet operational. In view of the measures already taken, the Safety Board does not see any need to issue KLM any further recommendations.

Following an internal investigation, air traffic control the Netherlands (LVNL) formulated two recommendations to improve the transfer procedure between the ground and runway controllers. According to the first recommendation, the ground controller must check whether the aircraft is following the agreed route before it can be transferred to the runway controller. The second recommendation stipulates that the runway controller must check whether the aircraft is in the correct position when issuing take-off clearance. To date air traffic control the Netherlands (LVNL) has not yet implemented these recommendations in its procedures.

Cockpit voice recorder
Among other features, commercial aircraft are equipped with a cockpit voice recorder (CVR) that records any sounds in the cockpit. This information can be used to reconstruct occurrences . In the case of the PH-BDP, CVR data was not available due to the fact that the CVR has limited recording capacity (approximately two hours) and the data was not safeguarded on time. However, the data should have been secured in view of the fact that it was known that a serious incident had taken place.

It emerged from the investigation that KLM was the only party that took measures to increase safety in response to the incident involving the PH-BDP. However, the Dutch Safety Board believes additional measures are necessary and has issued the following recommendations.

Recommendations

The Dutch Safety Board recommends that Amsterdam Airport Schiphol:

- prepares a risk assessment of air traffic taxiing near take-off and landing runways in collaboration with air traffic control and implements the outcomes in its procedures, unless the risk assessment shows otherwise;
- changes the infrastructure so that all taxiways made available to air traffic control have green centreline taxi lights indicating the route(s) to be followed only.

The Safety Board recommends that air traffic control the Netherlands:

- prepares a risk assessment of air traffic taxiing near take-off and landing runways in collaboration with the airport and implements the outcomes in its procedures;
- ensures - until such time as the risk assessment has been completed and the resulting outcomes have been implemented - that entries without green centreline taxi lights are no longer used during darkness if an aircraft is required to taxi across a taxiway.

The Safety Board recommends that the European Aviation Safety Agency (EASA) and Federal Aviation Administration (FAA):

- increase the minimum recording time of the cockpit voice recorder (CVR) in order to better safeguard recorded data for the purpose of incident and accident investigation.

T.H.J. Joustra
Chairman of the Dutch Safety Board

M. Visser
General Secretary

LIST OF ABBREVIATIONS

36C	Take-off runway 36 Centre
AAS	Amsterdam Airport Schiphol
ABL	analyse bureau luchtvaartvoorvallen (Dutch occurrence bureau)
AIBN	Accident Investigation Board Norway
AIP	Aeronautical Information Publication;
AO	Airside Operations
AOM	Airside Operations Manager
ASC	Aviation Safety Council of Taiwan
A-SMGCS	advanced surface movement guidance and control system;
ATC	air traffic control
ATIS	Automatic Terminal Information Service; automatic system providing airport information
ATPL	airline transportation pilot licence
ATSB	Australian Transport Safety Bureau
BOM	basic operating manual; basic manual for all aircraft types
CAD	Hong Kong Civil Aviation Department
CoA	certificate of airworthiness
CoR	certificate of registration
CPL	Commercial Pilot Licence
CRM	crew resource management
CTR	control zone
CVR	cockpit voice recorder
EHAM	Europe Holland Amsterdam; ICAO code for Amsterdam Airport Schiphol
FO	first officer
EU-OPS1	EU regulation prescribing aviation requirements for the operation of commercial air transport
FCOM	flight crew operating manual
FCTM	flight crew training manual
FDR	flight data recorder
FEW	few clouds with 1/8 sky cover
FMS	flight management system
FSF	Flight Safety Foundation
GC	ground controller (Schiphol ground)
ICAO	International Civil Aviation Organization
IVW	Inspectie Verkeer en Waterstaat (Transport, Public Works and Water Management Inspectorate)
KLM	KLM Royal Dutch Airlines
KNMI	Royal Netherlands Meteorological Institute
LVNL	air traffic control the Netherlands
NOTAM	Notice to airmen
NSA	National Supervisory Authority (for aviation service providers)
NTSB	National Transportation Safety Board

OM	operating manual
PIC	pilot in command
RAAS	runway awareness and advisory system
RAM	Royal Air Maroc
RET	rapid exit taxiway; runway exit adapted to accommodate a higher taxiing speed
RG	reference guide
ROM	route operations manual
RVGLT	regeling veilig gebruik luchthavens en andere luchtvaartterreinen (national regulations for the safe use of airports and other aerodromes)
Schiphol TWR	Schiphol air traffic control tower
SCT	scattered cloud with up to 4/8 sky cover (partly cloudy)
SID	standard instrument departure
SUP	tower supervisor
TWR	Schiphol tower (runway controller)
VDV	voorschriften dienst verkeersleiding (air traffic control regulations)
VEMER	veiligheids-, efficiency- en mileueffectrapportage (assessment on safety, efficiency and impact on the environment)
VFR	Visual Flight Rules

1 INTRODUCTION

1.1 Reason for the investigation

On 10 February 2010, a KLM Royal Dutch airlines Boeing 737-306, aircraft registration PH-BDP, operated a flight from Amsterdam Airport Schiphol to Warsaw. However, the aircraft did not take off from runway 36 Centre (36C) as scheduled but from an adjacent taxiway. The incident involved a runway confusion.

'Runway confusion' is an international aviation term used to describe incidents in which aircraft take off from or land on a taxiway, or take off or land using a runway other than the runway for which they have received a clearance. Runway confusions are potentially highly dangerous as they involve an aircraft at high speeds in order to take off or land on taxi or runways where no one is expecting them. In addition to various objects, such as other aircraft, vehicles, etc., there may also be work in progress at these locations, with all the ensuing risks of collision.

1.2 The investigation

1.2.1 Purpose of the investigation

This report is the outcome of the investigation conducted by the Dutch Safety Board. The Board aims to learn lessons from this incident in order to prevent a similar incident from recurring in future.

The investigation also included previous runway incursions[1] at Amsterdam Airport Schiphol investigated by the Board. Both incident categories (runway incursions and runway confusions) involve unintentional traffic movements on take-off runways or taxiways carrying the risk of collision.

1.2.2 Investigation questions

The key investigation question for this incident investigation is as follows: 'How could an aircraft take off from taxiway Bravo without the crew or air traffic control noticing this on time?'

This investigation question can be subdivided into three sub-questions:

- What are the direct causes?
- What underlying causes played a role?
- What measures should be taken in order to prevent runway confusion incidents (at Amsterdam Airport Schiphol)?

1.2.3 Scope and procedure

This investigation report describes and analyses the relevant facts, the environment (infrastructure, working processes and procedures, habits, etc) in which the PH-BDP crew and air traffic controllers were operating and the ensuing risks, from the time the aircraft departed from the gate to shortly after take-off. Although the investigation focuses on the aspect of safety management, no analysis was conducted of the safety management systems employed by the airline, the airport and air traffic control.

1 ICAO definition runway incursion: any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing and take-off of aircraft.

1.3 Reading guide

This report consists of five chapters. Chapter 2 describes the relevant facts directly relating to the incident and other relevant facts. The chapter also contains a short description of the relevant terms. Chapter 3 describes the underlying causes of the incident and contains an analysis of the facts relating to the take-off from the taxiway. Chapter 4 formulates the conclusions derived from the investigation. Chapter 5 contains the recommendations.

ICAO has formulated a number of standards and recommended practises for the purpose of facilitating the investigation of civil aviation accidents and serious civil aviation incidents. These standards and recommended practises are incorporated in Annex 13, 'aircraft Accident and Incident Investigation' to the Chicago Convention on International Civil Aviation. Annex 13 recommends a standard format for investigation reports. The format of Chapter 2 'Factual Information' is set out in accordance with Annex 13.

The justification of the investigation is included in appendix A. A draft version of this report was submitted to all the involved parties for review and comments. The resulting review comments are discussed in appendix B.

2 FACTUAL INFORMATION

2.1 Introduction

On 10 February 2010 at approximately 21:00[2], the Dutch Safety Board received a notification that a KLM Boeing 737-300 had taken off from a taxiway at Amsterdam Airport Schiphol. The investigation commenced the next day.

This chapter reflects the facts relevant to finding out the causes of the incident. Sections 2.2 and 2.3 briefly discuss a number of relevant concepts with regard to the infrastructure and operational processes at Amsterdam Airport Schiphol. Section 2.4 elaborates the history of the flight. The subsequent sections contain a summary of other relevant information.

2.2 Relevant infrastructure and operational processes at Amsterdam Airport Schiphol

2.2.1 Take-off and landing runways

Amsterdam Airport Schiphol has four main runways, each of which have a width of 45 metres, and one main 60-metre wide runway (18R-36L) designated for the take-off and landing of commercial aircraft. Depending on the traffic volume, at least one take-off runway and one landing runway will be in use at any one time. Depending on operational availability, air traffic control will select runway combinations on the basis of the weather conditions and the noise abatement standards (environment). The airport also has a shorter runway at Schiphol-East, which is mainly used for handling business flights and general aviation.

The volume of outbound and inbound traffic fluctuates over the course of the day. The airport and air traffic control refer to situations in which the volume of outbound traffic clearly is greater than the volume of inbound traffic as an 'outbound peak'. During an outbound peak, the airport usually operates two take-off runways and one landing runway. The reverse situation is referred to as an 'inbound peak', which usually involves the operation of two landing runways and one take-off runway.

All runways have a unique number[3] which designates whether the runway is being used for take-offs or landings. In the case of parallel runways, the number is followed by a letter indicating whether the runway in question is the left (L: left runway), right (R: right runway) or centre runway (C: centre runway).

Entries and exits

All runways have entries and exits, markings[4] and stop bars.[5] These short taxiway sections have a unique identifier consisting of a combination of numbers and letters, and connect the taxiway system with the relevant take-off or landing runway. If the runway is being used for take-offs, the section is referred to as an entry. If the runway is being used for landings, it is referred to as an exit. See W8 in figure 1.

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2 All times in this report are local times in the Netherlands unless stated otherwise.

3 The runway number consists of the magnetic heading in either take-off or landing direction, rounded to 10 whole degrees, and does not include the final '0'.

4 Markings: a yellow line in the centre of the taxiway indicates the direction of travel that must be followed. The entry has double yellow hold lines perpendicular to the centre line. These markings are intended for daytime and night-time conditions with good visibility. Hold lines are designed to prevent unauthorised entry to a take-off runway.

5 A stop bar is a row of recessed red lights embedded in the entry which, when activated, prevent traffic from inadvertently entering the runway or disrupting landing system radio signals. These stop bars are basically designed for use under low visibility conditions. However, some stop bars are activated at Schiphol even if non- low visibility conditions apply.

In order to take off, larger aircraft mainly use the entries located at the beginning of the runway. Aircraft that need less runway length to take off can use the entries located in the take-off direction further down the runway, known as intersections.

This is referred to as an intersection take-off. Air traffic control can use intersection take-offs to configure outbound traffic in a more efficient take-off sequence. The entries and exits are often located perpendicular to the direction of the take-off runway. Some are positioned at a 30-degree angle to the runway direction. These particular exits have a special function and enable aircraft that are still at a relatively high speed during the landing roll out to exit the runway. They are referred to as rapid exit taxiways (RET), also see figure 1.

2.2.2 Taxiways and de-icing platforms

Taxiways connect the take-off and landing runways with the aircraft parking positions at the gate (for passenger flights) or with the cargo aprons. Amsterdam Airport Schiphol features a 'one-terminal concept' with a centrally located passenger terminal surrounded by a tangential runway system comprising four of the five main runways. A double ring of taxiways is located between these main runways and the terminal building (except on the south side of the airport): taxiway Alfa is located on the inside, and taxiway Bravo on the outside. These taxiways are 23 metres wide.

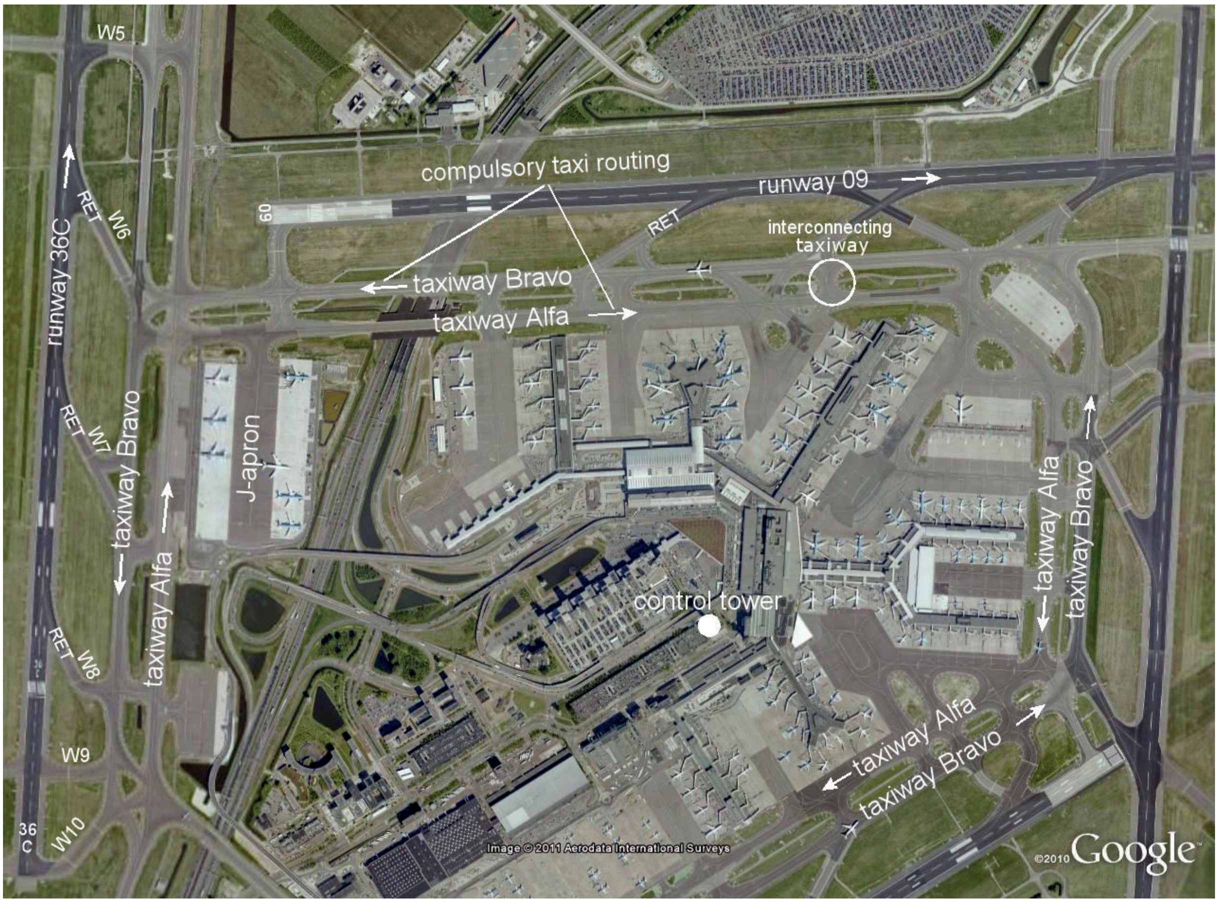

Figure 1: Part of the runway and taxiway system

Traffic on taxiway Alfa can switch to taxiway Bravo or in the opposite direction by means of interconnecting taxiways. Both taxiways Alfa and Bravo branch off to the parking stands and aprons located in other areas of the airport. The only traffic that this system does not accommodate is traffic using the westerly runways 36L and 18R, or traffic from or to runways 04 or 22 at Schiphol-East.

The runway system includes two de-icing aprons, which are located within the inner ring of taxiway Alfa, and are used for removing ice, snow or frost from aircraft.[6] The de-icing apron relevant to this investigation is Apron J (for Juliet). It is located to the east of take-off runway 36C and borders directly on taxiway Alfa.

In terms of infrastructure, most runway incursions can be attributed to the way in which taxiways are located in relation to runways. Although no separate risk assessment of the taxiway system was carried out, air traffic control the Netherlands (LVNL) did conduct a VEMER (an assessment on safety, efficiency and impact on the environment) regarding runway safety. This assessment provides insight into the role of the complexity of the total taxiway system and the associated risk of runway incursions. A number of hot spots were also identified, which mark the areas with a increased risk of runway incursions. Entry W8 is not located within a hot-spot area.

2.2.3 Compulsory direction of travel

Pilots taxiing at Amsterdam Airport Schiphol must follow the compulsory direction of travel (see figure 2) when taxiing along taxiway Alfa taxiway (clockwise) and taxiway Bravo (anti-clockwise) The compulsory direction of travel is published in the Aeronautical Information Publication (AIP). The AIP is an internationally recognised publication[7] that serves as a source of information for airport operators, pilots and organisations that use or publish aviation documents. The taxiways may also be used in the opposite direction if deemed necessary by air traffic control. The ground controller will inform pilots in advance if their flight is to be routed against the compulsory direction of travel.[8] ICAO does not provide any guidelines on fixed taxi routes or the direction of travel, and has not specified any conditions regarding deviations. In more general terms, ICAO has specified that traffic should be handled in accordance with all applicable procedures and traffic rules, as determined by the responsible air traffic control services.

Aircraft leaving the J-Apron may be routed either in the compulsory direction of travel (to taxiway Bravo taxiway via taxiway Alfa) or against the compulsory direction of travel (by taxiing southward on taxiway Alfa).

6 De-icing is crucial for aviation safety as the accumulation of snow, ice and frost on an aircraft is detrimental to an aircraft's aerodynamic performance.

7 An AIP is available in most countries. In the Netherlands, the AIP is maintained by the Transport, Public Works and Water Management Inspectorate and published by air traffic control the Netherlands (LVNL).

8 The AIP states that: 'aircraft shall comply with the compulsory taxi routes to and from the stands as depicted on the ground movement chart. Deviations from the taxi routings will be given on a timely basis by Schiphol Ground.' It should be noted that the ground movement chart does not feature any information on deviations from the compulsory taxi route.

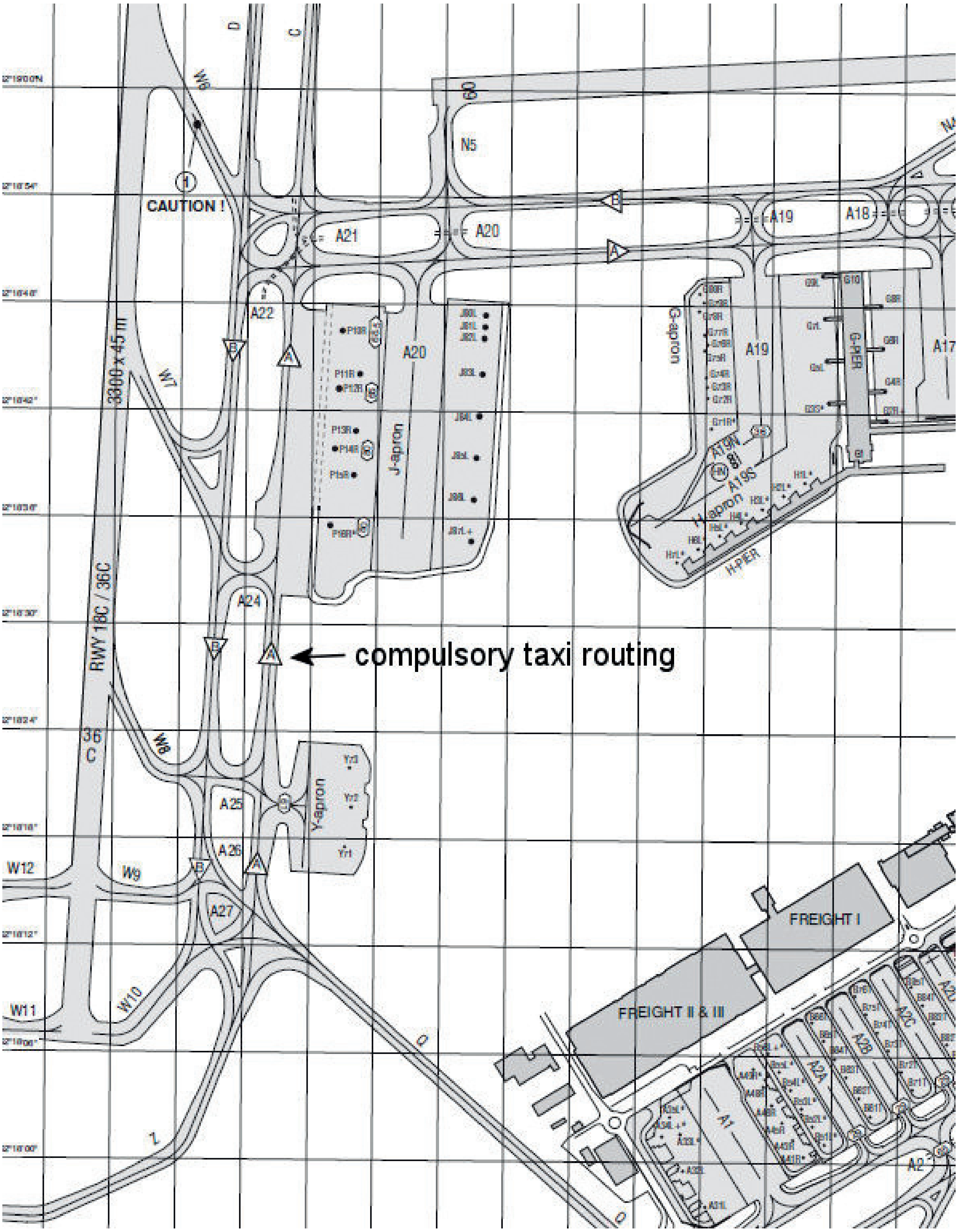

Figure 2: Compulsory direction of travel on taxiways Alfa and Bravo (Source: AIP)

2.2.4 *Air traffic control transfer procedures, instructions and take-off clearance*

General
Air traffic control and aircraft crew maintain radio contact on designated frequencies. The aircraft's position at the airport, the take-off or landing runway in use, the time of day and the volume of air traffic determine the radio frequency crew members should tune in to. During its time at the gate, the aircraft will be in radio contact with either Delivery[9] or Start-Up Control.[10]

When an aircraft is ready to start taxiing, the crew will contact the ground controller. The ground controller will then instruct the crew which taxi route the aircraft should follow to the take-off runway or de-icing apron. In principle, aircraft taxi along the published taxi routes, moving in the compulsory direction of travel. Depending on the traffic situation, the ground controller may assign a different route or direction of travel. While following a different route, the ground controller provides positive instructions.[11]

Transfer from ground to runway control
As soon as the aircraft approaches the scheduled take-off runway, the crew will be instructed to switch over to the runway controller. The ground controller will then transfer the aircraft to the runway controller. The regulations specify that the ground controller must transfer the aircraft at a time when there no longer is any room for misunderstanding on which taxiway the aircraft should use.

Instructions and take-off clearance from the runway controller
Once the crew has received the instruction from the ground controller to switch over, the pilot operating the radio will call the runway controller. The runway controller is responsible for determining when an aircraft is allowed to enter the take-off runway. Depending on the traffic situation at the entries, on the take-off runway or in other parts of the control zone (CTR), the runway controller can instruct the aircraft to either stop before entering the take-off runway or already line up the aircraft on the take-off runway.[12] In the latter case, the aircraft has not yet received clearance for take-off. In some cases, the crew may already receive permission to depart while the aircraft is on a taxiway. In that case the aircraft may then take off as soon as it enters the runway.

2.3 Other important information

2.3.1 *Cockpit work processes*
A Boeing 737-300 flight deck crew consists of two pilots: a pilot in command (PIC) and a first officer (FO). With the exception of training flights, KLM procedures dictate that the pilot in command always sits in the left seat and the first officer in the right seat. The pilot in command has final responsibility for ensuring safe flight operations. He is required to ensure that all procedures in the airline's operating manual (OM) are carried out. The pilot in command and first officer must continually apply the principles of crew resource management[13] to both their own and each other's activities.

One pilot controls the aircraft (the pilot flying) while the other has a support role (the pilot monitoring). After each flight pilots usually change from pilot flying to pilot monitoring and vice versa. The duties of the pilot monitoring include key supporting duties such as jointly monitoring the situation outside while taxiing and maintaining radio contact with air traffic control. During take-off he will monitor the speed and engine instruments and read out standard speeds and deviations to the pilot flying to support the take-off process.

9 Delivery issues route clearances to crews.
10 Start-up control issues permission to crews to start up the engines.
11 The air traffic controller will issue literal instructions on the route to be followed, such as 'first left, the first right', etc.
12 Line up: lining up the aircraft in its take-off position so that the aircraft's longitudinal axis is aligne with the take-off direction of the runway.
13 Crew resource management (CRM) means deploying all available resources (staff, equipment and procedures) in order to formulate well-founded and broadly-supported decisions.

The pilot monitoring must monitor the activities performed or not performed by the pilot flying. Once airborne, the pilot monitoring will check whether the flight path is being followed correctly and he will check the aircraft systems. While on the ground and during flight, the pilot monitoring will read out the checklists and carries out instructions from the pilot flying. Each airline has either its own standard operating procedures or applies those issued by the aircraft manufacturer.

According to the flight crew training manual (FCTM) issued by the aircraft manufacturer, the aircraft's position must be constantly checked against the ground movement chart while the aircraft is taxiing. During critical phases in the taxiing process, the crew must avoid distraction and plan in advance how they intend to complete the checklist. The crew must obtain permission from air traffic control before entering the runway. KLM uses its own manuals, such as the Training Operations Manual (TOM) and KLM Boeing 737 FCOM (Flight Crew Operations Manual). The FCOM has been supplemented with key operational sections of the FTCM. The FCTM has also been distributed to KLM pilots.

If any data needs to be entered (into a flight management computer, for example) during taxiing, this will be carried out by the pilot monitoring. Procedures prescribe that the pilot flying must check the data before data entry is effectuated. For further details on the various manuals, see appendix D.

2.3.2 Air traffic control at the central ATC tower at Schiphol

General
The air traffic control in the tower consists of ground control and runway control which are responsible for guiding aircraft at the airport from the tower. The ATC tower staff issue route clearances[14] for outbound traffic and coordinate aircraft push-back from the aircraft's parking position and engine start-up. The air traffic controllers also guide the taxi and take off processes until directly after take-off. Once the aircraft has climbed to 2,000 feet, the pilot contacts departure control, after which area control takes over and continues to guide the aircraft along the airways.

The processes and procedures used by air traffic control are described in the 'air traffic control Regulations Manual, Part 2' (Voorschriften Dienst Verkeersleiding, VDV). Among other procedures, the VDV describes the standard taxi route[15] procedures at Amsterdam Airport Schiphol, the transfer of aircraft from the ground controller to the runway controller and departing aircraft. For further information on the VDV and working methods, see the reference framework in appendix D.

Relevant ATC tower and staffing
Air traffic control at Amsterdam Airport Schiphol handles traffic in the control zone from two different towers: the main tower at Schiphol-Centre and a satellite tower near runway 18R-36L. ATC in the satellite tower handles all traffic taking off from or landing on runway 18R-36L. All the other traffic is handled by the ATC in the main tower. The staffing level in the ATC towers depends on the volume of traffic and staff are deployed on the basis of a cyclical traffic pattern during the day, evening and night. Only the activities in the main tower are relevant to this investigation.

Ground control
Ground control operates in an airport field designated for taxiing traffic: the manoeuvring area. The manoeuvring area does not include take-off and landing runways. Ground control is responsible for ensuring there are no collisions between aircraft, and between aircraft and other vehicles. Ground control also provides instructions to prevent aircraft from entering take-off and landing runways without being aware or without authorisation.[16]

14 Route clearance: permission to operate a flight along a specific route.
15 The Aeronautical Information Publication (AIP) refers to 'compulsory direction of travel', whereas the VDV uses the term 'standard direction of travel'.
16 These tasks and responsibilities are specified in Part 2 of the air traffic control Regulations Manual (VDV).

Ground control also ensures the smooth flow of ground traffic and distributes traffic across the available take-off runways – in accordance with the pilots' flight plans – so that outbound flights do not get in each other's way after take-off. The ground controller can also schedule aircraft for an entry at the beginning of the runway or intersection in consultation with the runway controller. He can provide the aircraft a taxi instruction or leave this up to the runway controller. The ground control process thus plays an important role in the efficient handling of outbound traffic. The ground controller's tasks and responsibilities are described in appendix C.

Runway control
Runway control handles outbound and inbound traffic and is responsible for all airborne traffic within the ATC control zone (CTR). It monitors compliance with the aircraft separation requirements and prevents collisions between aircraft and other traffic.

Runway control is also responsible for providing take-off clearance. There are regulations[17] when take-off clearance may be issued. In principle take-off clearance is given when the aircraft is on the take-off runway or is approaching the runway. In some cases, take-off clearance may be issued at an earlier stage. However, this is generally subject to the traffic situation.

During training, runway controllers learn to scan whether the runway is free before issuing take-off clearance. If there is no other traffic in the vicinity of the runway and no conflicting movements are anticipated, take-off clearance may be released. Interview statements have shown that the runway controllers scan the runway before issuing take-off and landing clearance. In principle, they will monitor the aircraft's ground roll during take-off and landing. Other aircraft movements that they generally want to continue to monitor include touchdown during landing and rotation[18] during take-off. Another critical moment that the runway controllers always want to monitor when parallel take-off runways are being used is establishing the first turn after take-off. The runway controller's tasks and responsibilities are described in appendix C.

2.3.3 Releasing a runway and entries for operation
At any given moment, air traffic control will be using a number of take-off and landing runways for handling traffic. If air traffic control needs to adjust runway usage at the airport, the ATC tower supervisor usually communicates with the airport's airside Operations Manager (AOM). Such an adjustment may be necessary in view of changing weather conditions, compliance with the noise abatement policy or the volume of outbound or incoming traffic requiring that different runways be used.

If air traffic control 'returns' a runway to the AOM, it will be taken out of service and the airport authority will then be responsible for its management. If air traffic control wishes to put a runway into service, the airport will first prepare it for use. During wintry weather, this may involve deploying snow clearance equipment[19] to remove snow from the taxiways and take-off or landing runways. Once a runway inspection has been conducted, the AOM can transfer the runway to air traffic control in consultation with the tower supervisor. From that moment on air traffic control will be responsible for runway usage and handling traffic. This procedure does not specify the use of specific entries or exits. Air traffic control works on the assumption that all entries and exits are available, unless they have been taken out of service (for maintenance purposes, for example).

17 ICAO Document 4444, Chapters 4.5, 7.6 and 7.9.
18 During touchdown, the main wheels will touch the ground. During rotation, the nose wheel will lift off the ground.
19 Snow clearance equipment: large equipment used by the airport to clear snow from the runways and taxiways and spray them for de-icing purposes.

2.4 History of the flight

The PH-BDP arrived at Amsterdam Airport Schiphol at 19:14 hours on 10 February 2010. The aircraft was on a return flight from Zurich, Switzerland. The aircraft taxied to gate D46, where the passengers subsequently disembarked. The flight deck crew were scheduled to fly the same aircraft to Warsaw in Poland using aircraft call sign KLM1369.[20] The scheduled departure time was 20:20.

It was dark, with visibility of over 10 kilometres. A runway controller, who also served as the tower supervisor (also see appendix C), was on duty in the main control tower at Schiphol-Centre. He was responsible for handling traffic landing on runways 36R and 06. Runway 36L was being used as the main take-off runway. The air traffic controllers working in the West satellite tower were handling traffic on runway 36L.

A ground controller on duty in the main ATC tower was responsible for air traffic taxiing in the North sector of the airport. The South sector was being handled by another ground controller who was also instructing a trainee ground controller. Assistant 2[21] was providing general support to the air traffic controllers and maintaining radio contact with all other vehicles and towing traffic in the field. Lastly, three officers from the start-up cluster[22] were also present. One of these officers was assistant 1, responsible for entering flights in the computer system used by the air traffic controllers.

At a given moment, air traffic control decided to designate runway 36C as the second runway for departure in view of the imminent outbound peak. A second runway controller came in to support his colleagues. He first handled traffic landing on unway 06 and then proceeded to handle outbound traffic on 36C. Once the AOM had released runway 36C for service, the second runway controller adjusted the runway lights. Once the runway had been released for service, air traffic control worked on the understanding that it could use all entries to runway 36C. The first aircraft took off from 36C at 20:21. PH-BDP was the eighth flight scheduled to take off from runway 36C and the first to use entry W8.

During flight preparation, the PH-BDP flight deck crew were expecting to take off from runway 09 and had entered the route together with the relevant standard instrument departure procedure in the flight management system (FMS). Now that the allocated runway had changed, the crew duly changed this information in the FMS. PH-BDP was now scheduled to take off from runway 36C. The crew were anticipating an intersection take-off[23] and had programmed the corresponding intersection, which in this case was W9, in the FMS.

The weather fluctuated between light snowfall and clear patches. In view of the wintry weather, the flight deck crew consulted with the ground engineer and decided to have the aircraft de-iced[24] on the de-icing apron (Apron J). This procedure would delay the flight. At 20:16 a pushback truck pushed the PH-BDP away from gate D46 and the crew started up the engines. According to their statements, the crew members, who were familiar with Amsterdam Airport Schiphol, had put aside the ground movement chart and consulted the departure procedure chart.[25] The pilot in command was the pilot flying on this flight.

20 KLM1369: KLM's radio call sign is: 'KLM' followed by the relevant flight number.
21 Assistant 2 is responsible for providing general assistance, which includes guiding vehicles in the manoeuvring area under the responsibility of the ground controller and vehicles towing aircraft crossing runways under the responsibility of the runway controller.
22 Start-up cluster: in addition to assistant 1, there is a delivery controller who issues route clearance and standard departure routes to flight crews. A start-up controller is responsible for coordinating the time at which engines can be started.
23 Intersection take-off: a take-off run that commences at one of the subsequent entries which are termed as intersections rather than the start of the runway.
24 The process of removing ice, frost or snow from an aircraft is known as de-icing. This process is crucial for ensuring flight safety.
25 The standard instrument departure (SID) chart specifies the route and procedure to be followed immediately after take-off, depending on the take-off runway used. The SID connects an airport to the airways.

As soon as the first officer, who was operating the on-board radio in his capacity as the pilot monitoring, had received permission from air traffic control, the pilot in command taxied the aircraft to Apron J.

The ground controller stated that he was occupied with the traffic involved in engine start-up and aircraft that had to be de-iced. During de-icing on Apron J, PH-BDP was parked in position P12. To the right of PH-BDP in position P10 was a China Airlines Boeing 747, flight number CAL5420.[26] The de-icing of Boeing 747 had been completed before the de-icing of PH-BDP. The crew were instructed by ground control sector North to taxi to runway 36C via taxiway Alfa (see appendix E). This involves crossing taxiway Bravo. The outbound peak had just started and there was still a relatively small amount of taxiing traffic. In case there is many taxiing traffic ground controllers prefer to route aircraft leaving Apron J via taxiway Bravo. In view of the braking action[27] (medium braking action) on the taxiways and fewer bends along the route, the ground controller now decided that the most logical route would be for the CAL5420 to taxi to entry W10 via taxiway Alfa.

At 20:31:15, the first officer reported that the PH-BDP was ready for taxi, see appendix E. PH-BDP then received the same instruction as CAL5420, and proceeded to follow the Boeing 747. According to the flight data recorder (FDR), the flaps moved into position 5 as the aircraft left Apron J. According to their statements, the crew completed the 'Before take-off checklist' shortly afterwards. As the aircraft taxied behind the Boeing 747 on taxiway Alfa, the PH-BDP's pilot in command and first officer briefly went through the standard instrument departure (SID) and once again the engine failure procedure. The taxiway's green centreline taxi lights were illuminated, and the pilot in command confirmed that taxiway Alfa was free of snow.

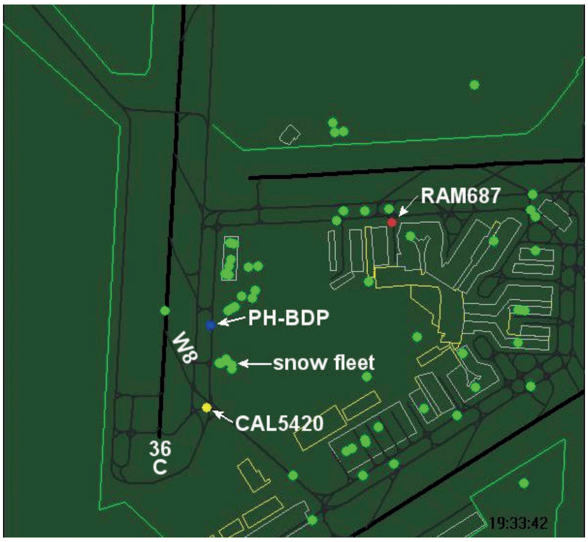

Figure 3: Traffic situation[28] on taxiways Alfa and Bravo near runway 36C at 20:33:42 (source: LVNL ground radar)

The ground controller stated that he had considered offering PH-BDP the use of intersection W8, but decided against it due to intensive use of his radio frequency. He decided to consecutively transfer CAL5420 and PH-BDP to the runway controller, who would then be free to decide on the taxi route for these flights as he himself saw fit.

As they taxied south on taxiway Alfa (just after Exit A25) the CAL5420 crew received an instruction from the ground controller to switch to the runway controller's radio frequency.

26 CAL5420: the radio call sign for China airlines is: 'Dynasty' followed by the relevant flight number, see appendix E.
27 There are three levels of braking action: 'good', 'medium' or 'poor'.
28 The infrastructure on this radar image does not correspond with the actual situation in terms of entries W8 and A25, and does not feature entry W9.

After having called runway control and stated that they were approaching intersection W10 (see figure 3) on runway 36C, the crew on board CAL5420 received permission to line up at W10.

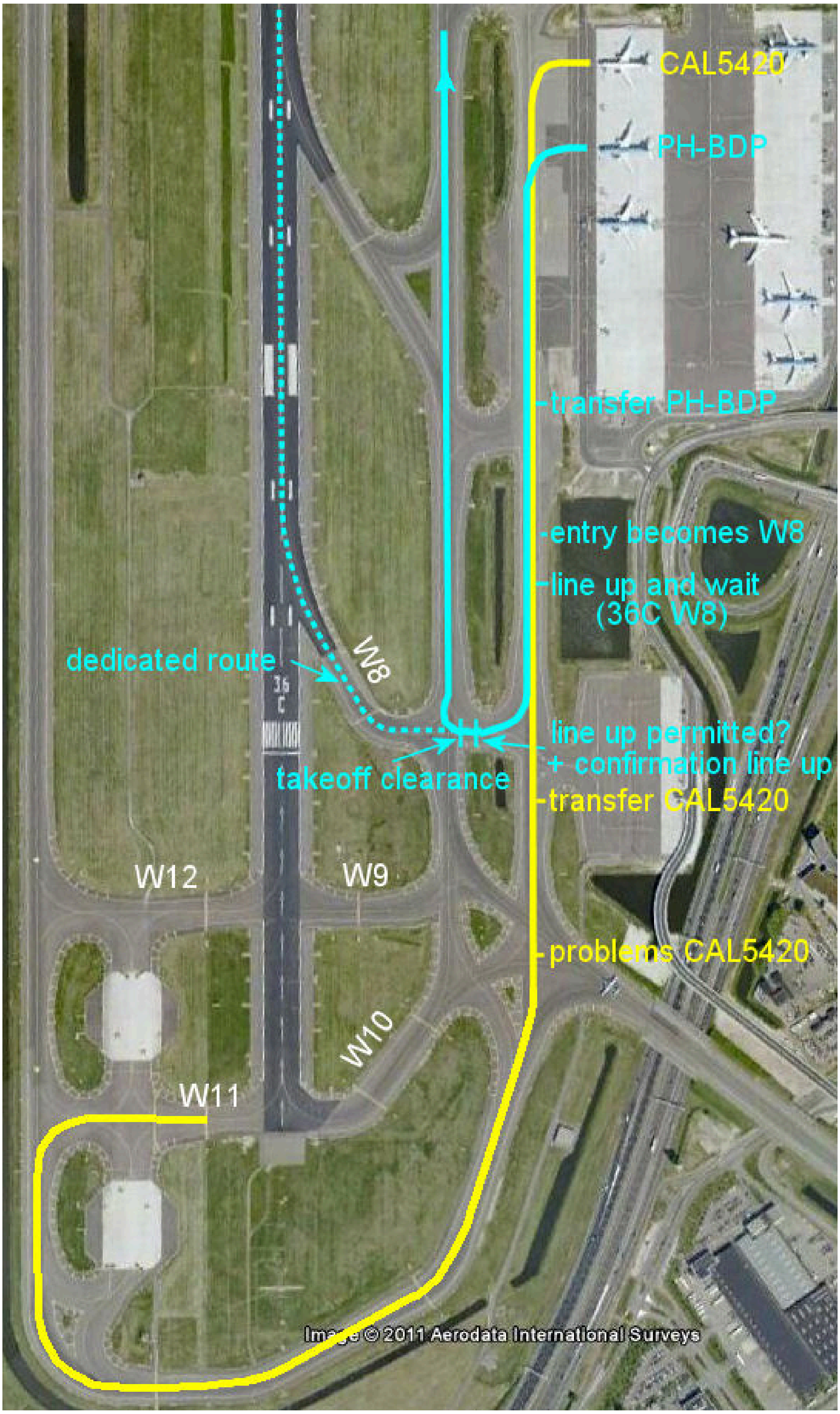

Figure 4: PH-BDP and CAL5420 taxi routes and take-off

During this phase of taxiing, the PH-BDP crew had the well-lit airport terminal to their left. The aircraft passed Apron Y (Yankee) where the airport's fleet of snow clearance equipment with flashing lights was assembled. The PH-BDP (in the process of taxiing in a southerly direction) had almost reached interconnecting taxiway A24 (see figures 2 and 4) on taxiway Alfa when the crew received the instruction to switch over to the runway controller's frequency. Shortly after passing the turn into A24 on taxiway Alfa, PH-BDP called the runway controller's frequency.

The runway controller instructed the PH-BDP crew to taxi to intersection and entry W8 when ready. After consulting with the pilot in command, the first officer reported at 20:33:49 that they were ready. The crew were instructed to line up runway 36C via W8 and wait. Both pilots stated that they had never taken off via entry W8 before.

Although reduced thrust would have sufficed in order to take off via entry W9, the pilot in command wanted to use maximum thrust to take off via entry W8. The first officer set the thrust to maximum in the FMS, and did not monitor the situation outside the cockpit together with the pilot in command. The aircraft left taxiway Alfa at 20:34:12 and turned onto interconnecting taxiway A25 (see figures 2 and 4). The illuminated part of the terminal area was now out of view. Instead the view was now dark with lights of taxiway Bravo, the edge lights[29] of take-off runway 36C and the lights from the motorways and cars. Because the first officer had not got the performance speeds for entry W8, he entered the previously calculated performance speeds for intersection W9 in the FMS. For background information on the relevant take-off performance calculations, see appendix F.

The runway controller noticed CAL5420 standing still on taxiway Alfa near W10. At 20.34:00, he requested that the CAL5420 crew make the right turn onto W10. However, the crew indicated that this would not be possible. The runway controller now had to find out which entry could be made available to CAL5420. He was aware that the apron near entries W11 and W12 was being used for snow storage and did not know whether W11 or W12 was available. After having been informed thereof by assistant 2, he ultimately instructed CAL5420 to taxi to entry W11 via taxiway Z (for Zulu, located to the south and west of runway 36C). After having sent CAL5420 to W11, and after having issued take-off clearance to PH-BDP he double-checked the ground radar to see whether any fences had been set up to cordon off the stored snow. This was necessary in order to determine whether there was enough space for CAL5420.

The pilot in command of PH-BDP listened in on the conversation between CAL5420 and the air traffic controller. He was no longer sure whether he had permission to enter the runway and asked the first officer to request confirmation. At this time, the PH-BDP was located in between taxiways Alfa and Bravo. The pilot in command allowed the aircraft to just taxi at very low speed while the first officer verified whether they had permission to line up. The runway controller confirmed that this was the case. According to the FDR, the aircraft's ground speed then increased to approximately 5 knots. The PH-BDP then received take-off clearance at 20:34:55. At that moment, PH-BDP was located on the change-over zone from A25 and taxiway Bravo with its nose pointed west. See figure 4 for further details.

According to the radar images and FDR data, the PH-BDP was lined up on taxiway Bravo from approximately 20:35:25. From that time onwards, the stationary aircraft started its take-off procedure with the crew selecting thrust to test engine performance in wintry conditions.[30] Part of this process involves both pilots watching the engine instruments while the pilot flying makes sure the aircraft does not start to slide on the potentially slippery surface. As the aircraft starts to move, the pilot monitoring then watches the speed indicator and has little time to look outside. Only the pilot flying looks outside at all times.

29 Edge lights are located on both sides of the runways, and demarcate the runway edges.

30 During wintry conditions, the anti-ice systems will be engaged. These systems use hot air from the engines. Engagement of the anti-ice systems requires a static take-off due to ice shedding, which refers to the removal of any ice that may be on the fan blades as a result of centrifugal forces. The static take-off procedure also includes checking thrust and whether the anti-ice system is working.

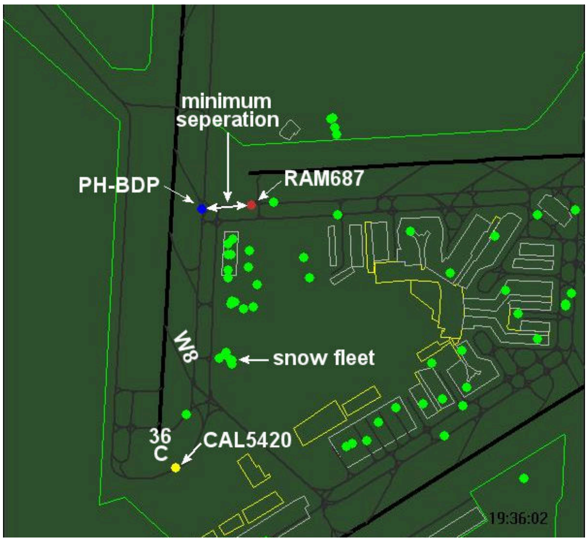

Figure 5: PH-BDP take-off from taxiway Bravo (source: LVNL ground radar)

According to FDR data, the aircraft started to accelerate for its take-off run at 20:35:22. Assistant 1 was looking at his ground radar screen and noticed the PH-BDP's unusually high speed on the taxiway. He pointed out to the runway controller that PH-BDP was taking off from the taxiway. According to their statements, the aircraft was located just south of Apron J at that time and was not in any immediate risk of collision. In view of PH-BDP's high speed, the runway controller decided to allow the aircraft to continue its take-off run. Other officers saw the aircraft lift off the ground just after assistant 1 had notified the runway controller.

Meanwhile, on the north side of the airfield from an easterly direction Royal Air Maroc flight RAM 687 was approaching the section of taxiway Bravo from which PH-BDP was taking off in a northerly direction, see figure 5. As PH-BDP passed the east-west section of taxiway Bravo, the distance between the two aircraft was approximately 280 metres, with the RAM687 approximately 30 seconds away from taxiway Bravo where PH-BDP was taking off. The aircraft lifted off between entries W6 and W5 at 20:35:44. The distance between PH-BDP and RAM687 was approximately 300 metres.

Air traffic control informed the crew of the incident while the aircraft was climbing. The crew informed air traffic control that they were unaware they had taken off from a taxiway. The onward flight and landing at Warsaw proceeded smoothly. PH-BDP arrived in Warsaw four minutes behind schedule.

For further background information on flight operations and air traffic control, see Appendices N and O.

2.5 Injuries to persons

None of the crew members or passengers suffered injury.

2.6 Damage to aircraft

The aircraft did not sustain damage.

2.7 Other damage

There was no damage to the taxiways or taxiway lighting.

2.8 Personnel information

	Dutch national, age 42; employed by the airline from 6 May 1992.
Licence	EU airline Transport Pilot Licence (A)
Most recent prof check	9 November 2009 Licence Performance Check (LPC)
Most recent line check	20 May 2009
Boeing 737 pilot in command	23 February 2005
Medical certificate	Class 1
Experience	Total: approx. 11,500 hours
	Boeing 737: 5,548 hours
	Boeing 737 as captain: 3,275 hours
	Last 90 days: 124.08 hours
	Last 30 days: 39.07 hours
	Last 24 hours: 8.56 hours

Table 1: Information relating to the pilot in command

	Dutch national, age 37; employed by airline from 6 February 1998
Licence	EU Commercial Pilot Licence (A)
Most recent prof check	21 November 2009 Licence Performance Check (LPC)
Most recent line check	18 April 2009
Boeing 737 first officer	03 May 2003
Medical certificate	Class 1
Experience	Total: approx. 7,588 hours
	Boeing 737: 3,883 hours
	Boeing 737 as first officer: 3,883 hours
	Last 90 days: 125.29 hours
	Last 30 days: 57.30 hours
	Last 24 hours: 8.56 hours

Table 2: Information relating to the first officer

The pilot in command held a valid Airline Transport Pilot Licence (ATPL) and a valid medical certificate. He had flown as a Boeing 737 pilot in command since February 2005. The first officer held a valid commercial pilot licence (CPL) and a valid medical certificate. He had flown Boeing 737s since May 2003. Over the course of their aeronautical careers, both pilots had taxied along the airport terrain thousands of times, approximately 50 percent of the time as the pilot flying and the other 50 percent of the time as the pilot monitoring.

2.9 Aircraft information

The aircraft held a valid certificate of airworthiness (CoA) and certificate of registration (CoR). According to technical documents no technical problems relevant to this incident were found.

2.10 Meteorological information

General
The weather conditions at Schiphol around the time of the incident were compiled on the basis of the information obtained from the Royal Netherlands Meteorological Institute (KNMI), Schiphol's Automatic Terminal Information Service (ATIS)[31] and information from the crews on board PH-BDP and CAL5420.

Winter weather with snow and frost prevailed at Schiphol on the days prior to the accident. There was snow on the airport terrain. On the day of the incident, the weather at Schiphol was influenced by a polar air system with a light frost and clouds at a minimum of 1,200 feet, with snow falling from time to time. Around the time of the incident a wind of 15 knots was blowing which varied from north to north-east. Visibility was 10 kilometres or more with occasional light snowfall, causing visibility to be reduced temporarily to 6,000 metres.

Take-off runway 36C was dry and snow-free with good braking action. The braking action advisory that applied on the taxiways and aprons was 'medium' as a result of snow. According to statements, taxiways Alfa and Bravo in the area near runway 36C were clean for the most part. There was a thin layer of snow on interconnecting taxiway A25.

Weather information can be found in appendix G.

2.11 Aids to navigation

Not applicable.

2.12 Communications

While taxiing, the crew had radio contact with various air traffic controllers. Runway 36C was put into use via intercom communication between the airport and air traffic control. Recordings of all conversations were available for the purpose of the investigation.

The transcript of radio communications between the crew and air traffic control can be found in appendix E.

2.13 Aerodrome information

Amsterdam Airport Schiphol (AAS) is a certified airport organisation. Every year the Transport, Public Works and Water Management Inspectorate (IVW) performs a prolongation audit for the purpose of extending the certificate. A more extensive recertification audit follows every five years for the purpose of renewing the airport certificate. The IVW audit standards are based on ICAO Annex 14[32] and the Regeling Veilig Gebruik Luchthavens en andere Terreinen (RVGLT) (this stands for national regulations for the safe use of airports and other aerodromes). The RVGLT requires that airports in the Netherlands fully comply with the standards specified in ICAO Annex 14 and also comply with a number of recommended practices[33] as further specified in the regulations. The certificate[34] implies that Amsterdam Airport Schiphol complies with the standards set out in ICAO Annex 14.

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31 ATIS, an automatic message for outbound and inbound traffic communicating the current weather conditions at the airport and operational details. This message is broadcast on various radio frequencies and is preceded by a letter.
32 Annex 14 contains standards and recommended practices for the design and standardisation of airports.
33 Standards: the standards set out in ICAO Annex 14. Recommended practices refer to the guidelines set out in ICAO Annex 14.
34 This only refers to an explanation of the system. The certification process does not form part of the investigation.

2.13.1 Infrastructure near runway 36C (see also appendix H)

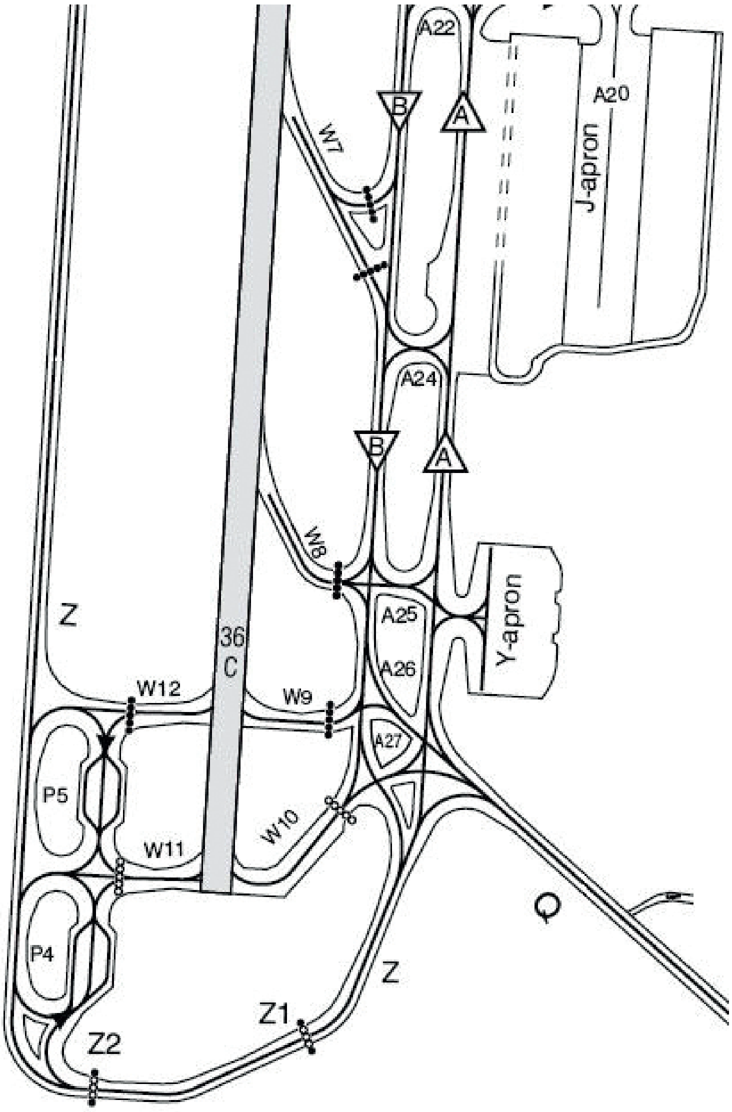

Figure 6: Overview of the entries and layout of the taxiways near runway 36C (source: AIP)

Runway 36C is surrounded by three parallel taxiways, i.e. a taxiway west of the runway and taxiways Alfa and Bravo on the east side of the runway. In total runway 36C features twelve entries to/exits from the runway (W1-W12).

When on taxiway Alfa and turning into interconnecting taxiway 25 to get to runway 36C, pilots have to cross first taxiway Bravo and then taxi down entry W8. W8 is positioned at an angle of approximately 30 degrees to runway 36C, because W8 functions as the rapid exit taxiway (RET) in the reverse direction when runway 18C is used for landing. Intersection W9 lies further south while W10 is located at the beginning of runway 36C. There is a taxiway junction near W10 leading to entry W10, taxiways Zulu and Quebec, and taxiways Alfa and Bravo, see figure 6. Intersections W11 and W12 are located on the west side of runway 36C.

2.13.2 Applied markings and lighting infrastructure
Amsterdam Airport Schiphol has applied the markings and installed the lighting and signs so as to enable use of taxiways Alfa and Bravo in both directions.

Markings
A broken white line marks the centre of the take-off or landing runway.

The taxiways also feature a continuous yellow line in the centre of the taxiway. This also applies to interconnecting taxiways such as A25 and entries W8, W9 and W10 to runway 36C, see figure 7.

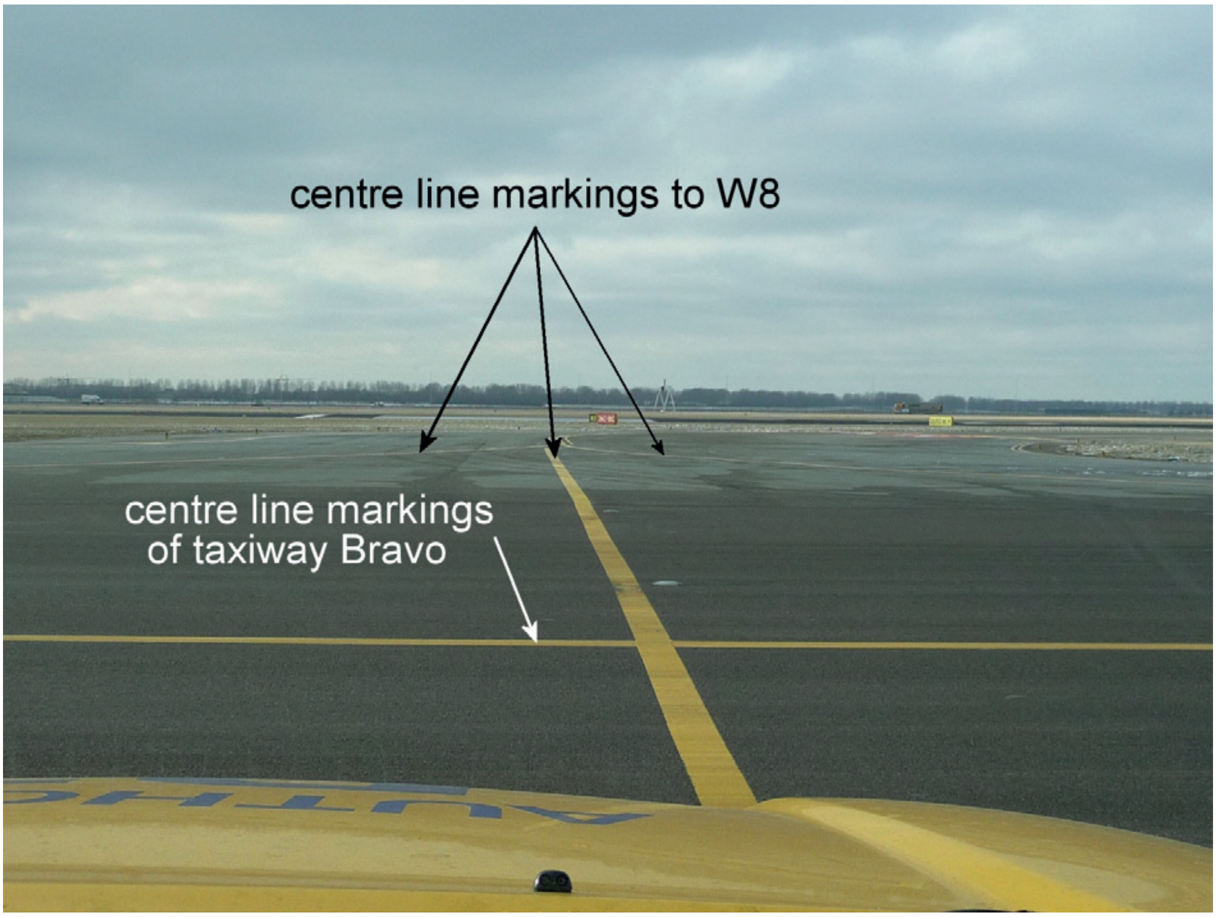

Figure 7: Yellow marking lines (centreline markings) during daylight on the intersection of interconnecting taxiway A25 with taxiway Bravo viewed into the direction of runway 36C.

Signs located along taxiways Alfa and Bravo near runway 36C
The illuminated signs located alongside taxiways Alfa and Bravo provide taxiway and take-off runway information in both directions, i.e. the compulsory directions and in opposite directions. For all relevant signs no failures were recorded at the time of the incident. See appendix H for an overview of the signs located along taxiways Alfa and Bravo.

Take-off runway and taxiway lights (see also appendix H)
The middle and sides of the runway feature white lights which mark the centre and edges of the runway

Taxiways Alfa and Bravo feature green centreline taxi lights which are visible from both directions. Blue markers (reflectors) on straight sections and blue lamps in curves mark the edges of the taxiways. No failures had been reported for the above lights at the time of the incident.

In accordance with the design, no green centreline taxi lights are visible at W8 for traffic departing via intersection W8 coming from taxiway Alfa via A25, or for traffic turning in from taxiway Bravo.

2.13.3 Description of snow clearance and spraying taxiways and runways

General
The winter logic system at Schiphol that records the movements and activities of spraying vehicles shows that preventive spraying (anti-ice/snow) took place in the late afternoon because the take-off and landing runways might become slippery as a result of expected snowfall and subsequent ice formation. The log shows that runway 36C and the normal entries W9 and W10 were sprayed.
No detailed record is kept of snow clearance activities on runways.[35] It takes around 40 minutes to clear away snow from a runway and the required entries. In practice the number of entries where snow is to be cleared are limited in order to keep the presence of snow clearance equipment[36] on runways and entries to a minimum. For runway 36C, this means that only W10 and W9 are swept.

The snow cleared by snow clearance equipment is deposited right next to the runways. The winter of 2009/2010 saw a great deal of snow fall in a short period of time, which is unusual for the Netherlands. The snow was collected at central locations, such as the de-icing aprons near entries W11 en W12.[37]

Runway inspection prior to the incident
An airport bird controller inspected runway 36C, including the signs and runway lights before the runway was released for operation. The AOM released runway 36C to air traffic control.

2.14 Flight recorders

The aircraft was fitted with a flight data recorder (FDR) and a cockpit voice recorder (CVR). A read-out was obtained from both recorders. The FDR was used to reconstruct the flight.

CVR's have a recording capacity of approximately two hours. After the maximum recording time has been reached, the recorder continues to record and overwrites the data recorded earlier. A ground engineer in Warsaw switched off the CVR's electrical power after the crew had left the aircraft. The quality of the CVR recording was good. In view of the late point in time at which the CVR's power had been switched off, the data relating to the take-off at Amsterdam Airport Schiphol had been overwritten.

Airline rules for using a CVR
KLM's basic operating manual (BOM) stipulates that the pilot in command should not allow the CVR to be switched off during the flight unless he or she believes that the data recorded could be relevant to an incident investigation. In that case the pilot in command is permitted to switch off the cockpit voice recorder.

The following actions are required to be carried out when switching off the cockpit voice recorder during a flight:

- the pilot in command is required to draw up an air safety report;
- the flight deck crew are required to make a record in the aircraft maintenance log marked with the text 'INCIDENT'. This is to ensure that the pulled CVR circuit breaker preserves the data on the CVR safeguarding it for the technical department and also that the circuit breaker is not reset, and the CVR is removed from the aircraft after arrival at Amsterdam Airport Schiphol.
- If a serious incident or accident has occurred during the flight and the aircraft's electrical power has been removed, the CVR circuit breaker must be pulled to preserve the data prior to resupplying the aircraft with electrical power to prevent CVR data from being inadvertently erased.

35 The airport records that snow clearance activities have taken place but does not record at which locations.
36 Snow clearance equipment refers to the entire fleet of snow clearance vehicles deployed to preventively or correctively keep the runway and taxiway system free of snow, black ice, etc.
37 For environmental reasons the de-icing aprons near W11 and W12 feature a separate drainage system to collect the de-icing fluids.

KLM is required to retain the data for the investigation of a serious incident or accident, notification of which is compulsory, for 60 days unless the investigating authority determines otherwise.

2.15 Wreckage and impact information

Not applicable.

2.16 Medical and pathological information

Not applicable.

2.17 Fire

Not applicable.

2.18 Survival aspects

Not applicable.

2.19 Tests and research

2.19.1 Report of the crew on board CAL5420
According to the crew on board CAL5420 the weather did not affect taxiing even though the yellow lines could not be clearly seen because of the thin layer of snow on the taxiways. While taxiing to runway 36C the crew were too late in turning into entry W10. They found the taxi route confusing and the taxi instructions not specific enough but failed to advise air traffic control thereof. No further investigation was conducted into this aspect.

2.19.2 Previous take-offs from runway 36C
The main take-off runway initially was runway 36L. In view of the start of the outbound peak air traffic control started operating runway 36C as the second runway for take-offs. The flight operated by the PH-BDP was the eighth flight scheduled to take off from runway 36C and the first to use entry W8.

2.19.3 Simulator sessions
The full flight training simulator was used twice for the purpose of this investigation.

Simulator session 1
In between the time the PH-BDP had left the de-icing apron and the time the crew had received the instruction to taxi W8, the crew performed tasks in accordance with the checklist and carried out radio communications in rapid succession but without these activities qualifying as being rushed.

After having received the instructions to taxi to W8, the crew's work load increased as a result of having to change the information in the FMS and having to turn off to the interconnecting taxiway A25. Mutual coordination among the two pilots, the performance of tasks and radio communications followed each other closely or took place simultaneously. A row of lights forming a straight line came into view and take-off clearance followed.

Simulator session 2
The purpose of the second simulator session was to verify the findings from the first session with the crew and to find out whether they were able to recall any further information or provide any further account of the situation.

The simulator session revealed that the first officer had looked outside on fewer occasions than he himself had thought. Due attention was given to the new route to W8 and flight CAL5420. During the simulator session debrief the pilot in command stated that he had followed the conversations between the ATC tower and CAL5420 and that they had distracted him. He also came to the conclusion that he had been watching more inside of the cockpit than he had thought.

Further details of the findings have been included in appendix I.

2.19.4 Visual information for the flight deck crew

During darkness flight deck crews are more dependent on visual aids in order to follow the required taxi route than during the daytime.

Appendix J explains what visual information was available to the crew on board PH-BDP.

2.19.5 Visibility of the Boeing 737 from the ATC tower

The infrastructure near runway 36C can be clearly seen from the ATC tower in daylight, as a result of which the positions of aircraft taxiing and taking off can continually be established accurately. This changes when it is dark.

When it is dark, there are more restrictive factors for air traffic controllers making it more difficult to establish the position of traffic accurately. The restrictive factors are described in appendix J.

2.19.6 Monitoring departing traffic by air traffic controllers

The general procedure is to first scan the runway prior to issuing take-off clearance. If there is little traffic the full take-off of the aircraft is monitored as much as possible. If the traffic volume is large, as a matter of routine runway controllers in any event endeavour to watch an aircraft taking off around the time of rotation because they believe this is an important moment.

2.20 Organisational and management information

2.20.1 Parties involved

The parties involved are the KLM and the pilots on board the PH-BDP, air traffic control the Netherlands (LVNL) and the air traffic controller and assistants on duty, and Amsterdam Airport Schiphol. For further information on the parties involved and their responsibilities, see appendix C.

In accordance with the regulations and guidelines, the responsibilities of the parties involved are detailed in a reference framework, see appendix D.

2.21 Other relevant investigations conducted by the dutch safety board

This report incorporates a number of investigations into runway incursions that occurred at Amsterdam Airport Schiphol, in which the response of the aircraft crews differs from the expectations of the air traffic controllers. Appendix K contains summaries and details of the underlying factors.

2.22 Other relevant investigations conducted abroad

This report incorporates a number of accidents and serious incidents showing similarities with the flight of the PH-BDP. The accidents involving Singapore airlines flight SQ006 (Taipei, 2000) and Comair flight 5191 (USA, 2006) show what accidents can be caused as a result of runway confusion.

According to information obtained from the Flight Safety Foundation there are a significantly lower number of fatal runway confusion incidents than fatal incursion incidents. The article states that the severity of such incidents should nevertheless not be underestimated because this threat is becoming increasingly manifest all over the world and runway confusion statistics are not yet complete. Runway confusion incidents usually reflect the same underlying factors as runway incursions.

A runway confusion incident involving Aeroflot flight AFL212 occurred at Oslo Airport Gardermoen on 25 February 2010. This turned out to be the second runway confusion incident at the airport following the incident involving Pegasus airlines flight PGT872 that had taken off from the same taxiway in October 2005. The infrastructure surrounding the relevant take-off runway at Gardermoen showed strong similarities with the infrastructure near runway 36C at Amsterdam Airport Schiphol.

The runway confusion incident involving Finnair flight FIN070 at Hong Kong International Airport in November 2010 also occurred in a layout comprising parallel runway systems. The take-off of the Airbus A340 from the taxiway located adjacent to the take-off runway was aborted. According to the Hong Kong Civil Aviation Department this was the fourth runway confusion incident that had occurred at the same location. As a temporary safety measure Hong Kong air traffic control stipulated that take-off clearance would not be issued as long as it has not been established with certainty whether traffic has passed the taxiway to be crossed.

More information on the above incidents and runway confusion investigations can be found in appendix L.

3 ANALYSIS

3.1 Introduction

Runway confusions are potentially highly dangerous as they involve an aircraft at high speed at locations where no one is expecting them in order to take off or land. In addition to other objects, such as aircraft, vehicles, etc., there may also be work in progress at these locations, with all the ensuing risks of collision.

This chapter examines how this serious incident could have occurred and what measures have been taken to prevent a similar occurrence.

3.1.1 The severity of the incident

Users, such as pilots, have certain expectations in respect of the use of runways and taxiways. On the basis of the clearance and instructions issued, air traffic controllers have certain expectations in respect of the traffic they supervise. In the vast majority of cases air traffic is compliant with the instructions. Nevertheless the response of a flight deck crew could turn out differently from what the air traffic controller and the other users had anticipated.

This also proved to be the case for the PH-BDP: the flight deck crew on board the Boeing 737 took off from a taxiway instead of the designated take-off runway. Air traffic control had not taken this possibility into account and had also failed to notice this straight away. This meant that the situation was no longer under control. On account of the traffic situation a collision could have occurred because other users were making their way to the taxiway, which they were going to use in the opposite direction.

As far as the Dutch Safety Board was able to establish, only one runway confusion incident had previously occurred at Amsterdam Airport Schiphol in the past decade. This took place on 24 December 2001 when an Alitalia aircraft took off from a taxiway located parallel to take-off runway 24. The take-off was aborted on time. Although a taxiway take-off rarely occurs, the Dutch Safety Board believes that the take-off from taxiway Bravo is not an isolated case. In the analysis the Board found that the incident shows similarities with runway incursion incidents at Amsterdam Airport Schiphol.

3.1.2 Structure of the investigation analysis

The analysis shows why barriers (procedures and carrying these out correctly, the infrastructural facilities, monitoring and suchlike) that could have prevented this incident failed to work. Since the majority of these barriers are determined by human factors, this aspect was explicitly included in the analysis.

The analysis first describes the extent to which the infrastructure of the taxiways and take-off runways played a role in the incident. Sections 3.2 through 3.3 subsequently describe why the decisions taken by and the actions of the flight deck crew directly led to the origin of the incident. Section 3.4 also analyses the role of air traffic control while Section 3.5. analyses that of the Transport, Public Works and Water Management Inspectorate. The other contributing factors are examined in Section 3.6. Lastly, Section 3.7 contains the measures that the parties involved took following the incident.

3.1.3 Factors known to contribute to runway confusion incidents

The Australian Transport Safety Bureau (ATSB) identified eight factors that contributed to the occurrence of runway confusion incidents during take-offs at night.[38] (see appendix L). These factors are shown in figure 8. Two factors did not contribute to the incident investigated, i.e. extra 'runway pavement' and 'fatigue of crew'. More information on the fatigue factor can be found in Section 3.3.1.

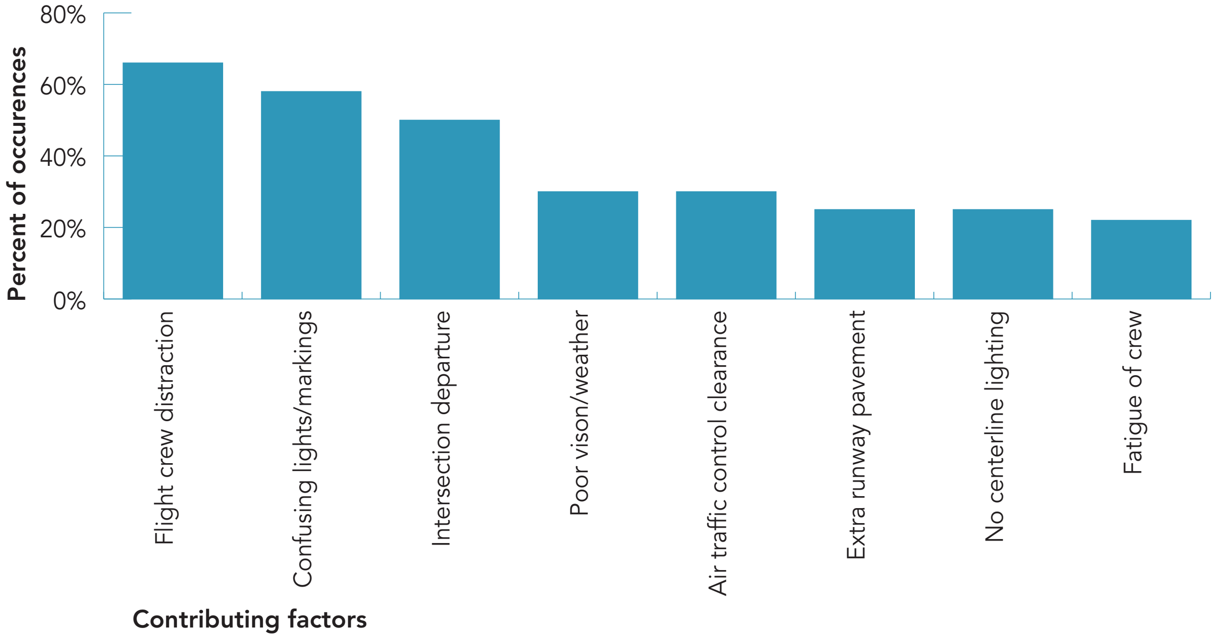

Figure 8: Factors contributing to misaligned takeoff occurrences at night (source: ATSB)

The other six factors were found to have contributed to the incident involving the PH-BDP and are discussed in the relevant chapters of the analysis, where applicable. In most cases they relate to the cockpit environment; some factors, however, apply to air traffic control. The following sections examine the relationship between these factors and the incident.

3.2 The runway and taxiway infrastructure at Schiphol

3.2.1 General

In terms of infrastructure, the layout plays a role in respect of situational awareness, distraction and confusion. The Flight Safety Foundation (FSF) also refers to such findings (see appendix L).

Amsterdam Airport Schiphol features a 'one-terminal concept' with a centrally located passenger terminal surrounded by a tangential runway system comprising four of the five main runways. A double ring of taxiways is located between these main runways and the terminal building, except for the south-side of the airport: taxiway Alfa is located on the inside, and taxiway Bravo on the outside (viewed from the terminal). Taxiways Alfa and Bravo are linked by means of interconnecting taxiways and both taxiways branch off to aircraft parking positions and aprons. Taxiways Bravo contains entries to and exits from the four main runways.

Runway 36C is surrounded by three parallel taxiways, i.e. a taxiway to the west of the runway and taxiways Alfa and Bravo on the east side of runway 36C. Runway 36C features twelve runway entries/exits in total (W1-W12).

38 Investigation report entitled 'Factors influencing misaligned take-off occurrences at night', ATSB, June 2010.

Apron J (Juliet) is located to the east of taxiway Alfa, see Apron J in figure 9. The compulsory direction of travel on taxiway Alfa near Apron J is northerly but if instructed by air traffic control an aircraft may leave Apron J by taxiing along taxiway Alfa in a southerly direction. The risk assessment carried out by Amsterdam Airport Schiphol on the use of Apron J, and the ATC de-icing procedures (see appendix D) are incomplete because they do not take account of the compulsory directions of travel on taxiways Alfa and Bravo.

3.2.2 Complexity of the taxiway system

Given the compulsory direction of travel, taxiway Bravo is used for traffic travelling to runway 36C. Taxiway Alfa can indeed also be used but in order for aircraft to take-off they must first cross taxiway Bravo via the interconnecting taxiways.

PH-BDP was instructed to use taxiway Alfa from Apron J to reach entry W8, and in order to do so first had to cross taxiway Bravo. Consequently a confusing layout situation arose. The fatal accident in Taipei in 2000, the two incidents at Oslo airport in 2005 and 2010 and the incident at Hong Kong airport in 2010 all occurred in a similar local layout comprising adjacent parallel take-off runways and taxiways where aircraft had to cross a taxiway or a take-off runway to reach the designated take-off runway (see appendix L).

In addition, a taxiway junction is located near entries W9 and W10, which leads to these entries, to taxiways Zulu and Quebec and to taxiways Alfa and Bravo (see figure 9). The junction can cause confusion among flight deck crews as was the case with the crew on board CAL5420, who consequently taxied too far in order to turn into entry W10 safely. It has emerged that crews feel that at some locations the taxiway system, particularly at junctions like the ones near entries W9 and W10, has an unclear layout. This junction has therefore been identified as a hot spot and has been communicated as such to aeronautical personnel in the AIP.

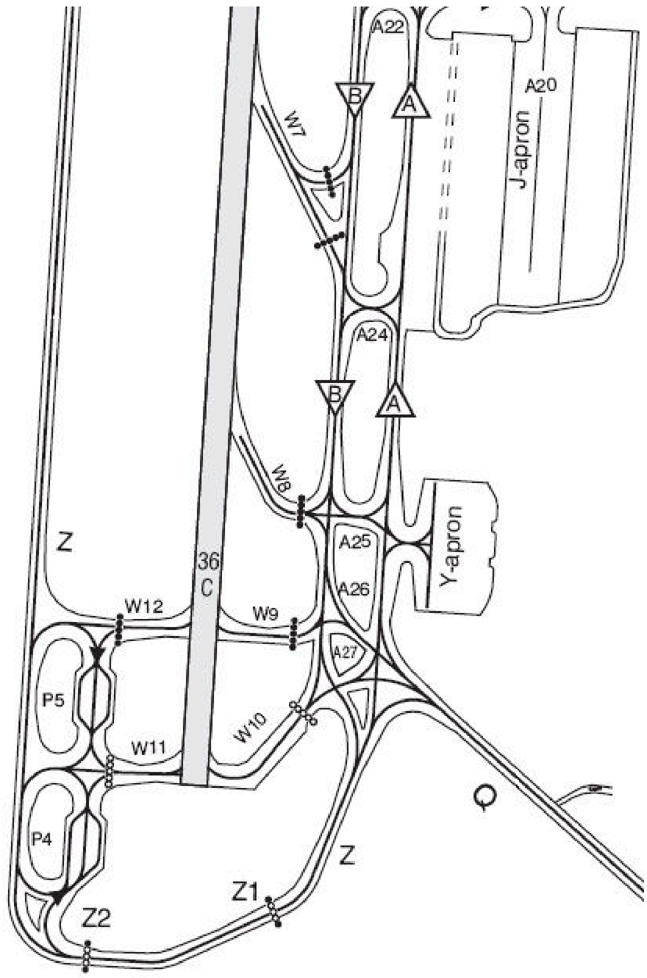

Figure 9: Overview of the entries and layout of the taxiways near runway 36C (source: AIP)

As has previously emerged from incidents in other countries, the layout of parallel runways and taxiways involves the risk of runway confusion. At Amsterdam Airport Schiphol when taxiway Alfa is used the risk of runway confusion increases because taxiway Bravo can be confused with take-off runway 36C.

3.2.3 Influence of weather conditions

Wintry weather conditions prevailed. There was snow on the airport terrain. The weather fluctuated between light snowfall and clear patches. Take-off runway 36C was dry and snow-free. According to statements, taxiways Alfa and Bravo in the area near runway 36C were clean for the most part. There was a thin layer of snow on interconnecting taxiway A25. In practice the number of entries where snow is to be cleared is limited in order to keep the presence of snow clearance equipment on runways and entries to a minimum. This means that snow was only cleared from entries W10 and W9 for runway 36C. According to the spray log and snow clearance logbook, snow had not been cleared from W8. The risk of incidents increases if all entries and taxiways are not cleared of snow and sprayed,[39] see also 3.6.4.

The PH-BDP taxied from taxiway Alfa, which was largely clean, to the interconnecting taxiway A25, which was covered with a thin layer of snow, and subsequently arrived at taxiway Bravo, which was also largely clean. The relatively long entry W8 was covered with snow and featured blue edge lighting but did not feature green centreline taxi lights. This may have created or intensified the effect of misleading passive guidance.[40]

The investigation did not reveal that the recent snowfall had had an immediate impact on the free view on the take-off runway and taxiway lighting for the PH-BDP crew. Indirectly, however, the snow on the airport grounds may have played a role in respect of the crew being able to distinguish the colours of the lights (see appendix J).

3.2.4 Markings

The centre of a take-off or landing runway features a broken white line. The taxiways feature a continuous yellow line in the centre of the taxiway (see figure 7). This also applies to interconnecting taxiways such as A25 and entries W8, W9 and W10 to runway 36C. There usually is a clear difference between the white broken lines on a runway and the continuous yellow lines on taxiways. When it is dark, however, the yellow line cannot be clearly distinguished by the beam of a Boeing 737's taxi lights. In addition, the yellow lines could not be seen clearly because of the thin layer of snow on the taxiways, according to the crew on board flight CAL5420.

Two yellow lines run from interconnecting taxiway A25. A yellow centreline marking crosses taxiway Bravo and runs straight ahead to entry W8. The other yellow line follows a northward curve to taxiway Bravo.

As stated above, entry W8 was covered with snow. From interconnecting taxiway A25 a yellow line was therefore visible but was no longer visible on the other side of taxiway Bravo. A yellow line running along a curve to the relatively clean taxiway Bravo was also visible. The yellow taxi line of an entry usually continues along the curve up to and including the runway centreline, serving as line-up guidance. This also applies to Amsterdam Airport Schiphol. By following the yellow line to taxiway Bravo the crew may have taken this as confirmation that they were on the take-off runway.

39 This had been established on a previous occasion. See the Dutch Safety Board's report entitled 'Loss of control on a slippery runway by EasyJet Boeing 737-700, registration G-EZJM, at Amsterdam Airport Schiphol on 22 December 2003'. The full report is available on www.onderzoeksraad.nl. When this incident and that of the PH-BDP occurred taxiways were available that had not been cleaned. The EasyJet crew had not been assured that they could not use a slippery taxiway. During the incident involving the PH-BDP the intention was to use entry W8 but air traffic control was unaware that it was covered with a thin layer of snow.

40 Misleading passive guidance refers to a pilot's own interpretation of information, which could inadvertently be misleading.

3.2.5 Runway and taxiways signs and lighting

Signs (see also appendix H)
There are no indications suggesting that the signs played a role when taxiway Alfa was used against the compulsory direction of travel. The relevant take-off runway and taxiways were all available for use. The technical condition of the corresponding sign and runway lighting was good, the lighting functioned properly and there were no irregularities. However, a number of yellow signs were partly covered with snow but this did not make the signs indecipherable.

The layout of the airport's infrastructure is based on the compulsory direction of travel on taxiways. Yet visible signs containing route information are located along the routes followed by the PH-BDP and CAL5420, i.e. against the compulsory direction of travel (see 2.2.3). The markings, lighting and signs have been placed so as to enable pilots to use taxiways Alfa and Bravo in both directions and to enable them to double check their position in both directions. Signs for both directions, containing information relating to the aircraft's position and taxi routes are located alongside taxiways Alfa and Bravo as well as at interconnecting taxiway A25.

The layout of the signs does not guarantee that the compulsory direction of travel will be followed nor the correct taxi routes aircraft have been instructed to use.

Lighting (see also appendix H)
The centre and edges of take-off runway 36C feature white lights. Taxiways Alfa and Bravo feature green centreline taxi lights which are visible from both directions. Blue markers (reflectors) on straight sections and blue lamps in curves and alongside the entire entries mark the edges of the taxiways and entries.

Amsterdam Airport Schiphol does not have a taxiway lighting system on which only the lights required for taxiing traffic are illuminated. As a consequence, when it is dark all taxiway lights are illuminated, including those on taxiway route sections aircraft crew are not instructed to follow. Crews therefore run the risk of making an error. The risk increases particularly when the route the aircraft is instructed to follow is not illuminated.

When coming from the direction of taxiway Alfa, no visible green centreline taxi lights are featured on interconnecting taxiway A25 and entry W8. From A25 only blue edge lighting is visible in the curves of W8, on account of which no clear taxiway structure can be determined. Consequently, no clear passive guidance exists on W8.

The lack of green centreline taxi lights at W8 is not published in NOTAMs or in the AIP. As a result air traffic controllers and pilots will not automatically be aware that the taxiway lighting could prove misleading for aircraft making their way from taxiway Alfa to entry W8.

During the reconstruction of the incident it emerged that from position A25 the green centreline taxi lights on taxiway Bravo are more clearly visible than the lighting on take-off runway 36C. As a result and because there is no centreline lighting on intersection W8, the lights on taxiway Bravo form an 'inviting' straight line of lights in the direction of take-off. The blue markers on taxiway Bravo became clearly visible after the Boeing 737's landing lights had been activated but are not as conspicuous as the green centreline taxi lights.

The conclusion can be drawn that the factors of 'no centreline lighting' and 'confusing lights' and consequently also 'intersection departure' (see figure 8) apply to this incident.

3.2.6 Visibility of take-off runway 36C during darkness
Footage was shot from a taxiing Boeing 737 outside the Uniform Daylight Period (UDP) for the purpose of determining aspects such as the visibility of runway 36C. Coming from taxiway Alfa and looking down interconnecting taxiway A25 to take-off runway 36C, it emerged that not only can the edge lights of the take-off runway indeed be seen but also the lights of a motorway in the background (see figure 10).

Since the depth of field cannot be seen when it is dark, the edge lights consequently form patterns with the lights in the background and they therefore cannot be clearly distinguished. The lighting on taxiway Bravo, on the other hand, is indeed clearly visible, as a result of which there is an increased risk that crews will confuse taxiway Bravo with take-off runway 36C.

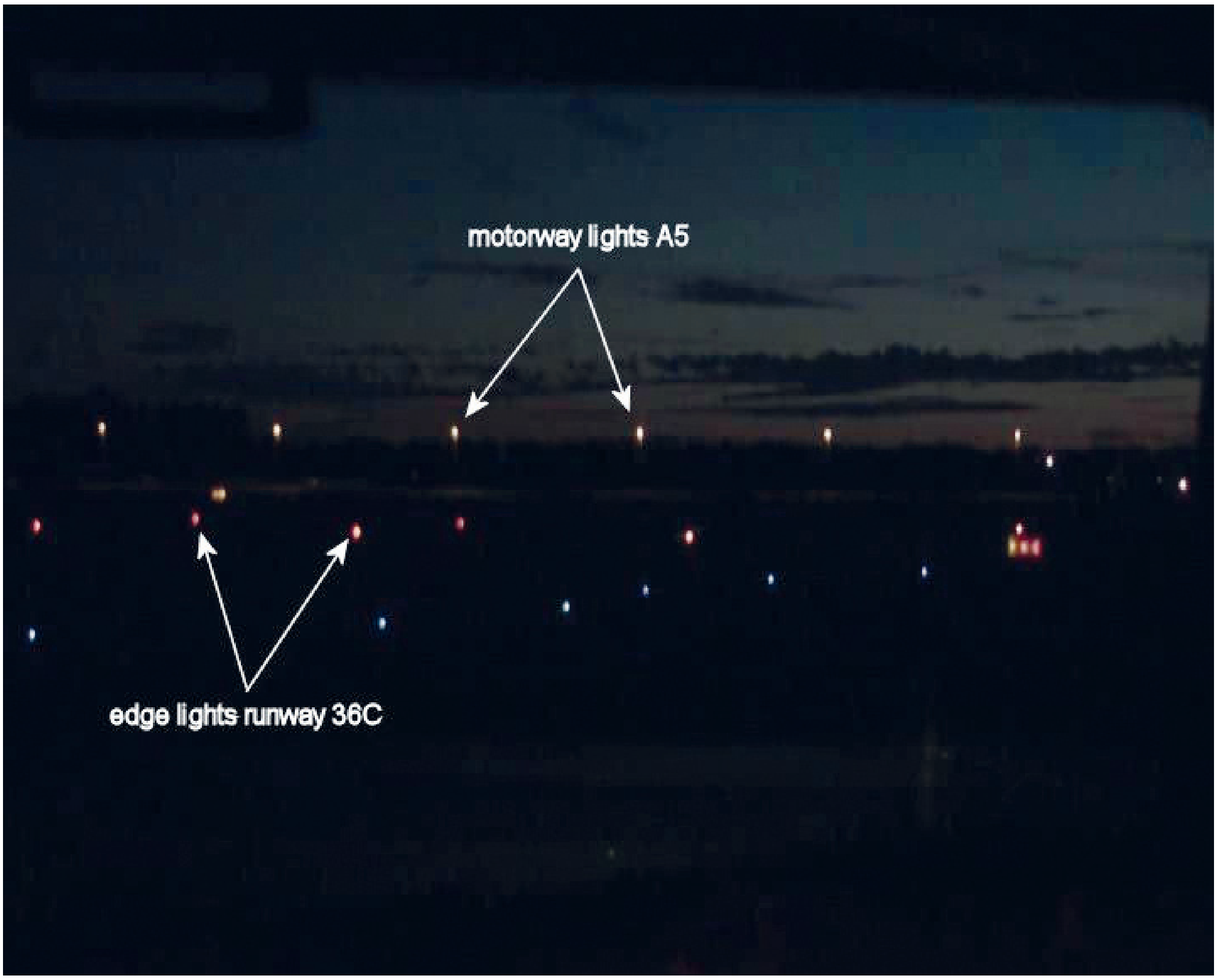

Figure 10: Patterns of the edge lights on runway 36C and the lights of the A5 motorway

It can be established that the background lights at and surrounding the airport contribute to the factors of 'poor vision' and 'confusing lights' shown in figure 8 in respect of the visibility of the runway.

3.2.7 Conclusion on the take-off runway and taxiway infrastructure

In terms of the layout of the infrastructure the airport complies with the general standards specified in ICAO Annex 14. However, in dark conditions this does not ensure that there is a clearly recognisable route via W8 to take-off runway 36C. The above shows that using entry W8 when it is dark involves more risks, particularly when aircraft are taxiing via taxiway Alfa to runway 36C. In view of the risks referred to earlier, there is a higher risk of runway confusion.

3.3 PH-BDP crew

3.3.1 Fatigue of flight deck crew

The crew stated that they had had sufficient rest and were fit. In addition the pilot in command stated that as a night person he actually preferred to work later during the day as was the case for this particular flight. There are no indications suggesting that the crew were fatigued.

3.3.2 A new taxi route for the flight deck crew

After the aircraft had been de-iced, the crew were instructed to taxi to runway 36C from Apron J via taxiway Alfa in a southerly direction. The crew were transferred to the runway controller's frequency on taxiway Alfa near interconnecting taxiway A24. He instructed the crew to go to intersection W8 provided the crew were ready to do so. Shortly after the transfer, the runway controller offered the PH-BDP crew the use of entry W8 because the crew were home-based and knew their way around Schiphol. The runway controller was unaware that entry W8 was covered with a layer of snow.

Entry W8 is located before entry W9, which the crew had prepared as the take-off entry. By using entry W8 the crew had the opportunity to depart earlier. This would mean that part of the delay incurred on account of having the aircraft de-iced could be made up. The pilot in command felt that flight punctuality was one of the permanent challenges of his job. Against this background, accepting a take-off via entry W8 was appropriate.

KLM also expects its pilots to operate with the customer's interests in mind. This also implies that on the basis of published time tables pilots operate as efficiently as possible and save fuel whenever possible. Accepting an intersection take-off is in line with this policy.

As a consequence the data in the Flight Management System (FMS) had to be changed for the take-off via entry W8. The crew were therefore not actually ready to depart from entry W8 as confirmed to the runway controller but expected to be ready when they had reached W8. The runway controller could have been aware of this because entry W8 had only been mentioned for the first time and is not a standard departure entry anticipated upon departure.

It takes time to change the data in the FMS and distracts a pilot during taxiing. As a result, the tasks were executed in such a way that the pilot monitoring was no longer monitoring the situation outside the cockpit together with the pilot in command and the latter was directing his attention more inside the cockpit. The orientation of the taxi route therefore was solely dependent on the pilot in command's judgement. Since the crew did not stop but continued taxiing, they were furthermore forced to work under pressure in order to enter and check the changes in the FMS. This also emerged from the simulator sessions.

This modus operandi with tasks being performed less thoroughly[41], such as monitoring the aircraft's position and checking each other's activities, is not uncommon and is not in breach of the regulations. This may, however, lead to human error, which in turn will jeopardise safety.

The crew operated at Schiphol several times a week for many years and were familiar with the taxiways. Nevertheless it was an unusual taxi route for the crew. Both pilots stated that they had never previously departed from entry W8. Only the pilot in command had taxied to runway 36C from the de-icing apron on several occasions, but according to him this was always via taxiway Bravo. When entering runway 36C from taxiway B, a taxiway is never crossed. Since the aircraft was taxiing on taxiway Alfa, taxiway Bravo first had to be crossed in order to enter the runway.

KLM has taxiing procedures in place for the purpose of enforcing positional awareness and to avoid making an error in respect of the taxi route to be followed. The management is responsible for specifying these procedures. In terms of their applicability, the KLM assumes that its crews will use their common sense and powers of observation where safety is concerned.

Normally, the aircraft's position during taxiing is monitored on the airport's ground movement chart (map of the runway and taxiway layout). This was not the case here because the crew were very familiar with Amsterdam Airport Schiphol, their home base.

41 The Efficiency Thoroughness Trade Off or ETTO principle refers to the practice in which people and organisations must weigh up spending time and effort to prepare their tasks and spending time and effort in performing these tasks. The challenge is to find a balance between completeness and efficiency. It is impossible to maximise both completeness and efficiency simultaneously. One aspect will be detrimental to the other aspect. (E. Hollnagel, The ETTO Principle: Efficiency Thoroughness Trade-Off (2009).

This procedure is not uncommon if crew are very familiar with the situation but it does in fact carry risks if an unusual route is suddenly required to be followed.

The cockpit crew were aware of their position on taxiway Alfa. From that time onward the crew should have been more thorough in establishing the route to entry W8. Pilots and air traffic controllers continuously make an effort to operate as efficiently as possible. Offering and accepting an intersection take-off is in line with this operational practice. The parties involved must weigh up the options and may never sacrifice safety in an effort to operate efficiently.

The conclusion drawn is that the crew failed to any account whatsoever of mistaking the take-off runway because – after having taxied across Amsterdam Airport Schiphol on numerous occasions - this risk did not apply to them. No longer explicitly monitoring the aircraft's position and checking each other's activities less may consequently be regarded as honest mistakes.[42] The resultant loss of positional awareness and the diminished functioning of crew resource management (CRM) resulted in jeopardising safety, without this being immediately apparent to the crew.

3.3.3 Lining up on taxiway Bravo

After turning off to interconnecting taxiway A25 from taxiway Alfa, the pilot in command had to taxi straight ahead to W8. Entry W8 was not clearly visible at that position on interconnecting taxiway A25 whereas the lighting of taxiway Bravo was. The pilot in command's orientation was also hampered by the change from light to darkness and with snow masking the entry to W8. The pilot in command had also been distracted by radio communications between the air traffic controller and another aircraft, the CAL5429, which was en route to runway 36C. The pilot in command was uncertain whether permission had been given to enter runway 36C via entry W8. At the pilot in command's request, the first officer confirmed this with the runway controller prior to reaching taxiway Bravo.

The air traffic controller provided take-off clearance on the transfer zone of interconnecting taxiway A25 to taxiway Bravo. This may possibly have served to confirm the crew's impression that they had meanwhile reached runway 36C. At that particular moment the pilot in command was no longer aware of his position in relation to the runway 36C (loss of positional awareness). Despite the crew's familiarity with the local situation and despite the visual markings indicating that it was a taxiway, the pilot in command turned onto taxiway Bravo assuming that it was runway 36C.

The simulator sessions revealed that from the time that the PH-BDP had entered interconnecting runway A25, the crew were busy steering, activating the lights, processing information and performing verifications. This meant that a great deal of attention had to be devoted to the cockpit processes. The first officer who had been busy with other tasks in the cockpit and therefore was unable to monitor the taxi route adequately, failed to notice the error. The 'flight crew distraction' factor described in figure 8 applied.

After the aircraft had lined up the likelihood of the crew still noticing the error was reduced. Only the pilot in command, who served as the pilot flying, looked outside when the aircraft started moving. The take-off procedure in fact specifies that the first officer, who served as the pilot monitoring, watches the instruments, particularly the speed indicator, and as a result mainly looks inside the cockpit .

It proved to be crucial to monitor the aircraft's exact position while it was taxiing; the more so as the crew had received take-off clearance while the aircraft was taxiing on interconnecting taxiway A25 and were able to commence the take-off run immediately after having lined up on the taxiway. During taxiing the crew lost their positional awareness causing them to take-off from a taxiway instead of the take-off runway. From a human factor point of view, take-off clearance probably played a role in terms of timing. The 'air traffic control clearance' factor in figure 8 therefore applies to the incident involving the PH-BDP.

42 An honest mistake is a wrong decision - in hindsight -, the unintentional negative outcome of which had not been anticipated.

The conclusion can be drawn that in the situation that had occurred, the parties involved had failed to recognise adequately the risks involved in offering and accepting entry W8, as a result of which the procedures were not carried out with the close attention required in this particular case.

The performance calculation
If a different entry is to be used, generally speaking a new performance calculation must be made because the available runway length will change, for example. The time required to recalculate performance[43] was so long that it would negate the time that had been gained. Based on their experience, the crew estimated that in terms of performance it would be possible to take-off via W8 by selecting maximum thrust for take-off. They used a V_1 of 148 knots that was intended for departure from entry W9.

The subsequent calculation incorporated in appendix F shows that the crew's estimate was correct. However, this modus operandi is not in line with company procedures.

3.3.4 Indications that a taxiway was being used
It was dark and bright lights illuminated the airport buildings and aprons. The pilot in command stated that when he was on taxiway Alfa he had noticed quite a lot of light from flashing lights and lamp posts to the left and that the situation was dark on the right-hand side.

During darkness the human eye is sensitive to altering to light- and dark conditions. This can reduce the ability of the human eye to distinguish colours.[44] In these circumstances green light is known to be perceived as a kind of white light.[45] There was snow on the airport terrain and this intensified the reflection of light. It reduced the crew's ability to distinguish colours.

It should therefore not be ruled out that the taxiway's green centreline taxi lights resembled the colour of the white lights on the take-off runway. The film reconstruction (see appendix J) shows that the yellow lines and blue markers were not clearly visible or noticeable with the Boeing 737's standard taxi lights. This situation improves with activated landing lights during line-up. The blue edge lights in the curves make the contours of A25 clearly visible. To the extent the crew consciously noticed this, it failed to get through to them and change their mindset.

Taxiway Bravo is some fifty percent narrower than take-off runway 36C but the crew failed to notice this. However, it was the first officer who had detected that there were mounds of snow on the side of the taxiway as a result of snow clearance activities. It emerged from the interview with the pilot in command that the crew had taken off from St. Petersburg the day before where the take-off runway was only partly visible due to the snow on the runway. It should therefore not be ruled out that this experience, whereby take-off runways sometimes seem to look narrower in snowy conditions because snow has not been cleared away from the entire width of the runway, may possibly have played a role for the PH-BPD crew.

3.4 Air traffic control the netherlands (LVNL)

3.4.1 Compulsory direction of travel
In principle air traffic control the Netherlands maintains the direction of travel on taxiways Alfa en Bravo specified in the AIP. This carries the advantage that the pilots can prepare for the taxi route while reducing the air traffic controller's radio load. However, depending on the traffic situation, the air traffic controller may assign a different route or direction of travel. Air traffic control's interpretation thereof is that the controllers may deviate from the compulsory direction of travel to improve the traffic flow or to facilitate aircraft crews. This happens often, see figure 11.

43 Performance refers to performance standards which indicate at what speeds the aircraft can rotate, safely reject take-off or climb safely after engine failure during take-off.
44 For more information and literature references on this topic, see appendix J.
45 Physiology experts of the Royal Netherlands Air Force's Aviation investigated the effect of light and dark situations on the human eye at the time of the incident, see appendix J. When determining the scope of the investigation, for the sake of completeness the Board included this aspect in the analysis but has not explored it in depth.

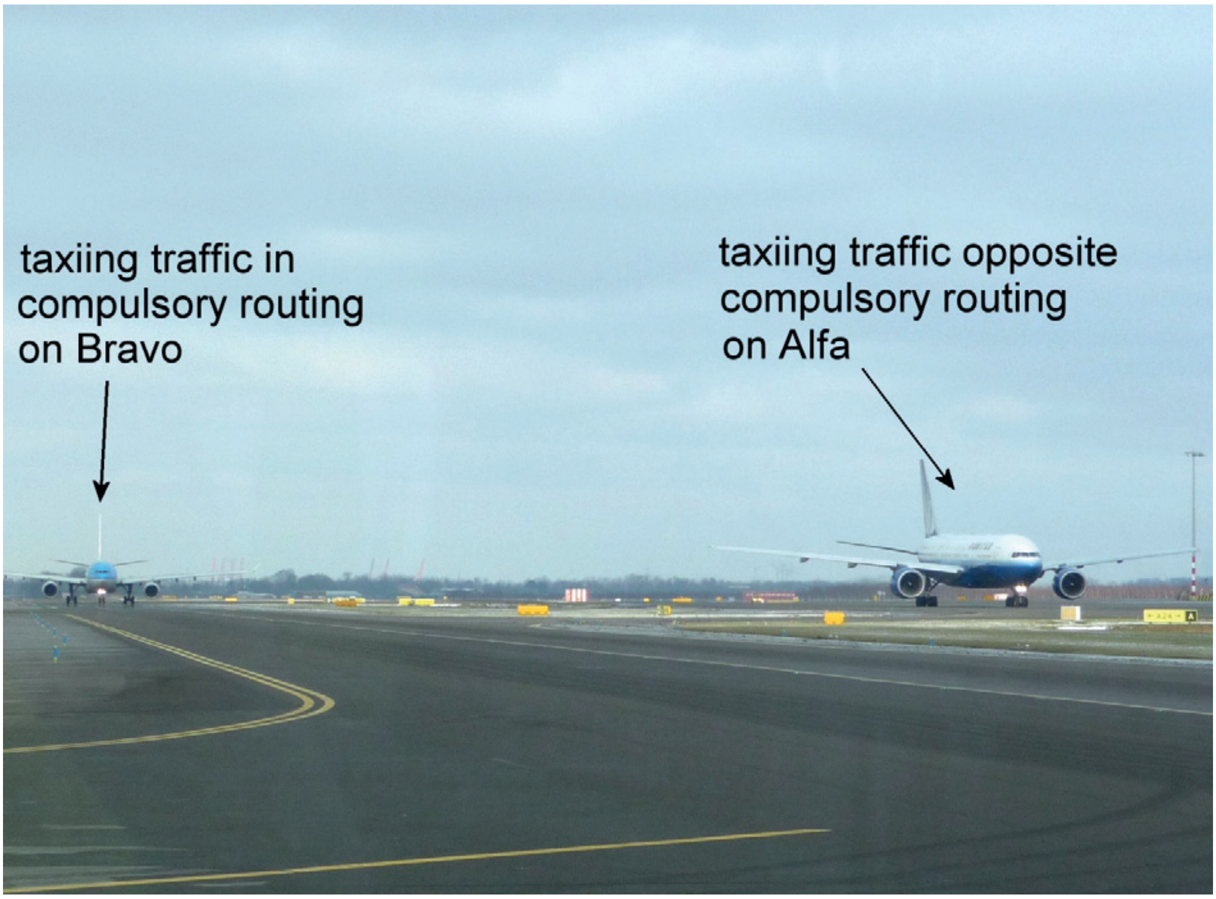

Figure 11: Traffic travelling on taxiways Alfa and Bravo in a southerly direction at Schiphol

Since apron Juliet, the de-icing apron, is located alongside taxiway Alfa, when using entry W10 of runway 36C, the most obvious taxi route to follow is taxiway Alfa in a southerly direction. The taxi routes that the CAL5420 and PH-BDP were instructed to follow were in accordance with the applicable procedures.[46] These procedures do not incorporate the safety measures in place to prevent aircraft from taxiing along the incorrect route. However, on the basis of their experience air traffic controllers do assess the traffic that they expressly wish to monitor. In that sense risks are weighed up.

The result of not taxiing in accordance with the specified – or standard - direction of travel is that the aircraft is required to cross a parallel taxiway for an intersection take-off. The risk of incidents occurring consequently increases. This also corresponds with the findings of the Flight Safety Foundation (see appendix L), who have stated that deviating from standard taxi routes and performing intersection take-offs may form contributing factors in the occurrence of runway confusion incidents. In respect of the situation at Amsterdam Airport Schiphol it has not been established – and it is therefore unclear - how these risks are controlled.

3.4.2 Transfer from ground to runway control

An aircraft may be transferred from the ground controller to the runway controller if there no longer is any room for error in the taxi route the aircraft should follow. On account of ensuring the traffic flow or efficiency, the procedure is not always strictly followed and an aircraft is transferred to a runway controller at an earlier stage. In practice air traffic is transferred as soon as the traffic movements are assessed as 'non-conflicting', i.e. the likelihood that an aircraft will travel the incorrect route (and as a result may be in conflict with other traffic), is so low that it is justifiable to transfer it to the runway controller. The CAL5420 and PH-BDP on taxiway Alfa were transferred to the runway controller.

46 These procedures are set out in the AIP, the manual for air traffic control Regulations I, Part 2 (VDV), and in the Runway Combination De-icing Procedures.

The criterion 'if there no longer is any room for error in the taxiway the aircraft should follow', however, involves many more factors than the 'non-conflicting' movement of traffic and plays an even greater role if aircraft do not taxi along standard routes. This definitely applies when taxiway Bravo is first to be crossed before the aircraft is able to line up on runway 36C. The risk of making an error thus increases. It was concluded that when the CAL5420 and PH-BDP were transferred from ground to runway control the transfer procedure requirement was not met because there was still room for error.

On account of the increasing volume of taxiing traffic the ground controller meanwhile transferred CAL5420 and PH-BDP to the runway controller but this increased the latter's workload. When an aircraft is transferred early the runway controller takes over the responsibility for taxiing aircraft, which also require his attention in addition to his primary responsibility for traffic taking off. Because the runway controller suddenly had to solve a problem with the CAL5420, he was unable to direct sufficient attention to the PH-BDP. He stated that he had in this case consciously focused more attention on the CAL5420 because he had established that CAL5420 was having difficulty in finding the correct route at the junction near entry W10. What he did state was that he had still seen the PH-BDP taxi to the take-off runway in a westerly direction on interconnecting taxiway A25. That was at the time he had issued take-off clearance to the crew on board the PH-BDP.

3.4.3 Take-off clearance and monitoring aircraft

Take-off clearance
The runway controller had issued take-off clearance before the aircraft had crossed taxiway Bravo. In principle take-off clearance is issued when the aircraft is on the take-off runway or is approaching the runway.[47] This is generally conditional on the traffic situation. It is not explicitly stipulated that air traffic controllers should actually be able to see the relevant aircraft when issuing take-off clearance. In practice this sometimes is, and sometimes is not the case.[48] The time at which take-off clearance is issued may contribute to the occurrence of incidents. Take-off clearance is the final barrier before an aircraft commences its take-off run and indicates that it is safe to take-off. In between the time that take-off clearance is issued and the time at which the take-off run actually takes place, circumstances may change or be different than originally thought, as was the case with the PH-BDP. This has also been evidenced by several runway incursion incidents (see appendix K).

An early take-off clearance involves risks. The Flight Safety Foundation has also established similar findings (see appendix L). For safety reasons runway controllers should therefore continue to monitor an aircraft when early take-off clearance is issued. This did not happen due to the fact that the runway controller directed his attention to the CAL5420 and possibly also on account of the other aircraft under his responsibility. This can be regarded as an honest mistake[49] on account of his decision to focus his attention on CAL5420 in particular. The runway controller did not perceive his reduced focus on PH-BDP[50] as a risk.

Monitoring
It is crucial to monitor aircraft after having issued take-off clearance, particularly when clearance is given at a relatively early stage. Before issuing take-off clearance runway controllers usually scan a runway. They are trained to do so. The runway controller is therefore likely to have scanned the runway briefly while issuing take-off clearance to the PH-BDP. While scanning the runway, however, he could not have seen the PH-BDP on the runway because the PH-BDP was still on A25 at the time take-off clearance was issued. The runway controller stated that he had still seen the PH-BDP at that time. On account of his focus on the CAL5420 and the other air traffic under his responsibility, he no longer monitored the PH-BDP after having issued take-off clearance. No one subsequently noticed the PH-BDP lining up and the commencement of the aircraft's take-off, in part possibly because ground radar does not show the direction of line-up.

47 ICAO Document 4444, Chapters 4.5, 7.6 and 7.9.
48 This may depend on a possible conflict with the movements of other traffic, which requires further attention, or because the runway controller pays closer to attention to air traffic receiving take-off clearance in particular due to other traffic.
49 See Section 3.3.2, footnote 42.
50 ETTO see Section 3.3.2, footnote 41.

The runway controller again focused his attention on the PH-BDP when assistant 1 pointed out to him that the aircraft was taking off from taxiway Bravo.

In view of PH-BDP's high speed and the traffic situation, the runway controller decided to allow the aircraft to continue its take-off run. As a result of the runway controller not intervening, the risks involved in aborting the take-off were prevented. The Board did not conduct a further investigation into the runway controller's decision.

The air traffic controllers stated that they assume that their instructions are followed correctly. They endeavour to check this as far as possible in their work processes. This means that monitoring does not take place in all circumstances. There are certain moments which air traffic controllers definitely want to monitor, notably the time of an aircraft's rotation and the first turn following take-off when two parallel runways are used for take-offs. This may result in focusing on monitoring the final section of the take-off run and on the commencement of a flight. This may have played a role when the incident occurred because two parallel take-off runways were being used, and around the time the PH-BDP lined up an aircraft had just taken off from runway 36C (see figure 3).

While assistant 2 does function as a safety net for the runway controller, and this includes monitoring aircraft, in practice this only applies to the extent permitted by other activities. Due to the snowy conditions and other traffic it was busy, and assistant 2 also failed to notice the PH-BDP lining up on and taking off from taxiway Bravo. The runway controller had no back-up staff to assist in monitoring aircraft.

The runway controller's workload increased when the CAL5420 and PH-BDP were transferred to him. In previous runway incursion investigations the Dutch Safety Board found that workload was a recurring factor in the occurrence of runway incursion incidents, particularly the aspect of monitoring. In an internal report[51] on the prevention of runway incursions air traffic control the Netherlands (LVNL) similarly finds workload a point requiring attention on account of the consequences arising for monitoring activities but as far as the Board is aware LVNL has not attached any consequences to this. In the incident involving the PH-BDP it can also be established that the implications of taking away some of the work from the ground controller ultimately resulted in traffic taking off not being monitored closely.

Factors impeding monitoring
When it is dark taxiways Alfa and Bravo cannot be distinguished from the ATC tower and the position of entry W8 is difficult to see. Stationary aircraft, such as the PH-BDP on that occasion, are even more difficult to see and they easily merge with the peripheral lighting. Advertising signs emit a great amount of back lighting as well. When it is dark, further factors impede monitoring which includes scanning. Ground radar, however, is always available. Flight deck crews are also more dependent on visual aids for following the intended taxi route than during the daytime. Despite the higher risks involved, the ATC processes for taxiing aircraft during darkness are the same as in daylight.

3.4.4 Background to the air traffic controllers' actions
As stated earlier, like pilots air traffic controllers continuously make an effort to operate as efficiently as possible. Offering an intersection take-off is in line with this operational practice. The parties involved must weigh up the options and may never sacrifice safety in an effort to operate efficiently.

Apart from safeguarding safety it is air traffic control's duty to provide services as efficiently as possible. Taxiing against the compulsory direction of travel, the early transfer of the aircraft to the runway controller and the take-off clearance issued to PH-BDP serve to illustrate this. The way in which the air traffic controllers handled PH-BDP was in line with the general modus operandi.

51 Investigation report entitled 'runway incursions at Amsterdam Airport Schiphol, Operating Years 2005 and 2006', 16 April 2007 version. In addition to 'Recommendations' the report contains a section on 'Points requiring attention' just as is the case for monitoring in this report.

When looking back on their actions during the incident the air traffic controllers involved did not see any possibilities for preventing an incident, such as that involving the PH-BDP, unless it would be acceptable to handle air traffic less efficiently.

The air traffic controllers' modus operandi is a conscious organisational decision. air traffic control the Netherlands (LVNL) has previously stated that individual independence is a trait fostered in the practice of the air traffic controller's profession. In a previously published report[52] the Dutch Safety Board concluded that this could only be achieved safely if clear frameworks have been defined. In its response to the above report in 2011 air traffic control the Netherlands (LVNL) acknowledged the lack of a clear distinction between strict guidelines and a general framework.

3.4.5 Uncontrolled situation involving the risk of collision

The risk of air traffic taking off from a taxiway is that other traffic, which is unexpected, may pose a collision risk. Runway confusions are therefore potentially highly dangerous as they involve an aircraft at high speed at locations where no one is expecting them in order to take off or land. In addition to other objects, such as aircraft, vehicles, etc., there may also be work in progress at these locations, with all the ensuing risks of collision. Radar images show that a Royal Air Maroc Boeing 737 was making its way to take-off runway 36C via taxiway Bravo.

There are electronic systems – safety nets – that have the ability to detect when aircraft are taxiing along taxiways at too high a speed. This may indicate that the relevant aircraft is going to take off from a taxiway. Aircraft may be equipped with the runway Awareness and Advisory System (RAAS) that warns the flight deck crew as soon as the aircraft's speed exceeds 40 knots on a taxiway. The PH-BDP was not equipped with RAAS, see also Section 3.7.1. There are also systems that warn air traffic control when aircraft are taxiing along a taxiway at too high a speed. In the Hong Kong incident[53] (see appendix L) air traffic control was able to intervene because the system sounded a warning. There is no such system at Amsterdam Airport Schiphol.

Once the take-off run had commenced, apart from their own observations, there no longer were any safety nets available to either the flight deck crew or the runway controller which could have brought to their attention on time that the PH-BDP was taking off from the taxiway.

3.5 Transport, public works and water management inspectorate (IVW)

Systemic oversight

KLM, Amsterdam Airport Schiphol and air traffic control the Netherlands held certification at the time of the incident. This implies that the parties complied with the certification standards. The Dutch Safety Board did not conduct any further investigation into this aspect.

Infrastructure inspection

Following the incident involving the PH-BDP, IVW conducted an investigation at Amsterdam Airport Schiphol. The Inspectorate found that several interconnecting taxiways, including the A25, did not contain green centreline taxi lighting and that pilots regularly lost their bearings near entry W10. The Inspectorate found, however, that the layout of taxiways Alfa and Bravo south of Apron J complies with the ICAO standards.

The Inspectorate found no reason to take action on the infrastructure. The airport is responsible for making infrastructural changes and improvements exceeding ICAO standards.

52 See also the Dutch Safety Board's report 2007112, F-GUGI, airbus A318, Schiphol 'Near collision during a 'touch-and-go-landing'. The full report is available on www.onderzoeksraad.nl.

53 See for example 'Serious incident involving FinnairFIN070, Hong Kong International Airport, 26 November 2010' (appendix I), in which a warning system was operating. However, runway Incursion Alerting System Schiphol (RIASS) has been available to LVNL since the end of 2010. This system does not sound a warning for a taxiway take-off.

Inspection at KLM
The Inspectorate obtained information from KLM about the action taken by KLM, the internal investigation conducted by KLM and the action taken in respect of the pilots involved. KLM postponed its internal investigation into the PH-BDP because according to KLM the IVW's focus was directed more towards personal sanctions and because the Dutch Safety Board was conducting its own investigation.

KLM assured that postponing its internal investigation would not impede learning safety lessons as soon as possible. The information made available by the Inspectorate to the Dutch Safety Board shows that no further measures were taken.

National Safety Authority
De National Supervisory Authority (NSA)[54] obtained information from LVNL and contacted LVNL on several occasions. NSA's primary objective was to ensure that LVNL has undertaken every effort on the basis of its procedures and processes to prevent a similar incident from occurring.

The NSA and LVNL have in principle agreed not to make available the results of LVNL's internal investigation in writing to NSA unless circumstances so dictate. The reason being the protection of the information held by LVNL on the basis of the Dutch Safety Board's impending investigation, which protection LVNL wishes to maintain. For that reason information was only shared verbally using presentations.

The NSA has drawn the conclusion that LVNL has performed its investigation into the incident in accordance with the new LVNL procedure. The manner in which this was conducted and the investigation results have served to demonstrate sufficiently to the NSA that LVNL has taken adequate action to prevent the occurrence of a similar incident and that the NSA consequently sees no reason to take additional measures.

The Board finds the following surprising:

a. in respect of this incident the NSA has based its conclusion on verbal presentations alone;
b. has agreed on the principle of not communicating in writing;
c. the NSA has not explicitly monitored the implementation of the recommendations as referred to in Section 3.7.3, and has not specified a required term for processing the recommendations.

3.6 Other factors concerning the parties involved

3.6.1 Human factor incidents at KLM
Aircraft crews are made aware of safety, cost effectiveness and punctuality but the immediate responsibility for dealing with these aspects lies with the pilot in command. The emphasis on efficiency and safety may to a certain extent become dependent on the corporate culture or trends, depending on the emphasis an airline places on these aspects and whether or not incidents occur. When operating the Boeing 737, the pilot monitoring often is not always in a position to monitor the pilot in command's activities when the aircraft is taxiing. The KLM will not propagate this modus operandi but has, on the other hand, not explicitly prohibited it in its procedures.

KLM regarded the incident as one of several human factor incidents, which were showing a declining trend prior to the incident. KLM stated that as a result of the incident, human factor-related incidents had continued to decrease. The airline attributed this to increased awareness among crews. These types of effects are known to ebb away over the course of time. This is inevitable but the result is that awareness should be regarded as a soft barrier because it provides insufficient safeguards.

54 The NSA is part of IVW, see also Section 4.4 under 'Oversight of air navigation service providers'.

Investigation has shown that KLM has acknowledged the risks involved in runway confusion and runway incursion incidents for some time. Runway confusion and runway incursion incidents, however, have not been classified as high priority in KLM's safety management system. KLM is of the opinion that risks occurring in other areas are higher on the priority list.[55]

3.6.2 Safeguarding information for the purpose of a safety investigation

In KLM's regulations the safeguarding of cockpit voice recorder (CVR) data is left to the pilot in command. It was clear to the crew that the incident was serious. Although switching off the CVR immediately upon arrival in Warsaw would have still been on time to prevent the relevant data from being overwritten, this was not the case. Valuable CVR data were therefore lost. The Board considers the absence of CVR data for the purpose of the investigation a great deficiency.

The Board believes that the airline should have made every effort to safeguard the data on time. Particularly when the airline is aware at an early stage that an incident has occurred involving one of its aircraft, as was the case here. Above all, the Safety Board feels that the maximum CVR recording time of two hours is far too short.

3.6.3 Interaction between pilots and air traffic controllers

ATC proposed an intersection take-off to the KLM crew in order to handle departing air traffic efficiently. With the crew only seeing advantages as well, they accepted the proposal. It emerged from the air traffic controllers' statements that intersection take-offs often are carried out at the request of home-based crews. The conclusion drawn is that air traffic controllers and crews strengthen each other in promoting efficiency by using shorter taxi routes and intersection take-offs.

3.6.4 Interaction between Amsterdam Airport Schiphol and air traffic control the Netherlands (LVNL)

Management and use of the infrastructure

The airport manages the infrastructure. The airport therefore bears the costs of maintenance and investments under ICAO Annex 14 or adjustments arising from the lessons learned from incidents. In terms of infrastructure, intersection W8 has been designed for use during non-low visibility conditions and complies with the standards set out in ICAO annex 14.[56] For Amsterdam Airport Schiphol (AAS) intersection W8 is suitable for use as long as non–low visibilities conditions apply. The airport puts the infrastructure at air traffic control the Netherlands' (LVNL) disposal. Subject to low visibility conditions, LVNL assumes that intersection W8 can be used if runway 36C has been released for service by the airport.

LVNL is responsible for the air traffic control processes. On the one hand, LVNL is dependent on the quality of the infrastructure, such as the quality of the existing taxiway lighting. On the other hand, air traffic control occasionally uses the infrastructure in a different manner than originally intended, for instance by allowing air traffic to taxi against the normal direction of travel while the taxiway lighting has not been designed to fully accommodate this. The layout and use of the infrastructure may therefore give rise to confusion or unpredictable pilot action, which may have an immediate impact on the air traffic controllers' work. This risk is not immediately clear to crews and air traffic controllers during day-to-day operations.

Risk assessment

The Australian Transport Safety Bureau (ATSB) identified eight factors in the occurrence of runway confusion incidents during take-offs at night, see figure 8. As the previous analysis shows, six of the eight factors contributed to the incident involving the PH-BDP. The risks or the effects of these factors would have been eliminated if the PH-BDP had taxied along the compulsory direction of travel on taxiway Bravo.

55 Examples include Traffic Collision and Avoidance System (TCAS) and runway excursion incidents.
56 ICAO Annex 14 specifies that blue edge lighting and green centreline taxi lights are required on taxiways outside the Uniform Daylight Period (UDP) and for visibility values of less than 350 metres.

After all, despite the distraction and early take-off clearance, and despite a route that was not clearly recognisable, etcetera this could not have given rise to runway confusion because when turning off in the direction of runway 36C, no other taxiway could be crossed. And if entry W8 had been missed, the PH-BDP could have taxied in the direction of W9 and W10. The conclusion drawn is that the contributing factors were not unique to this incident. The factors and their effects could have been avoided. The incident therefore was in part caused by using taxiway Alfa to reach entry W8.

The use of a taxiway may have consequences that are not entirely calculable without having conducted a risk analysis. Except for highlighting the hot spots neither the airport nor LVNL was able to provide a risk assessment of the section of runway 36C relevant to this investigation and the adjacent taxiway system. The risk assessment carried out by the airport on Apron J fails to account of aircraft not following the compulsory direction of travel. The taxi procedures employed by air traffic control during de-icing are only intended to lighten the ATC's workload. The possible consequences and risks involved in taxiing along a potentially confusing layout of taxiways (including the lights and markings) and taxiing in the opposite direction to the compulsory direction of travel, were insufficiently clear as a result.

It can be concluded that the risks of using taxiways during darkness, in particular entry W8 combined with not using taxiway Alfa in the compulsory direction of travel, were insufficiently clear. Had this indeed been the case, the procedures or the infrastructure could have been changed as a result.

3.6.5 Interaction between KLM and IVW

KLM felt that IVW's approach towards the incident and those involved threatened the incident-reporting culture because IVW focused on enforcement. KLM postponed its internal investigation[57] pending the Dutch Safety Board's investigation to protect its staff and not to frustrate their willingness to report incidents. This might lead to the conclusion that enforcement on the basis of incidents could undermine safety culture in the sense that individuals may no longer be willing to cooperate with KLM's internal investigation into safety.

3.6.6 Runway incursions and runway confusions at Amsterdam Airport Schiphol

Appendix K contains an overview of several runway incursion incidents previously investigated by the Board. They show examples of actions taken by crews and ATC, which, just as the incident involving the PH-BDP, turned out differently from what was expected.

As far as the Dutch Safety Board was able to establish, only one runway confusion incident had previously occurred at Amsterdam Airport Schiphol in the past decade. Given the findings resulting from the ten runway incursion investigations,[58] the Board believes the take-off from taxiway Bravo is not an isolated case. In terms of infrastructure and ATC processes, several investigations have brought to light similar findings.

3.7 Measures taken following the incident

3.7.1 KLM Royal Dutch airlines

Runway Awareness and Advisory System(RAAS)

There was no runway awareness and advisory system (RAAS) on board the PH-BDP. In March 2011 KLM Flight Operations took a decision in principle to equip its entire fleet with RAAS. However, a decision to go ahead with the implementation of the system has not yet been taken because KLM is not yet satisfied with the way the system operates. RAAS will not be implemented for the time being.

57 KLM stated that under European regulations an internal investigation following an incident is permitted to be discontinued.

58 The ten reports can be downloaded from www.onderzoeksraad.nl

Threat and error management
Threat and error management implies that the pilots seated in the cockpit must jointly decide on their modus operandi. During briefing sessions pilots highlight possible threats to their flight and circumstances to make each other aware of the possible risks. To support its own flight operations, KLM focuses on threat and error management during a special simulator session. The threat and error management procedure was incorporated in the Flight Crew Operating Manual (FCOM) on 1 July 2010.

Procedure for verifying the take-off runway
The FCOM now incorporates a check in the take-off procedure for all aircraft types to verify whether the take-off runway or entry is correct prior to an aircraft entering the runway. Until recently such a check had not been performed by KLM.

It can be established that KLM has tightened its safety strategy by incorporating the threat and error procedure and adjusting the take-off procedure accordingly.

3.7.2 Amsterdam Airport Schiphol
Amsterdam Airport Schiphol sees no reason to implement additional measures in respect of the infrastructure.

Only a joint checklist for snowy conditions[59] was compiled by the airport together with air traffic control the Netherlands on 1 December 2010 to create clarity on the exact entries to be used in such conditions. This is crucial in order to decide whether to clear snow from an additional entry on the one hand or put a runway into use at an earlier point in time on the other.

3.7.3 Air traffic control the Netherlands (LVNL)
As a result of the serious incident involving the PH-BDP LVNL has formulated two internal recommendations on the basis of its own investigation. They are as follows:

Adjust the procedure for ground and runway controllers to ensure the following:

1. the ground controller must make certain that the aircraft follows the route instructed in the clearance issued by the ground controller before the latter transfers the aircraft to the runway controller, and
2. prior to issuing take-off clearance the runway controller must make certain that the aircraft can only take-off from the position as intended in the take-off clearance.

According to the Board the first recommendation does not apply to the incident because the PH-BDP followed the route instructed by the ground controller when the aircraft was transferred from ground to runway control. At the time of publication of this report the Board had established that the recommendations had not yet been implemented.

3.7.4 Transport, Public Works and Water Management Inspectorate (IVW)
IVW, including the NSA, does not see any need to take measures.

59 If there is no snow, a runway will be released for service together with all the corresponding entries subject to other restrictions or maintenance.

4 CONCLUSIONS

1. While taxiing the crew lost their positional awareness as a result of which they took off from taxiway Bravo instead of the adjacent take-off runway 36C.

2. Pilots and air traffic controllers continuously make an effort to operate as efficiently as possible. Offering and accepting an intersection take-off is in line with this operational practice. The parties involved must weigh up the options and may never sacrifice safety in an effort to operate efficiently.

3. In the situation that had arisen, the parties involved failed to recognise adequately the risks involved in offering and accepting entry W8, as a result of which the procedures were not carried out with the necessary close attention required in this particular case.

   Findings relating to the crew

   - The aircraft was taxiing on taxiway Alfa and therefore first had to cross taxiway Bravo in order to enter take-off runway 36C. This was an unusual taxi route for the crew.
   - The crew accepted take-off from entry W8 to enable them to take-off earlier.
   - Since the crew did not stop but continued to taxi, they came under time pressure because they had to enter and check the changes they made in the FMS.
   - The crew did not monitor the aircraft's position using a ground movement chart.
   - The pilot in command had been distracted by radio communications between the air traffic controller and another aircraft that was en route to runway 36C.

   Findings relating to air traffic control

   - When the PH-BDP was transferred from the ground controller to the runway controller they failed to comply with the specified requirements because there still was room for error.
   - The runway controller assumed responsibility for monitoring the taxiing aircraft with the premature transfer of CAL5420 and PH-BDP.
   - Because the runway controller suddenly had to solve a problem with the CAL5420, he paid less attention to the PH-BDP than proved to be necessary.
   - The runway controller issued take-off clearance before the aircraft had crossed taxiway Bravo.
   - Air traffic control failed to notice the PH-BDP lining up and the commencement of its take off.

4. Despite the higher risks involved, the ATC procedures for taxiing aircraft during darkness are the same as in daylight.

   Findings

   - Aircraft crews are more dependent on visual aids during darkness than during daylight for following the required taxi route and this contributes to crews becoming more vulnerable to misleading passive guidance.
   - Coming from taxiway Alfa and looking down interconnecting taxiway Alfa 25, the lighting on runway 36C formed patterns with the lights of the motorway in the background as a result of which the take-off runway could not be clearly distinguished.
   - When it is dark, the air traffic controllers restrictive factors come into play when visually monitoring aircraft.

5. The airport complies with the ICAO standards for airports. This does not automatically guarantee that flight deck crews will follow the correct route.

   Findings

   - In the prevailing circumstances, the infrastructure of entry W8 failed to provide adequate visual stimuli to make the crew aware that their position was incorrect.
   - The risk assessment on the use of Apron J carried out by Amsterdam Airport Schiphol is incomplete as it fails to account of the compulsory directions of travel on taxiways Alfa and Bravo. The de-icing procedures employed by LVNL are only intended to lighten the ATC's workload.
   - The yellow taxi lines and the blue markers on both sides of the taxiway cannot be clearly distinguished by using the Boeing 737's taxi lights.
   - There are no electronic warning systems at Amsterdam Airport Schiphol to warn the air traffic controllers in the ATC tower on time that an aircraft is taking off from a taxiway.

6. The cockpit voice recorder has a recording time of two hours, which is inadequate for aviation occurrence investigations.

5 RECOMMENDATIONS

The Board recommends that Amsterdam Airport Schiphol:

- prepares a risk assessment of air traffic taxiing near take-off and landing runways in collaboration with air traffic control and implements the outcomes in its procedures, unless the risk assessment shows otherwise;
- changes the infrastructure so that all taxiways put at air traffic control's disposal have green centreline taxi lights indicating the route(s) to be followed only.

The Board recommends that air traffic control the Netherlands:

- prepares a risk assessment of air traffic taxiing near take-off and landing runways in collaboration with the airport and implements the outcomes in its procedures;
- ensures - until such time as the risk assessment has been completed and the resulting outcomes have been implemented - that entries without green centreline taxi lights are no longer used during darkness if an aircraft has to taxi across a taxiway.

The Board recommends that the European Aviation Safety Agency (EASA) and Federal Aviation Administration (FAA):

- increase the minimum recording time of the cockpit voice recorder (CVR) in order to better safeguard the availability of data for the purpose of incident and accident investigation.

Parties to be issued a recommendation by the Dutch Safety Board should notify the Board of all implemented and proposed measures within 90 days of receiving the recommendation, and – if necessary – of the time required to implement these measures or, in the event that no measures are implemented, of the reason for this decision. If the recommendation is not addressed to the Minister of Infrastructure and the Environment, the Minister must be sent a copy of the involved party's response to the recommendation.
After the response term has elapsed the Dutch Safety Board will publish the responses received on the report on its website: www.onderzoeksraad.nl.
If no response is provided, this will be reported on the aforementioned website.

APPENDIX A: JUSTIFICATION OF THE INVESTIGATION

Notification and investigation by the Dutch Safety Board
On 10 February 2010 at approximately 21:00, the Dutch Safety Board was notified that a KLM Boeing 737-300 aircraft type had taken off from a taxiway at Amsterdam Airport Schiphol. The Board regarded this incident as serious and commenced an investigation the next day. In accordance with the standards specified in ICAO Annex 13 a mandatory investigation is required to be conducted into serious incidents and the findings thereof published.

In addition to the Dutch Safety Board's investigators, at the Safety Board's request representatives from the Dutch Airline Pilots Association (VNV), the Dutch air traffic controllers Guild, KLM, Amsterdam Airport Schiphol and the Transport, Public Works and Water Management Inspectorate (IVW) joined the investigation team. The investigation was conducted in accordance with the recommended practises set out in ICAO Annex 13 with the Dutch parties involved being the operator, air traffic control and the airport. The PH-BDP is a Boeing aircraft, which means that the United States of America was therefore formally involved as the State of Manufacturing and Design. Since the operation of the aircraft did not play any role in this incident at all, an accredited representative from the United States of America was not involved in the investigation.

The investigation
The investigation commenced on 11 February 2010 with a brief conversation with the runway controller. On the same day Dutch Safety Board investigators conducted extensive interviews with the pilot in command and the first officer together with representatives of the Dutch Airline Pilots Association (VNV). The Board was also able to use the interviews conducted by KLM's Investigation Department.

Little progress was made on the investigation until mid-May with priority having been given to finalising and publishing the investigation report of the Turkish Airlines Boeing 737 that had crashed, after which this investigation was fully resumed. The following investigations and main activities were carried out, commencing in 2010:

- June 14: investigation by the investigation team using a flight simulator together with experienced pilots having specific knowledge of KLM's Boeing 737 operations.
- 7 July: investigation using a flight simulator together with the crew involved on board the PH-BDP.
- 20 August: reconstruction of the actual taxi route followed and the taxi route the aircraft should have followed using a Boeing 737. The footage was used for the analysis.
- During the period September through October interviews were held with the ATC officers involved.
- During the period November 2010 through January 2011 the investigation information was analysed in detail and the interviews that had been processed were submitted for review at the end of March and early April 2010. The investigators worked on compiling the report from January.

Reference framework for human factors
It is abundantly clear that human factors play a key role in the occurrence of accidents. It is generally accepted that this depends on the environments people encounter at work. The environment – which is also referred to as 'context' – comprises physical, psychological and organisational factors.

Tools were developed for the purpose of reflecting the context in a structured manner and as completely as possible. The TRIPOD model is such a tool and is used to identify the corresponding Basic Risk Factors for human factors.

Academics hold varying views on the contribution of human factors to accidents but it is abundantly clear that the human factor plays a key role in the occurrence of accidents. In the meantime it has become generally accepted that people who make errors, or make wrong decisions – sometimes in hindsight – are tempted to do so or are offered the opportunity to do so by the environment in which they are working.

The environment – which is also referred to as 'context' – comprises physical, psychological and organisational factors. Physical factors, for instance, are the meteorological conditions and the infrastructure in which the parties involved are required to perform their work. Psychological factors relate to the mindset of the parties involved and relate to aspects such as preoccupation and perception. Organisational factors, such as work pressure, information provision and the allocation of responsibility.

If an investigation reveals that human factors contributed to the occurrence of the accident, it is important to investigate the context in which the parties involved found themselves at the time the human factors came into play. In the light of the factual information about the incident (Chapter 2) and the TRIPOD Basic Risk Factors, the points concerning the incident with the PH-BDP that in any case require attention are as follows:

		Pilots involved	**air traffic controllers involved**
EEC	Meteorological and physical conditions	View and recognisability of the runway runway	Visibility and positions of aircraft to be monitored
DE	Infrastructure design	Recognisability of taxiways and the runway	Use of standard taxiway routing
HW	Availability of the infrastructure	-	Availability of entry W8 in these conditions
PR	Practicability of procedures	Positional awareness and FMS data entry and verification	Transfer of the aircraft from ground control to runway control
TR	Crew resource management	Effectiveness	-
IG	Weighing up the risks of potentially conflicting interests	Thoroughness versus flight punctuality	Thoroughness versus efficient flow of traffic

Legend: EEC (Error Enforcing Conditions), DE (Design), HE (Hardware), PR (Procedures), TR (Training), IG (Incompatible Goals)

Table 3: Breakdown of the Basic Risk Factors for pilots and air traffic controllers

Project team

J.W. Selles	Investigation Manager

Core team

A. Samplonius	Investigator in charge, Senior Investigator
H. van Ruler	Senior Investigator (until April 2011)
K.N.R van Schaardenburgh-Verhoeve	Senior Adviser, Research & Development

Support

P. Blommers	Project Assistant
J.D. Zwaan	Project Assistant W.F. Furster Investigator
M.J. Schuurman	Investigator
P. Lips	Senior Investigator
E. de Croon	Adviser, Research & Development

The following people were added to the project team under the supervision and responsibility of the Dutch Safety Board:

B. Benard	Dutch airline Pilots Association (VNV), Accident Investigation Group
P.P.M van de Ven	Accident Investigator, KLM
R.J.M. van Diemen	Dutch air traffic controllers Guild
E. P. Grovenstein	Airside Operations Manager, Amsterdam Airport Schiphol
R.J.W. Woudstra	Inspector, airports and airSpace Supervisory Authority (Toezicht Luchthavens en Luchtruim)

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APPENDIX B: COMMENTS RECEIVED FROM THE PARTIES INVOLVED

A draft version of the report, excluding the consideration and recommendations, was submitted to the parties directly involved for the purpose of checking any factual inaccuracies pursuant to the Kingdom Act regarding the Dutch Safety Board (Rijkswet Onderzoeksraad voor Veiligheid). The Dutch Safety Board has incorporated the comments received in the final report, mainly those relating to factual inaccuracies. The comments that have not been included in the final report have been listed on the Board's website, visit: www.safetyboard.nl. The Board has added to each comment an explanation on why these points were not adopted in the report. The chapters, sections and pages cited in the comments do not always correspond with the numbering used in the final report.

The draft version of this report was submitted to the following parties for review:

- KLM
- Air traffic control the Netherlands (LVNL)
- Amsterdam Airport Schiphol
- Ministry of Infrastructure and the Environment
- Transport, Public Works and Water Management Inspectorate (IVW)
- Pilot in command
- First officer
- ATC tower supervisor
- Runway controller
- Ground controller
- Assistant 2
- Assistant 1
- Airside Operations Manager

All of the above parties provided their comments on the report to the Board except for the ATC tower supervisor.

APPENDIX C: THE PARTIES INVOLVED AND THEIR RESPONSIBILITIES

KLM Royal Dutch airlines

The organisation
KLM Royal Dutch Airlines was founded in 1919 and has its home base at Amsterdam Airport Schiphol. KLM merged with Air France in 2004 joining the Air France-KLM holding company. KLM forms KLM Group's core business operating from the Netherlands and includes KLM Cityhopper, Martinair and Transavia. KLM's revenues are derived from three core activities: passenger transport, cargo transport and aircraft maintenance.

The company has a fleet of some 110 aircraft, over 40 of which are Boeing 737s. These figures may vary slightly depending on the phasing out of older aircraft types, such as the Boeing 737-300s, including the PH-BDP, and the launch of new aircraft.

As the holder of the Air Operator Certificate (AOC), which is a licence to operate flights under European and Dutch legislation, KLM is responsible for flight operations and aircraft maintenance. The Operations Manual (OM) contains the position descriptions and the responsibilities of all officers. The accountable manager is responsible for ensuring that operational activities are facilitated and performed in accordance with the laws and regulations.

The pilot in command
In accordance with European regulations the pilot in command is responsible for a safe operation of flight. During a flight, he is permitted to depart from company rules, operational procedures and methods if he deems it necessary in the interest of safety.

The first officer
The first officer is responsible for assisting the pilot in command in respect of his duty to achieve safe flight operations and in doing so complies with the pilot in command's instructions. The first officer is required to monitor the critical phases of the flight (if performing support tasks) and must inform the pilot in command about each departure from the rules. If this is in the interests of safety, he must call the pilot in command's decision into question, if necessary. In the event the pilot in command falls ill the first officer takes over the pilot in command's tasks.

Air traffic control the Netherlands (LVNL)

LVNL organisation
LVNL is an independent administrative authority and is accountable for its performance to the Minister of Infrastructure and the Environment.[60] LVNL is charged with promoting the safety of air traffic as far as possible in the Amsterdam flight information region (FIR), which extends above Dutch territory and a large part of the North Sea. Pursuant to the (Dutch) Law for Aviation, air traffic services are provided in the interests of ensuring the overall safety of air traffic and the safe, orderly and expedient handling of air traffic. The LVNL organisation holds certification. The certificate[61] implies that LVNL complies with the standards.

When providing air traffic services at Amsterdam Airport Schiphol, LVNL is required to comply with the rules laid down for route and runway usage. LVNL shares the duty of care in respect of distributing the noise load across the statutory enforcement points surrounding the airport. Air traffic service provision comprises three tasks: air traffic control, flight information and emergency assistance.

60 At the time of the incident, the Ministry's name was the Ministry of Transport, Public Works and Water Management.
61 The certificate does not form part of the investigation.

Please find below a summary of the duties and responsibilities of the officers involved in this incident. The descriptions of their responsibilities were obtained from Part 2 of the air traffic control Regulations (VDV), to the extent relevant.

ATC tower supervisor
The ATC Schiphol Tower (Schiphol TWR) is responsible for providing local air traffic control in the Schiphol control zones (CTRs) and the Amsterdam Airport Schiphol manoeuvring area. The ATC tower supervisor operationally manages the Tower Unit (TWR unit) and performs general coordination tasks. The ATC tower supervisor's tasks include monitoring staff performance, procedures, work methods, systems and equipment in the tower. The tower supervisor's job can be combined with that of runway controller.

Runway controller
The runway controller is responsible for the CTR except for flights under the charge of the ground controller. The runway controller's tasks include handling inbound and outbound flights and activating the runway and approach lights. He is responsible for visually monitoring as far as possible the required separation of the aircraft in his charge and other aircraft of which he has been notified. He issues instructions to prevent collisions between one or more aircraft as well as between aircraft and vehicles.

The ground controller
The ground controller is responsible for manoeuvring area control (taxiways and aprons) except for the take-off and landing runways released for operation. The ground controller's tasks include issuing pushback and taxi instructions, transferring departing aircraft and aircraft that have to cross a runway in use to the runway controller, issuing instructions in order to prevent the uncontrolled or unauthorised entering of take-off and landing runways by aircraft, and operating the taxi lights. He also issues instructions to prevent collisions between one or more aircraft as well as between aircraft and vehicles.

Assistant 2
Tower assistant 2 performs a general assistance role in the ATC tower and supports the runway controller (safety net function). He or she supervises vehicles in the manoeuvring area under the responsibility of the ground controller and supervises traffic crossing or driving down the runways under the responsibility of the runway controller.

Amsterdam Airport Schiphol

Airside Operations in the airport organisation
Airside Operations (AO) is responsible for a wide range of tasks. In general AO is responsible for maintaining safe and orderly operations in the airport area where aircraft are located (on airside), and is responsible for planning and directing aircraft handling.

More specifically, and in connection with this incident, AO manages the infrastructure and is required to put all the take-off and landing runways, taxiways and aprons at disposal ensuring they are safe for use. AO is also responsible for snow clearance and ice prevention activities, including coordinating with air traffic control restrictions relating to taxiway and runway usage arising from slippery conditions.

Airside Operations Manager (AOM)
The AOM is responsible for supervising Airside Operations (AO), including 'winter operations', inspecting the infrastructure and for ensuring sufficient airport capacity in the event of infrastructural maintenance.

MINISTER OF INFRASTRUCTURE AND THE ENVIRONMENT

At the time of the incident this was the Ministry of Transport, Public Works and Water Management, which is now called Ministry of Infrastructure and the Environment.

Transport, Public Works and Water Management Inspectorate (IVW)
The Inspectorate is responsible for the supervision of civil air traffic in Dutch airspace and on Dutch territory.

The oversight of airlines registered in the Netherlands, airports and air navigation service providers[62] is a form of systemic oversight and production inspection. If the parties who are subject to oversight comply with the legal requirements, they will be issued a certificate by the Inspectorate.

Commercial aviation has been regulated such that the supervised parties themselves carry primary responsibility for managing safety and consequently for controlling the risks. Standards have been imposed pursuant to laws and regulations but the supervised parties themselves determine how they will comply with the standards.

The annual systematic supervision (oversight) of the supervised parties carried out by the Inspectorate focuses on testing whether the management system set up by the supervised parties complies with the regulations. These systems are assessed by way of reality checks to determine whether they function adequately and are effective.

If the Inspectorate establishes that a supervised party has departed from the requirements or standards, it may take the following steps:

- The Inspectorate will notify the supervised party of the departure from the requirements or standards and will request that corrective and preventive action be taken. This involves the supervised party itself ascertaining what the most effective action would be. In consultation with the Inspectorate a realistic term will be set for resolving the issue;
- The Inspectorate will subsequently check whether the supervised party is implementing the corrective and preventive action it has promised to carry out according to schedule;
- If the supervised party has not promised to undertake any action or fails to carry out any action the Inspectorate may take the following measures in the event of non-compliance:[63]
  - issue a warning;
  - impose administrative sanctions, such as a penalty and an order for incremental penalty payments;
  - enforce an administrative order, which includes revoking licences;
  - publish the above information.

The Inspectorate can also carry out a product inspection (compliance-based inspection) depending on the characteristics of the supervised parties. This usually involves testing a specific piece of hardware based on the number of features laid down by law but may also involve the way a procedure or work instruction is carried out.

Supervision of airlines registered in the Netherlands
The rules and regulations with which airlines registered in the Netherlands are required to comply are largely determined by ICAO and EU OPS. The latter prescribes basic requirements such as those for amongst other things the Air Operator Certificate (AOC). By issuing an AOC to an airline the Inspectorate declares that the airline will be able to take responsibility for safe flight operations. The ICAO standards indirectly form the basis for the current annual supervision of these airlines.

62 Air traffic control the Netherlands (LVNL), Maastricht Upper Area Control Centre (MUAC), KNMI and Meteoconsult.
63 Sanctions pertaining to criminal law are reserved for the police and the prosecutor.

Airport oversight
The rules and regulations with which airports are required to comply are largely determined by Dutch[64] and ICAO regulations. Oversight relates to aspects such as the construction, layout, equipment and safe use of airports and other aerodromes with a view to ensuring safe and orderly operations at airports and aerodromes.

An airport operator must have a safety management system encompassing the relevant business processes in place. These processes have not been specified in detail but the design and development of infrastructure is regarded as a relevant business process.

The operator of Amsterdam Airport Schiphol itself is responsible for ensuring that new or modified infrastructure designs comply with the current regulations and that infrastructure is designed and delivered in such a way that it can be used safely.[65]

Supervision of air navigation service providers
The National Supervisory Authority (NSA), a division of the Transport, Public Works and Water Management Inspectorate, carries out the activities[66] described in 'Single European Sky' legislation and performs supervision of air navigation service providers each year pursuant to the above legislation.[67]

Observing oversight in the event of adverse events
If airspace users are involved in adverse events IVW will initially talk to the supervised organisation in order to find out the possible cause. The Inspectorate will request the supervised organisation to report directly on the facts and circumstances relating to the incident in order to gain an understanding of the extent to which additional measures are required. The Inspectorate supervises the investigations conducted by the parties and the way they have handled the incident for the purpose of safeguarding aviation safety and to take measures pertaining to administrative law, if necessary.

The Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA)
The FAA and EASA are responsible for aviation safety in the USA and the European Union respectively. This includes the certification of aircraft and aeronautical products, including cockpit voice recorders (CVRs). Although both organisations were not directly involved in this incident, they are the appropriate authorities that may specify criteria for the length of a CVR recording. The two organisations have been included in this report due to the fact that the lack of CVR data impeded the safety investigation.

64 The Regulations laid down by the Minister of Transport, Public Works and Water Management dated 27 October 2009, no. CEND/HDJZ-2009/1166 (National Regulations for the Safe use of airports and Other Aerodromes, RGVLT) and the Regulations laid down by the Minister of Transport, Public Works and Water Management dated 25 June 2010, no. CEND/HDJZ-2010/988 (Regulations amending the National Regulations for the Safe Use of airports and Other Aerodromes and any other regulations).
65 Aerodrome Manual, Part 2, Chapter 5.5: The process for developing and maintaining the infrastructure')
66 The European Commission has specified requirements for the organisation of oversight, which are incorporated in EC Regulation 1315/2007 on safety oversight in air traffic management.
67 EC Regulation 2096/2005 of 20 December 2005 laying down common requirements for the provision of air navigation services.

APPENDIX D: REFERENCE FRAMEWORK

General

A reference framework forms part of a Dutch Safety Board Investigation. It describes the situation as may be expected pursuant to regulations, guidelines and the fulfilment of a party's own responsibility. By using the reference framework for the purpose of assessment and identifying deviations, insight can be gained into areas where improvements can be made and/or supplementary measures are required.

The reference framework in this report has four parts. The first part relates to the civil aviation laws and regulations in force. The second part is based on international and national industry guidelines as well as internal company guidelines and manuals. The third part relates to the framework for human factors and the environment which people encounter at work. The fourth part describes the Board's expectations regarding the approach adopted by the parties involved towards their own responsibility for safety and safety management.

This chapter makes a distinction between binding laws and regulations on the one hand, and non-binding standards, on the other. While many of the international regulations are not directly binding, they become binding if the regulations have been implemented in national legislation. Since implementation as referred to above takes place on an almost continual basis, these types of international regulations have been grouped under the first category of binding laws and regulations.

Laws and regulations

The regulation of civil aviation has a strong international focus. For this reason international regulations form the main basis for this part of the reference framework.

International and national guidelines

The international regulations relevant to this investigation encompass the following:

1. The Standards and Recommended Practices for international civil aviation set out in the Annexes supporting the Convention on International Civil Aviation also known as the Chicago Convention.
2. Regulations of the European Union (EU)

Re 1 The Chicago Convention annexes
Virtually all countries across the globe are signatories to the Convention, which sets out the principles and regulations for numerous matters that are important for the development of international civil aviation. It also forms the legal basis for the establishment of the International Civil Aviation Organization (ICAO). The Chicago Convention features a large number of annexes that regulate a range of topics in great detail. These annexes do not have the same binding force as the Convention itself but they do play a large part in the regulation of international civil aviation.

The annexes include the Standards and Recommended Practices. In any event, it is mandatory for the member states to implement the Standards as closely as possible in their national legislation. If a member state departs from a Standard, it must notify ICAO thereof. A Recommended Practice is a recommended working method that a member state may incorporate in national legislation. However, this is not mandatory; incorporating a working method does not need to be reported but is recommended.

Re 2 EU regulations
European Union regulations apply directly to the member states and are in fact similar to national legislation. The following regulation is relevant to this investigation:

Regulation (EC) 1315/2007 of 8 November 2007
This regulates the supervision of air traffic management and amends the current regulations.[68] The Regulation refers to the regulation establishing the role and function of the national supervisory authority'[69] (NSA). While the responsibility for the safe provision of service lies with the provider, the member states should ensure effective oversight through their national supervisory authority. For the Dutch situation this means that the national NSA is required to carry out effective supervision of LVNL.

National laws and regulations

National Regulations for the Safe Use of airports and Other Aerodromes (RVGLT)
The Regulations laid down by the Minister of Transport, Public Works and Water Management dated 27 October 2009, no. CEND/HDJZ-2009/1166 (National Regulations for the Safe Use of airports and Other Aerodromes, RVGLT) sets out rules relating to the construction, equipment and safe use of airports and other aerodromes with a view to ensuring safe and orderly operations at airports and aerodromes. These regulations also apply to Amsterdam Airport Schiphol.

Law for Aviation
Chapter 5 of the Dutch Aviation Act contains the relevant regulations governing air traffic, air traffic control and the air traffic control organisation.

RELEVANT MANUALS

KLM Royal Dutch airlines

General
Pursuant to EU-OPS 1 (Aeroplanes) KLM has set out the company's standards and procedures in the KLM Operations Manual which consists of four parts, referred to as A through D. The Operations Manual is approved by the Netherlands Civil Aviation Authority.

Part A of the Operations Manual includes the basic operations manual (BOM) and the reference guide (RG) and encompasses the policy, instructions and procedures for all aircraft types (non-type related) required for carrying out safe flight operations.

Part B of the Operations Manual contains the policy, instructions and procedures for each specific aircraft type (type related) required for carrying out safe flight operations. For the Boeing 737, this is the KLM Flight Crew Operations Manual (FCOM).

Part C of the Operations Manual contains instructions and information on the routes and airports included in the Route Operations Manual (ROM).

Part D of the Operations Manual is KLM's Training Operating Manual (TOM), which specifies the requirements and instructions for staff training and education. The manufacturer's Flight Crew Training Manual (FCTM) does not fall under Part D of the Operations Manual. The FCTM provides background information on how to operate a specific aircraft type. Should the FCTM contain instructions or guidelines that are inconsistent with Part B of the Operations Manual, the latter will be normative.

68 Commission Regulation (EC) No 2096/2005.
69 Commission Regulation (EC) No 549/2004.

Amsterdam Airport Schiphol

ICAO Annex 14, Chapter 5, and the ICAO Aerodrome Design Manual, Part 4, Chapter 9.2, set out the requirements for the lighting, markings and signs used for taxiways and runways.

Air traffic control the netherlands (lvnl)

The regulations and procedures with which LVNL is required to comply, in addition to the ICAO Standards and Recommended Practices, are set out in European as well as national legislation (see Section 3.2) and in internal regulations, such the air traffic control Regulations (VDV). LVNL furthermore issues the Netherlands Aeronautical Information Publication (AIP) and Notices to airmen (NOTAMs) on behalf of the Netherlands aviation authority.

Air traffic control Regulations (VDV)
The air traffic control Regulations (VDV) summarise all the procedures, working methods, rules and regulations that operational staff are required to follow in order to carry out their tasks safely and efficiently. The VDV is a manual that is not subject to approval from the Netherlands civil aviation authorities.

The VDV specify how LVNL should perform air traffic control in the Netherlands and consists of eight parts. The part relevant to this investigation is the VDV Schiphol Tower/Approach section.

The tasks and responsibilities of the supervisor, the runway controllers, ground controllers and those of Assistant 2 are described in appendix C.

Runway Combination De-icing Procedures
These procedures are mainly intended for ground controllers and serve as a practical guide for handling ground traffic during de-icing in the winter season. The procedures specify the taxi routes to be used by air traffic control for the most frequently used runway combinations during inbound and outbound peaks. The starting point is to alleviate the area surrounding Apron J during de-icing in order to distribute the workload between the North and South ground sectors.

Aeronautical Information Publication (AIP)
The AIP is designed to be a manual for airman issued with the authority of a state and containing aeronautical information of a lasting character essential to air navigation. It includes the Dutch laws and regulations, flight procedures and information about airports and aerodromes, including the air traffic control procedures and arrival and departure procedures. Any changes made to the regulations, procedures or information are incorporated in the AIP.

Notice to airmen (NOTAM)
NOTAMs contain temporary flight information. No NOTAMs were relevant to this incident.

Transport, Public Works and Water Management Inspectorate (IVW)

Supervision of air navigation service providers and airspace users
IVW describes supervision in the airspace domain in the oversight arrangement and uses 1 December 2008 as the reference date. The arrangement contains an explanation of the organisation of airspace and the domain players. It depicts the manner in which IVW has organised supervision in an annual plan and an inspection programme, the IVW reporting method and how IVW measures the effect of supervision.

Safety management – points requiring attention

Safety management relates to the manner in which organisations fulfil their responsibility for safety, aside from the applicable laws, regulations, standards and guidelines. This involves aspects such as the manner in which the risks for the parties involved are identified and structurally controlled. The organisation requires a structure in order to implement the entire process transparently and to create opportunities for continuous improvement. This structure is referred to as the safety management system. Various accidents in the past have shown that the structure of the safety management system and the manner in which the parties involved implement this system play a crucial role in managing, guaranteeing and continuously improving safety.

The Dutch Safety Board employs five general safety principles to determine whether, and if so how, the parties have fulfilled their own responsibility. The Dutch Safety Board has notified the Minister of the Interior and Kingdom Relations of the above by letter.

1. Acquire demonstrable insight into the safety risks serving as a basis for safety strategy.

   The starting point for achieving the required level of safety is as follows:

   - assess the entire system, and
   - identify the corresponding risks.

   This will serve as a basis for establishing which hazards need to be managed, and which preventive and repressive measures should be taken in order to do so.

2. Define a demonstrable and realistic safety strategy

   In order to prevent and manage adverse events, a realistic and practicable safety plan or safety strategy should be defined. This safety strategy is based on the following:

   - relevant current laws and regulations (see Section 3.2);
   - the applicable industry standards, guidelines and best practices, the individual insight and experience of the organisation and the safety objectives drawn up specifically for the organisation.

3. Implement and enforce safety strategy

   Safety strategy should be implemented and enforced, and the identified risks managed by ensuring the following:

   - a description of how the defined safety strategy will be implemented, focusing on the specific objectives, including the resulting preventive and repressive measures;
   - a transparent and unambiguous division of responsibilities for safety in practice with regard to the implementation and enforcement of safety plans and measures that are accessible to everyone;
   - a clear definition of the required staff and necessary expertise in the various roles;
   - clear and active central coordination of safety activities.
   - realistic training and testing of safety strategy.

4. Tightening up safety strategy

   Safety strategy should be continuously evaluated and tightened up on the basis of the following:

   - carrying out periodic risk analyses in terms of safety, observation rounds, inspections and audits, which activities should in any event be performed whenever changes to basic principles are made (pro-active approach);
   - setting up a system for monitoring and investigating near accidents and accidents on the complex, and performing an expert analysis thereof (reactive approach).

   Evaluations will be performed on the basis of the above, and improvement areas identified which can be actively managed.

5. Management control, commitment and communication

   The management of the parties and organisations involved should ensure the following:

   - that internally expectations regarding the safety objectives are clearly defined and realistic, and that the ‘people on the shop floor’ is receptive to the idea of making continuous improvements to safety;
   - ensure clear external communication regarding general working methods, how these are tested, procedures in the event of deviations and so on, based on clear agreements made with the parties in the surrounding area.
   - agreements in the daily environment

APPENDIX E: RADIO TELEPHONY TRANSCRIPTBIJLAGE

S&P/Performance
Air Traffic Control the Netherlands
Schiphol East

Luchtverkeersleiding Nederland
Air Traffic Control the Netherlands

Reference : S&P/Performance

Version : Final

Frequencies & positions : 121,800Mhz = Schiphol ground Noord
Toren tafel 1=werkpositie van vkl. Freq. 118,100MHz
119,225 MHz = frequentie gebruikt door Tower-supervisor.
124,875Mhz = Amsterdam radar, Sector 2.

Transcript " 2010-02-10 KLM1369 start van B"

GC=Schiphol Ground	KLM=KLM1369	DCO=Schiphol Departure Control	AMS=Amsterdam Radar
TWR=Schiphol Tower	CAL=CAL5420		
Sup=Tower supervisor.	KLM2=KLM1723		

Time (UTC)	Between	Content	Time (UTC)	Between	Content
			19:10:00	Departure ATIS	This is Schiphol Departure Information X. Main take off runway 36L. Main landing runway 06. Runway conditions: runway 36L clear and dry. Braking action good. Taxiways and aprons: slush 3 mm, 25%. Braking action medium. Operational report: de-icing procedures in force. Contact your handling agent. 040 degrees 16 knots. Variable between 360 and 060 degrees.Visibility 10 kilometers. Few1200 feet. Sct 1600 feet. Bkn 4000 feet. T:-1. DP:-3. QNH1014 Hpa. End of information X.
			19:19:02	Departure ATIS	This is Schiphol Departure Information Y. Main take off runway 36L. Secondary take off runway 36C. Main landing runway 06. Runway conditions: runway 36L clear and dry. Braking action good. Runway 36C clear and dry. Braking action good. Taxiways and aprons: slush 3 mm, 25%. Braking action medium. Operational report: de-icing procedures in force. Contact your handling agent. 030 degrees 17 knots. Variable between 360 and 060 degrees. Wind secondary runway 030 degrees 19 knots. Visibility 10

Transcript " 2010-02-10 KLM1369 start van B"

GC=Schiphol Ground TWR=Schiphol Tower Sup=Tower supervisor.	KLM=KLM1369 CAL=CAL5420 KLM2=KLM1723	DCO=Schiphol Departure Control	AMS=Amsterdam Radar

Time (UTC)	Between	Content	Time (UTC)	Between	Content
					kilometers. Few1200 feet. Sct 1600 feet. Bkn 4000 1feet. T:-1. DP:-3. QNH1014 Hpa. End of information Y.
			19:21:54	Departure ATIS	This is Schiphol Departure Information Z. Main take off runway 36L. Secondary take off runway 36C. Main landing runway 36R. Runway conditions: runway 36L clear and dry. Braking action good. Runway 36C clear and dry. Braking action good. Taxiways and aprons: slush 3 mm, 25%. Braking action medium. Operational report: de-icing procedures in force. Contact your handling agent. 030 degrees 17 knots. Variable between 360 and 060 degrees. Wind secondary runway 030 degrees 19 knots. Visibility 10 kilometers. Few 1200 feet. Sct 1600 feet. Bkn 4000 feet. T:-1. DP:-3. QNH1014 Hpa. End of information Z. **(opmerking:** Z bleef active tot na 19:43)
19:23:13		**Opmerking:** KLM1369 moet van GC de Snowdesk op 121,6 oproepen voor de-icingwerk op J-apron.			
19:29:38	CAL-GC	Ground, CAL5420, we are th…co……. completed the de-icing. Ready for taxi.			
19:29:47	GC-CAL	CAL5420 turn left on A to runway 36C			
19:29:52	CAL-GC	Turn left on A for runway 36C, CAL5420.			
19:31:15	KLM-GC	Grond, goedenavond weer. De 1369 at P12 for taxi.			
19:31:19	GC-KLM	KLM1369 ….. roger….turn left on A to runway 36C.			
19:31:25	KLM-GC	Left on A, 36C, 1369.			
			19:32:22		RAM687 gaat taxiën en moet van GC via left turn on B to 36C.
19:33:13	GC-CAL	CAL5420, the tower on 118,1.			
19:33:18	CAL-GC	118,1 CAL5420, good day.			
19:33:20	GC-KLM	KLM1369 follow the 74, you are in turn behind him. The tower 118,1.			
19:33:25	KLM-GC	1181, follow the 74. KLM1369. Hoi.			
19:33:31	GC-KLM2	KLM1273 at W10 you are in sequence behind a			

Transcript " 2010-02-10 KLM1369 start van B"

GC=Schiphol Ground TWR=Schiphol Tower Sup=Tower supervisor.	KLM=KLM1369 CAL=CAL5420 KLM2=KLM1723	DCO=Schiphol Departure Control	AMS=Amsterdam Radar

Time (UTC)	Between	Content	Time (UTC)	Between	Content
		company 737 coming from the right from A.			
19:33:27	KLM2-GC	At W10 behind the company 737 via A, KLM1273.			
					Opmerking: Vanaf 19:27:00 is vkl te horen op T1
19:33:23	CAL-TWR	Schiphol Tower,good evening, CAL5420..eeh…. approaching W10, hold short 36C.			
19:33:32	TWR-CAL	CAL5420, good evening, line up runway 36C.			
19:33:36	CAL-TWR	Line [onverstaanbaar] 36C, CAL5420.			
19:33:40	KLM-TWR	Tower, goedenavond, KLM1369 ready in sequence 36C.			
19:33:43	TWR-KLM	1369 goedenavond, eeehmm..proceed to W number 8 if you're ready.			
19:33:49	KLM-TWR	Ah..we are ready W8, KLM1369.			
19:33:52	TWR-KLM	Da's mooi, line up and wait 36C W8.			
19:33:54	KLM-TWR	Line up 36C W8, KLM1369.			
19:34:00	TWR-CAL	CAL5420 able to make a right turn to W10?			
19:34:03	CAL-TWR	Eeemm..sorry sir, we eeh…ehh.. over[go] W10. Request to taxi on Z then return t…. [*vkl breekt in op deze uitzending*]			
19:34:12	TWR-CAL	..Okay taxi then via Z cross Z1 to ..eeh.. W12.			
19:34:21	CAL-TWR	Ahh. Sorry sir, we need to eeh.. line up on runway via W1…11 , CAL5420.			
19:34:30	KLM-TWR	Cleared to line up, KLM1369?			
19:34:33	TWR-KLM	1369 line up W8 36C.	19:34:33	GC-KLM2	KLM1….273, the company is going to W8, so you may proceed to W10 as number 1 now.
19:34:36	KLM-TWR	Line up and wait W8 36C, KLM1369.			
			19:34:41	KLM2-GC	Eh..proceeding to W10, KLM1273.
			19:34:44	GC-KLM2	1273, tower 118, 1.
			19:34:46	KLM2-GC	1181, tot ziens. KLM1273.
19:34:47	TWR-CAL	CAL5420 you can proceed to W11…			
19:34:51	CAL-TWR	Eehh, thank you sir, sorry about that, CAL5420.			
19:34:54	TWR-CAL	That's no problem.			
19:34:55	TWR-KLM	KLM1369, from W8 cleared for take off.			
19:34:59	KLM-TWR	Cleared for take off W8 36C, KLM1369.			
19:35:04	KLM2-TWR	Toren, goedenavond, KLM1273 W10 behind the		**Opmerking**	KLM1273 komt via Q naar W10 aangereden

Transcript " 2010-02-10 KLM1369 start van B"

GC=Schiphol Ground TWR=Schiphol Tower Sup=Tower supervisor.	KLM=KLM1369 CAL=CAL5420 KLM2=KLM1723	DCO=Schiphol Departure Control	AMS=Amsterdam Radar

Time (UTC)	Between	Content	Time (UTC)	Between	Content
		China.			
19:35:09	TWR-KLM2	KLM1273, goede…avond, at W10 line up 36C.			
19:35:13	KLM2-TWR	W10, line up 36C, KLM1273			
19:36:36	TWR-KLM	KLM1369…..			
19:36:38	KLM-TWR	1369, go..			
19:36:40	TWR-KLM	Heeft u het door gehad, meneer?			
19:36:42	KLM-TWR	Eh. ..nee…..			
19:36:46	TWR-KLM	Remain the frequency.			
19:36:50	KLM-TWR	Eeh… okay.			
19:36:51	TWR-KLM	En 1369, kunt u zo meteen even bellen?			
19:36:56	KLM-TWR	Eeh.. ja, dat is prima.			
19:36:58	TWR-KLM	Is dat pas op de destination of kunt u onderweg al bellen?			
19:37:02	KLM-TWR	Eeh..destination pas.eeh..			
19:37:04	TWR-KLM	Okay. We gaan even kijken voor een aparte frequentie zo meteen. For the time contact 11905.			
19:37:09	KLM-TWR	11905 for 1369.			**Intercom:**
			19:37:12	TWR-DCO	De 1369… daar gaan we zo een frequentie doorgeven, want die heeft wat geks gedaan, hiero.
			19:37:16	DCO-TWR	Zeg, dat nog eens, d'r is iets geks?
			19:37:19	TWR-DCO	Nou, die 1369 krijgt zo meteen even een frequentie, want dan moet ik even met 'm praten.
			19:37:21	DCO-TWR	Okay, prima.
19:37:27	KLM-DCO	Departure hello, KLM1369.eehh.. level 40, climbing 60.			
19:37:31	DCO-KLM	1369, climb level 140.	19:37:31	**Opmerking**	KLM1273 krijgt take off clearance W10 36C
19:37:33	KLM-DCO	Climb level 140, KLM1369.			
19:38:34	DCO-KLM	KLM1369, can you switch the other box, please to 119, 225. Tower has a question for you.			
19:38:41	KLM-DCO	119225..ehh..1369. Tot ziens.			
19:38:45	DC-KLM	Op de andere kant u naar 124875, Amsterdam.			
19:38:49	KLM-DCO	124875, KLM1369, hoi.			
		Descrete frequecy 119,225MHz.			**Amsterdam radar 124,875MHz**

Transcript “ 2010-02-10 KLM1369 start van B”

GC=Schiphol Ground TWR=Schiphol Tower Sup=Tower supervisor.	KLM=KLM1369 CAL=CAL5420 KLM2=KLM1723	DCO=Schiphol Departure Control	AMS=Amsterdam Radar

Time (UTC)	Between	Content	Time (UTC)	Between	Content
19:39:31	KLM-Sup	Tower, KLM1369….			
19:39:33	Sup-KLM	Ja 1369, goedenavond..ehh. heeft u even nagedacht over de situatie?			
19:39:40	KLM-Sup	Eh.. ja, uiteraard…… eeh… ik kan het niet verzinnen.	19:39:36	KLM-AMS	Radar, goedenavond, KLM1369, level 90, climbing level 140.
19:33:45	Sup-KLM	Eeh.. we hebben u laten gaan, omdat u een dusdanig hoge snelheid had, maar u …realiseert u zich dat u van de táxitrack gestart bent?	19:39:40	AMS-KLM	KLM1369, climb to flight level 190 and proceed direct to DRE.
19:39:54	KLM-Sup	Nee, dat realiseer ik me niet….okay, dank u wel.	19:39:45	KLM-AMS	Climb 190, DRE direct, KLM1369.
19:39:58	Sup-KLM	We maken daar wel even een notitie van. De verkeersleider heeft u niet afgebroken omdat er op dat moment geen verkeer was en het veiliger vond u te laten gaan, dus vandaar.			
19:40:06	KLM-Sup	……ik begrijp ‘m….ehh…. ik zal d’r ook een notitie van maken en het melden…….. ehm…..nou, dank u wel voor het doorgeven			
19:40:13	Sup-KLM	Okay, doe voorzichtig.			
19:40:14	KLM-Sup	Dank u wel.			
			19:42:02	AMS-KLM	KLM1369, climb to flight level 250.
			19:42:05	KLM-AMS	Flight level 250, KLM1369.
			19:45:39	AMS-KLM	KLM1369 contact Maastricht 133, 855.
			19:45:43	KLM-AMS	133855, KLM1359, bye.

APPENDIX F: AIRCRAFT PERFORMANCE CALCULATIONS

General

An aircraft performance calculation includes calculating the maximum speed at which an aircraft take-off can still be safely aborted. The calculation of the 'decision speed' referred to as 'V_1' allows an aircraft to come to a halt before reaching the end of the runway in the event of engine failure. The basic principle is that when an aircraft reaches higher speed it is safer to continue take-off. The decision speed determined for taking off via entry W9 was 148 knots.[70]

The following should be taken into account in respect of the performance calculations. The calculations below are based on tables contained in the Flight Crew Operating Manual (FCOM), the assumed conditions on the runway and taxiways and data obtained from the Flight Data Recorder (FDR). The calculations are indicative.

During the incident light snowfall applied. Since the taxiways and runway had been sprayed and the snow did not settle, it can be established that the snow-free sections of the runway and taxiways were 'wet'. If taxiways and runways are considered as being wet the applicable braking action will approximate 'good'.

Taxiway Bravo had been sprayed and was snow-free, according to statements made by the crew.

Taxiway Delta, which continues on from taxiway B in a northerly direction, had been sprayed earlier that day and was probably snow-free. The Automatic Terminal Information system (ATIS) stated 'medium' braking action for the taxiways. The performance calculation tables in the aircraft manufacturer's Flight Crew Operating Manual (FCOM) take amongst other things account of the runway conditions, referring to 'good', 'medium' or 'poor' braking action accordingly.

In the event of wintry conditions derated take-off power does not apply to the Boeing 737 as standard. ATIS refers to the criteria with the term 'braking action'. Even if braking action is designated as 'good', derated take-off power is not applied as standard.

Performance calculations for runway 36C

Runway 36C had been sprayed, was snow-free and braking action was 'good'.

Available runway length from runway 36C: entry W8 – 2,650m (changed while taxiing)
entry W9 – 2,985m (originally scheduled)

Aircraft manufacturer data states that in the event runway friction is 'good', the required distance should be at least 1,185m (with a 15% margin) in order to bring the aircraft travelling at a speed of 148 knots to a halt.

70 1 knot equals 1,852 metres an hour.

The original calculation via entry W9

The crew had the following calculations made via the standard performance calculation programme for the anticipated take-off from runway 36C via entry W9:

V_1 = 148 knots (decision speed)
V_r = 152 knots (rotation speed)
V_2 = 156 knots (safe climb-out speed on one engine)

The calculation programme applied the condition that maximum engine power was not required. Derated take-off power applied with the limiting factor being an obstacle in the aircraft's departure route rather than runway length.

The intended take-off from runway 36C via entry W8

The crew had re-entered the following calculations via the standard performance calculation programme for the intended take-off from runway 36C via entry W8:

V_1 = 148 knots (decision speed)
V_r = 152 knots (rotation speed)
V_2 = 156 knots (safe climb-out speed on one engine)

The crew used the speeds corresponding to take-off via entry W9 with de-rated take-off power. In this case the crew would have taken off with maximum engine power on the runway, with the limiting factor being an obstacle in the aircraft's departure route rather than runway length.

Required take-off runway length (acceleration up to 148 knots[71])based on the FDR:	1,125
Required runway length (deceleration up to 0 knots) according to the aircraft manufacturer, incl. 15% margin:	1,185
Available runway length for take-off via entry W8:	2,650

Margin: 340 m

71 The runway length calculated incorporates two seconds' response time.

APPENDIX G: METEOROLOGICAL INFORMATION

General

The weather observation at Schiphol around the time of the incident was compiled on the basis of information obtained from the Royal Netherlands Meteorological Institute (KNMI), Schiphol's Automatic Terminal Information Service (ATIS)[72] and information obtained from the crew on board PH-BDP and CAL5420.

KNMI weather information

General situation:
A fairly strong north-easterly flow brought continental polar air. There was a lot of cloud, producing snowfall in many areas. It snowed from time to time at Amsterdam Airport Schiphol.

The weather conditions on the basis of routine observation (see table) at 19.25Z (= 20.25 local time):
Ground wind direction was 030 degrees (approximately northeast) at 15 knots, variable between 350 and 050 degrees. The outside temperature was minus one degree Celsius, dew point minus 3 degrees Celsius and visibility 10 kilometres or more.
Cloud cover[73] was 1/8 to 2/8 (FEW) at a height of 1,200 feet, 3/8 to 4/8 (SCT) at 1,600 feet and 5/8 to 7/8 (BKN) at 4,000 feet. TEMPO announced a temporary change in the weather lasting less than an hour, with light snowfall and visibility reducing to 6,000 metres. Air pressure was 1,014 hectoPascal.

EHAM	101925Z	03015KT	350V050	9999	FEW012	SCT016	BKN040	M01/M03
Q1014	TEMPO	6000 -SN						

ATIS weather information

ATIS information bulletin 'Z' was valid from 20.22 up to at least 20.43 local time, and more or less shows the same weather observation as the KNMI adding that runway 36C (Centre) was dry, free of snow and ice and braking action was good. Twenty-five percent of the taxiway and apron surfaces were covered in 3-mm thick slush and braking action was medium.

Further weather information

The PH-BDP crew stated that it snowed slightly and that there was little snow on the take-off runway and taxiways. There was no snow on taxiway Alfa and there was a little snow on interconnecting taxiway A25. The visibility was fine.

The CAL5420 crew also stated that it snowed slightly, which did slightly affect visibility.

De Airside Operations Manager (AOM), who had been there shortly after the incident stated that at the most some light powdery snow had settled, which the wind had blown to the south side.

72 ATIS, an automatic message for outbound and inbound traffic containing the prevailing weather conditions at the airport and operational details. The message is broadcast on various VHF frequencies and is preceded by a letter.
73 Cloud cover: from 1/8 to 8/8, with 8/8 indicating full cloud cover.

APPENDIX H: THE INFRASTRUCTURE NEAR RUNWAY 36C

Introduction

The infrastructure relevant to this investigation is runway 36C with taxiways Alfa and Bravo located to the east of the runway and taxiway Zulu to the south and west.

Take-off runway 36C can be accessed from taxiway Alfa via interconnecting taxiway A25 by first crossing taxiway Bravo and then taxiing down intersection[74] W8. The direction of entry W8 is located at a 30-degree angle to runway 36C because intersection exit W8 serves as a rapid exit taxiway – in the opposite direction – when runway 18C is used for landing. Intersection W9 is located further southwards and W10 is located at the beginning of take-off runway 36C. Entries W11 and W12 are located to the west of runway 36C.

According to the published regulations[75] a compulsory northerly direction of travel applies to taxiway Alfa at interconnecting taxiway A25 and entry W8 with a compulsory southerly direction of travel applying to taxiway Bravo. Connecting taxiways are located between the two taxiways.

Taxiways

Taxiway markings consist of a continuous yellow line in the centre of the taxiway (taxiway centreline marking) and green centreline taxi lights marking the centre of the taxiway in the direction of travel. Blue lamps (taxiway edge lights) or blue markers (taxiway reflectors) indicate each side of the taxiway.

Signs along taxiways alfa and bravo near runway 36c

Amsterdam Airport Schiphol has arranged the signs to align with the standard taxiing direction on taxiways Alfa and Bravo. The signs located along taxiways Alfa and Bravo show taxiway and take-off runway information in both the compulsory and opposite direction of travel.

Take-off and landing runways

The markings on take-off and landing runways include a broken white line in the centre of the runway (runway centreline marking) and white lights, which indicate the centre of the runway (runway centre lights). White lights are located along both sides of the take-off and landing runways (runway edge lights) and indicate the runway edges. Red lights indicate the end of the landing runway.

Amsterdam Airport Schiphol has placed enhanced taxiway centreline markings at all entries. This is additional marking on both sides of the centreline marking to warn pilots that they are approaching a take-off runway. In addition, all entries feature compulsory sign marking on the asphalt in accordance with ICAO recommendations.

74 An intersection refers to a section of taxiway serving as the entry to a take-off runway or as the exit from a landing runway.

75 The Aeronautical Information Publication (AIP), published by LVNL, states that the directions of travel are compulsory.

Apron J (Juliet) is located alongside taxiway Alfa and is used for removing ice, frost or snow from aircraft. Apron J features four aircraft parking positions for de-icing aircraft. These parking positions are designed for parking aircraft with their noses facing the direction of taxiway Alfa. Yellow lines indicate the direction of travel to taxiway Alfa from Apron J. These lines run from each de-icing position to taxiway A and are not illuminated.

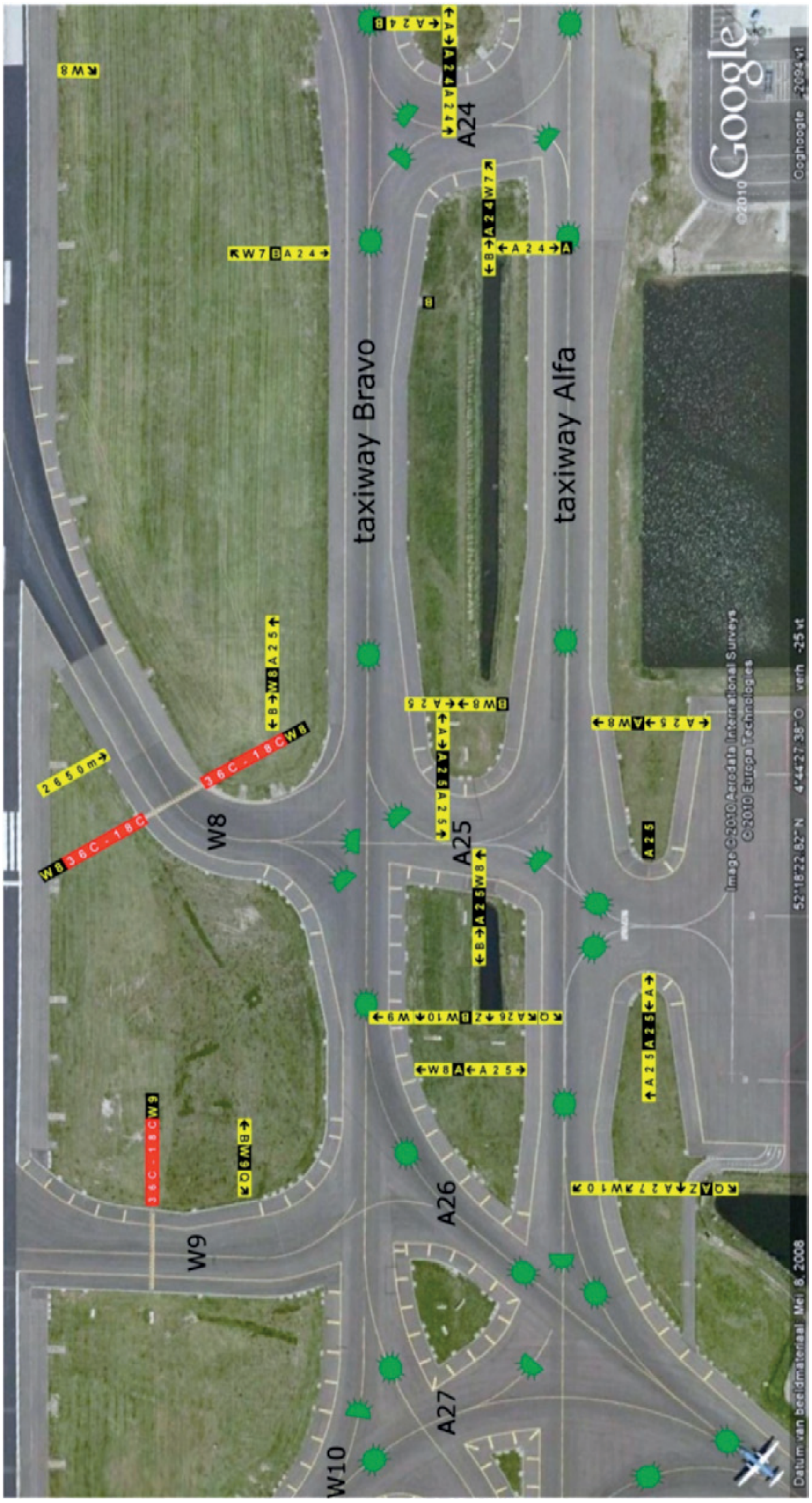

Figure 12: The visibility of taxiway lighting depends on the direction of travel

The lamps are only visible on the rounded sides but not on the flat sides. Taxiway A features green centreline taxi lights and a yellow centreline. The green centreline taxi lights are visible from two directions, i.e. North-South and South-North. Signs are located alongside taxiway Alfa which are readable in both the compulsory direction of travel and in the opposite direction of travel.

At interconnecting taxiway A24 leading to taxiway Bravo, the yellow centreline and the green centreline taxi lights fork off running to the right to interconnecting taxiway A24 and straight ahead to taxiway Alfa. The green centreline taxi lights have been installed on A24 in such a way so that they are only visible in a southerly direction if the route followed is 'taxiway Alfa-A24–taxiway Bravo'.

At interconnecting taxiway A25 the yellow centreline forks off to the right and straight ahead. The yellow centreline leading to the right indicates the route to interconnecting taxiway A25 leading to taxiway Bravo while the yellow centre line leading straight ahead indicates the route to taxiway Alfa. The green centreline taxi lights do not run along the fork but only run along taxiway Alfa.

While there are green centreline taxi lights on A25, these are only visible, however, if an aircraft enters interconnecting taxiway A25 from taxiway B or via W8 from runway 18C. Blue markers (reflectors) demarcate the straight sections of taxiways while the curves feature blue lamps.

Stop bar W8

A stop bar is illuminated at intersection W8 in low visibility conditions. Low visibility conditions did not apply at the time of the incident and the stop bar at W8 was consequently not illuminated. In the event of low visibility conditions air traffic control does not use W8.

The situation around taxiway Bravo

Taxiway Bravo features green centreline taxi lights and a yellow taxiway centreline marking. The green centreline taxi lights are visible from two directions, i.e. North-South and South-North. Turn-offs W8 and W9 for runway 36C (for take-offs and landings) are indicated by yellow centreline marking. The entries, including W8, feature blue taxiway edge lights on both sides. In accordance with the design none of the turn-offs feature green centreline taxi lights to prevent taxiing traffic from inadvertently entering runway 36C and causing a runway incursion.

Along taxiway Bravo the yellow centreline and the green centreline taxi lights both fork off after exit W9. Both the yellow centreline and the green centreline taxi lights indicate the route leading to the right to entry W10. The yellow centreline and the green centreline taxi lights also indicate the route to be followed to the taxi route leading around runway 36C. The green centreline taxi lights on taxiway Bravo are visible from a North-South and South-North direction. Signs are located alongside taxiway Bravo which are readable in both the compulsory direction of travel and in the opposite direction of travel.

APPENDIX I: SIMULATOR SESSIONS

General

The simulator sessions firstly served as an additional tool for analysing the crew's activities in their work environment and their circumstances. Secondly, the sessions served to prepare the film reconstruction of the taxi route, see appendix J.

However, there were restrictions in the use of the simulator. The effects of snow in the simulator programme were too drastic and therefore could not be used. The lights on the taxiways, runways and signs were not representative of the visual information that was either available or unavailable to the crew. This also applied to the effects of the lights of the snow clearance vehicles, which were unable to be simulated.

Lastly, it should be noted that the assessment of the processes to be carried out in the cockpit were to a certain extent subjective. It was also taken into account that the crew's mindset, particularly that of the pilot in command, which had been built up during the actual flight, strongly determined the crew's actions. In this connection, the lack of CVR information around the time at which the incident occurred proved to be a great loss. Since the project team carried out the simulated flight with prior knowledge (and were unable to generate mental drift or an incorrect mindset), in terms of investigation questions the project team restricted itself to the more measurable factors, such as work pressure and verifying actions.

The radar data, FDR data and radio telephony transcript formed the basis for a time-frame corresponding with that of the original flight. During the first simulator session, the taxi route was followed a total of 12 times, finishing with a take-off from taxiway Bravo. The taxi route was followed once via entry W8 to take-off runway 36C, finishing with a take-off. The crew on board flight KL1369 participated in the second simulator session. The session debrief supplemented the reconstruction of the facts, continuing the interviews previously held with the crew.

Simulator session 1

On the basis of the previous interviews conducted with the PH-BDP crew nothing special occurred. From the time the simulated flight left the de-icing apron, a flight was operated in line with KLM 737 operations. This reference plus the expertise present and common airmanship among the investigation team formed the basis for the findings resulting from the simulator session.

By experimentally determining the correct taxi speed the investigation team were able to gain an idea of the work pressure and the activities to be performed. The investigation team's findings are as follows:

- The activities carried out in accordance with the checklist and radio telephony communications took place in rapid succession but there is no question of the crew rushing through the work.
- The work pressure increased after W8 had been offered.
- The conclusion drawn is that at the time the aircraft entered interconnecting taxiway A25 until lining up on taxiway Bravo, a great deal happened:
  - The pilot in command followed communications between CAL5420 and air traffic control;
  - The first officer changed the information in the FMS and had this checked by the pilot in command;
  - Communications took place between the first officer and the pilot in command about what permission they had received;
  - The crew had to use the moment air traffic control was not communicating with other air traffic immediately to request confirmation of the earlier instructions received about lining up on runway 36C;
  - Communication took place about line-up and wait instructions, and receiving these instructions, and take-off clearance followed shortly afterwards;
  - The crew carried out the activities on the checklist and the runway items.

Simulator session 2

The purpose of the second simulator session was to verify the findings from the first session with the crew and to find out whether they were able to recall any further information or provide any further account of the situation. Three runs of the taxi phase were carried out in total, finishing with a take-off from taxiway Bravo.

While taxiing along taxiway Alfa in a southerly direction there was abundant light to the left but it was dark to the right. The pilot in command recalled two large yellow signs with snow on them. Both pilots recalled that there was 'some snow' on interconnecting taxiway A25. At W8 they only experienced darkness. The two pilots stated that they had never taken off via W8 and that they were unfamiliar with entry W8.

During the simulator session debrief the pilot in command stated that he had followed the conversations between the ATC tower and CAL5420 and that they had distracted him. He also came to the conclusion that he had been focussing on task inside the cockpit rather than watching outside of the cockpit more than he had thought.

According to the first officer he had looked outside briefly while the aircraft was on A25. He had seen some snow lying on the taxiway and was interrupted by the pilot in command because the latter had asked to him to have take-off clearance for runway 36C confirmed. He then saw a long row of lights. Later, when the aircraft was on taxiway Bravo, nose facing northward, he subsequently looked up once again briefly. The impression was that the first officer had looked outside on fewer occasions during incident than the investigation team had initially thought.

The first section of the taxi phase proceeded quietly. After the route to W8 had changed the crew began to rush. During the original taxi phase they found that the options they were required to weigh up and the activities they needed to carry out in order to accept W8 also required their attention. Consequently, they were unable to pay adequate attention to other matters. Account could not be taken of this effect in the simulator.

Despite the fact that the pilot in command had stopped on A25, the conversation between ATC and CAL5420 captured his attention. When turning onto taxiway Bravo he confirmed whether the important calculated speeds on the take-off card had been entered in the FMS. During the session the pilot in command felt that he must have had his head down quite a lot while the original flight was taxiing along A25.

During the simulator session 2 debrief the crew found that the actual situation had been approached to a reasonable degree. The pilot in command pointed out that the radio frequency was busier that he recalled and that the crew had received a line-up and wait instruction on taxiway Alfa instead of take-off clearance. During the third run, the taxi phase and the subsequent take-off were simulated as fully as possible. This took 20 seconds longer in total than the original take-off.

APPENDIX J: ANALYSIS OF THE FOOTAGE SHOWING THE RECONSTRUCTION OF THE PH-BDP TAXI ROUTE

Introduction

The reconstruction did not incorporate the light snowfall at the time of the incident. As it is difficult to approach the light intensity perceived by the human eye with a film camera during night-time conditions, the footage was shot at different times between dusk and complete darkness.

The intensity of the lights on the take-off and landing runways corresponded with the situation during the incident and the visibility was similar. As was the case during the incident, a Boeing 737 and a Boeing 747 were used for the purpose of the reconstruction. A number of snow clearance vehicles were deployed during the reconstruction in order to simulate the flashing lights.

The footages shot from the air traffic control tower at Schiphol-Centre and the Boeing 737 cockpit are discussed successively.

Observations from the ATC tower at Schiphol-Centre

General differences between daylight and darkness
The purpose of the film reconstruction shot from the ATC tower was to establish the air traffic controllers' visibility of the infrastructure and aircraft. It was not possible to replicate the snow on the airport terrain at the time of the incident for the purpose of the reconstruction.

In daylight the infrastructure near runway 36C is clearly visible. Runway 36C with W10, W9 and W8 can be clearly seen. Taxiways Alfa and Bravo can be clearly distinguished from each other as well as from runway 36C. The positions of air traffic taxiing and taking off can continually be established accurately.

This picture changes when it is dark. Various types, colours and intensities of light now become visible from the ATC tower. Viewed from the ATC tower most of the light sources were located in the area directly in front of the tower. The abundant lights from the lamp posts located along the roads and parking areas, the apron lighting, advertising signs and buildings are noticeable and are all located between the ATC tower and taxiway Alfa. The bright light emitted by advertising signs is particularly conspicuous and dominant.

The area further along containing the runways, the taxiways and the periphery beyond was relatively dark. Beyond taxiway Alfa, which itself was no longer visible, the edge lights on runway 36C can be seen thanks to the patterns formed by the lamps, but not because they are bright or conspicuous.

Part of the light coming from beyond the Amsterdam Airport Schiphol terrain is static light from the A5 and A4 motorway lights. A further part of the light continuously moves through the scene, i.e. car lights. The number and intensity of the light sources therefore vary.

De-icing Apron J
The de-icing apron is clearly noticeable from the ATC tower on account of the presence of lamp posts that light up the entire apron such that little difference can be seen between daylight conditions. The aircraft and all the equipment on the apron can be clearly seen as a result.

Taxiways
The green centreline taxi lights on taxiways Alfa and Bravo are not visible between the de-icing apron and W9. The blue edge taxiway lights – which are only located in the curves - are barely noticeable but do not demarcate the contours of a taxiway.

The taxiway lighting is not visible in the light intensity[76] that applied at the time of the incident and the exact positions of aircraft taxiing and taking off cannot exactly be established. Taxiways Alfa and Bravo, the interconnecting taxiways and entries could no longer be distinguished. If the light intensity is increased, the green and blue taxiway lamps are indeed noticeable from the ATC tower.

Take-off runway 36C
The lights on take-off runway 36C are clearly noticeable. This is due to the white edge lights on the runway, which clearly demarcate the runway contours. The white lights in the centre of the runway cannot be seen. The entries to the take-off runway likewise are not noticeable. Using the runway edge lights as a reference, it is only possible to visually determine the relative position of aircraft. The routine and the trained eye of the air traffic controllers do help.

Situation at entry W10
Entry W10 is more clearly noticeable from the ATC Tower than entries W8 and W9 because one continues to look down W10 more. The green and blue taxiway lighting on entry W10 can be seen reasonably well.

Taxiway turn-offs A25 and W8
Located between taxiways Alfa and Bravo is a connecting section called A25 that also continues on from W8. Blue taxiway lights have been placed in the curve leading from taxiway Alfa to taxiway Bravo along the edges that are not noticeable from the ATC tower. An air traffic controller can generally estimate the location of A25 and W8 because of a large advertising sign located practically in the sightline of the ATC tower to W8. The snow clearance equipment is also clearly visible in the same sightline on account of all the red flashing lights and headlights on the different vehicles.

The stop bar at W8 was not illuminated due to non-low visibility conditions. The stop bar at W6 can be clearly seen.

Entries W11 and W12
Entries W11 and W12, which form part of the apron, are located at the beginning of take-off runway 36C. As shown in the film reconstruction the apron is not visible when it is dark. As a result it is not possible for the ATC tower to establish whether there are any obstacles on these taxiways.

Noticeability of the Boeing 737
The aircraft contours are barely noticeable when it is dark. The visibility of the aircraft itself primarily depends on what aircraft lights are being used, the aircraft's position and direction of travel as well as the lights in the background. Since aircraft with their lights switched on are continuously surrounded by other peripheral light, aircraft could be seen the most clearly as long as they kept moving. Stationary aircraft were not noticeable even though their lights were on.

While taxiing on taxiway Alfa, commercial aircraft such as the PH-BDP use an anti-collision light, logo lights that illuminate the aircraft's tail, navigation lights on the wing tips and at the rear of the fuselage, and a taxi light which illuminates the taxiway. The Boeing 737 is noticeable mainly due to the logo light and can be clearly seen from the ATC tower depending on the aircraft's direction of travel. The anti-collision light is noticeable but this depends on the intensity of the logo light. The aircraft's navigation lights are barely noticeable. Aircraft landing lights illuminate the take-off runway directly in front of the aircraft and are extremely bright as a result of which they are continuously visible to the air traffic controller.

The visibility of the Boeing 737 diminishes as soon as the aircraft turns, nose pointing westward, via interconnecting taxiway A25. With this view of the rear of the aircraft none of the illuminated tail areas are visible to the air traffic controllers at all. To the extent the anti-collision light can still be seen directly, it merges with the mix of flashing lights on the snow clearance vehicles positioned on Apron Yankee.

76 A higher light intensity could improve the visibility of the taxiways from the ATC tower but the disadvantage is that the light will blind the crews on board taxiing aircraft.

This continues to be the case when the Boeing 737 lines up on taxiway Bravo. A Boeing 737 is clearly noticeable with its strobe lights and landing lights switched on as soon as the aircraft has lined up in a northerly direction. If the aircraft lines up on take-off runway 36C via W8, it is positioned more clearly towards the North and as a result is not affected by the flashing lights of the snow clearance equipment. The aircraft will then be located between the white edge lighting. If the aircraft is on taxiway Bravo, the aircraft will appear to be located in front of the white lights.

Noticeability of the Boeing 747
The Boeing 747 is clearly noticeable due to the aircraft's large, illuminated tail area, its navigation lights and anti-collision light, and one can obtain a good idea of the aircraft's contours because of the position of the various lights. On taxiway Alfa, at W10, the logo lights, the anti-collision light and the contours of the aircraft itself were clearly noticeable.

Observations from the Boeing 737 while the aircraft was taxiing

The objective was to analyse what visual information and signs were available to the KLM crew while taxiing to runway 36C in the dark. It was not possible to replicate the snow on the airport terrain at the time of the incident for the purpose of the reconstruction.

Leaving the de-icing apron
In order to leave the de-icing apron and travel to taxiway Alfa the aircraft must follow a right-angle curve to the left. During the film reconstruction it emerged that it is difficult to determine the location of taxiway Alfa owing to the fact that the de-icing apron seamlessly transitions into taxiway Alfa. The edge of taxiway Alfa also features blue markers (reflectors) and not blue lamps. The markings/lines are indeed visible but can only be used as a taxiing aid when the aircraft uses its landing lights. The de-icing apron does not feature any asphalt-embedded lights to demarcate the various aircraft parking positions or serve to guide taxiing aircraft. The de-icing apron is well-lit by the bright lights on the lamp posts. This creates a great contrast between the brightly illuminated de-icing apron and a relatively dark taxiway section around the de-icing apron.

Travelling along taxiway Alfa in a southerly direction
The Boeing 747 can be clearly seen when travelling along taxiway Alfa. The distance to the Boeing 747 can be estimated accurately as a result. Taxiway Alfa features green centreline taxi lights which can be clearly seen. It is difficult to distinguish the edges of taxiway Alfa with only the Boeing 737's standard taxi lights. The signs showing A24 and A25 are clearly readable.

When travelling along taxiway Alfa there is a considerable contrast between the lights to the left and right of the aircraft. The left-hand side is fully illuminated with light emitted by the floodlights on the various aprons, the flashing red lights of the snow clearance equipment[77] and the lights of the airport buildings. Straight ahead, the taxiway lights can mainly be seen against a dark background environment. The picture on the right-hand side, in a westerly direction, is quieter and darker with lights distributed across the airport terrain reflecting shaded lights of the taxiways, take-off runways and the periphery beyond. The identification signs were clearly readable during the reconstruction.

The markings cannot be clearly identified as a yellow line with the Boeing 737's normal taxi lights. However, when the aircraft's landing lights are switched on the colour yellow can be distinguished. The blue taxiway edge lights can be clearly seen in the curves, making the presence of a turn-off clearly noticeable. This is further reinforced by the green taxi lights demarcating the full curve leading to a turn-off.

77 At the time of the incident the snow clearance equipment probably consisted of a fleet of 10 vehicles. During the film reconstruction, for practical reasons the number of vehicles was limited to seven.

Right curve at A25 leading to taxiway Bravo and W8
Green lights do not indicate the right curve on taxiway Alfa leading to A25. There are no green centreline taxi lights leading straight ahead on A25 to W8 and in the curves leading both northward and southward for air traffic coming from taxiway Alfa. All curved edges on taxiway A25 leading to taxiways Alfa and Bravo as well as W8 feature blue edge lights making the contours of A25 clearly visible.

In the knowledge that take-off runway 36C is located there, the white runway edge lights are noticeable but form patterns with the lights of the motorway in the background. The lights on the take-off runway are not clearly visible or clearly distinguishable from other lights. The yellow taxiway markings do, however, indicate where W8 is located. The right curve on A25 leading northward to taxiway B is also indicated. These markings, in turn, are difficult to see with the Boeing 737's standard taxi lights. They are more noticeable with the aircraft's landing lights and the yellow colour of the line can also be seen.

If the aircraft, nose facing west, is stationary at a midway point on interconnecting taxiway A25, part of the take-off runway signs were found to be masked by the centre window mullion viewed from the left seat of a Boeing 737. The beginning of W8 is barely recognisable from a midway position on A25. Due to the fact that entry W8 is located at a 30-degree angle to take-off runway 36C with the first section at right angles to taxiway Bravo, the illuminated blue edge lights alone do not demarcate the taxiway. From this position with the Boeing 737 it was also found that the white edge lights on take-off runway 36C visually correspond with the lights of the A5 motorway, which runs parallel to runway 36C. Due to the fact that W8 runs at a 30-degree angle to take-off runway 36C, the signs indicating the take-off runway are not located at right angles to the direction viewed from the centre of A25 to take-off runway 36C. The contours of a non-illuminated stop bar at the beginning of W8 are not visible.

Position of taxiway Bravo looking northward
The footage shows that when looking northward at taxiway Bravo a long row of green taxiway lights are visible. The colour green is indeed noticeable but in the absence of a different coloured light source it emerged that the green row of lights optically tend to reflect the colour white. The white lights on take-off runway 36C are indeed noticeable but do not clearly distinguish the take-off runway contours.

If the Boeing 737's landing lights are switched on, the blue markers (reflectors) on the edges of taxiway Bravo become clearly visible but are not as conspicuous as the green centreline taxi lights. The blue taxiway lamps on A25 are no longer visible when the aircraft is lined up facing north. In addition no nearby identification signs are visible from this position. What is visible, however, are a number of red lights from the stop bar on W6 located further along showing 'No entry'.

Looking northward, the end of taxiway Bravo is not visible on account of the fact that the green taxiway lights appear to end in a black area. However, it can be clearly seen that the green row of taxiway lights run across a considerable distance in a northerly direction. Looking northward at taxiway Bravo, the blue taxiway lights marking the next turn-off are not clearly visible.

Simulated take-off from taxiway Bravo
If the take-off of a Boeing 737 is simulated from taxiway Bravo in a northerly direction, what one notices immediately is that the red lights of the stop bar near W6 (No entry) become more clearly visible. This is further reinforced because the red lights on the stop bar near W6 are located at such an angle to taxiway Bravo that when travelling northward along taxiway Bravo the red lights are practically located in the pilot's sightline. Various yellow signs as well as blue edge taxiway lights are passed at a short distance and are also clearly visible.

The ability of the human eye to distinguish colours

The retina is a thin layer of tissue lining the inside of the eyeball. The retina is made up of two types of cells that register the light coming into the eye, namely the cones and rods. The rods are extremely sensitive to light but cannot be used to focus and see colours. The cones enable you to see colours and focus clearly. The cones, however, are less sensitive to light.

In well-illuminated conditions the cones and rods are both used (photopic vision). When it is very dark, only the rods are used (scotopic or night vision). In general, if people are surrounded by darkness, in terms of light intensity the eyes transition between photopic and scotopic vision (mesotopic vision). The colours of lights can indeed be perceived at night if the light intensity is high enough.

The eye needs to adjust or adapt to the light conditions. It takes longer to adapt to darkness from an illuminated environment (dark adaptation, approximately five minutes, depending on the difference in the level of light) than to adapt from darkness to light. While adapting, the ability to perceive colours changes. Royal Dutch Air Force flight physiologists indicated that green light may be perceived as a type of white light. They drew the conclusion that particularly in combination with the presence of snow on the airport terrain, the light and dark conditions while taxiing affected the crew’s ability to perceive the colours of the taxiway lights.

In view of the other factors that also played a role in the incident, the aspect of the human eye and the ability to perceive colours was not examined in further detail.

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APPENDIX K: OTHER DUTCH SAFETY BOARD INVESTIGATIONS

RUNWAY INCURSIONS

The Dutch Safety Board previously conducted investigations into runway incursions at Amsterdam Airport Schiphol occurring in the period 2004-2007. A number of the incidents investigated are summarised below. The relevant investigation reports can be downloaded from www. onderzoeksraad.nl

Runway incursion involving a Boeing 757, 29 January 2004, Amsterdam Airport Schiphol
While taxiing in daylight the crew on board a Boeing 757 twice followed a different route than air traffic control had instructed them to follow. The crew subsequently made another error as a result of which the aircraft entered a landing runway. A Boeing 737 that was landing was forced to make a touch-and-go landing.

The incident took place in an area designated as a hot spot. The complex layout, the hold lines which may not have been sufficiently visible due to the effect of light reflection and precipitation, the entry angle to the runway and the non-illuminated stop bar (no low visibility conditions procedures in force) were unfavourable for the crew and also affected the air traffic control process. Air traffic failed to adequately monitor the aircraft in order to prevent the incident, possibly as a result of work pressure. This incident prompted the airport to adapt the layout.

Runway incursion involving a Boeing 767, 23 September 2004, Amsterdam Airport Schiphol
A Boeing 767 crew's interpretation of a taxi instruction differed to that of air traffic control. The aircraft consequently crossed an operative runway without permission. The incident occurred in daylight.

The interpretation of the taxi instruction and the names of the infrastructure were ambiguous as a result of contextual differences between the pilots and air traffic controllers. It could not be ruled out that ATC's workload contributed to ATC monitoring aircraft other than the Boeing 767. According to procedure, the aircraft was first required to be transferred from the ground to the runway controller in order to cross an operative take-off or landing runway. After crossing the runway, the aircraft was then required to be transferred back from the runway to the ground controller. This involved extra work while at that particular time no other air traffic would take-off or land on the runway that the aircraft had cross. By departing from the specified procedure for transferring an aircraft from ground control to the runway controller, the ATC's workload would not have increased unnecessarily.

Runway incursion involving a Cessna Citation, 25 October 2006, Amsterdam Airport Schiphol
While taxiing during darkness the pilot had received clearance to cross an inoperative runway. At a given moment the pilot deviated from the taxi route intended by ATC, which ran through a hot spot area. ATC failed to notice this. The pilot subsequently crossed a different runway where a cargo aircraft was preparing to take-off. The cargo aircraft had received take-off clearance while taxiing.

The interpretation of the taxi instruction was ambiguous as a result of contextual differences between the pilots and air traffic controllers. On account of maintenance work a non-standard taxi route was used, the signs were not illuminated and no green centreline taxi lights were visible to the pilot for the route he was required to follow. However, the taxiway lights leading to the take-off runway were illuminated. The detour and risks had not been reported in the appropriate flight information documents (NOTAMs). In the preceding weeks, on four occasions an aircraft had followed an incorrect taxi route at the same location without resulting in any changes to the ATC work processes or the infrastructure. At the end of 2007 the taxiway lighting at the above location was changed to prevent aircraft taxiing along an incorrect route (misleading guidance).

Runway incursion involving an Airbus A319, 5 March 2007, Amsterdam Airport Schiphol
The crew on board an Airbus A319 incorrectly assumed that they had received take-off clearance. The aircraft began its take-off run while a cargo aircraft was simultaneously crossing the runway after having received permission to do so from ATC. Both the crew and ATC detected the threat and take-off was aborted. The incident occurred in daylight.

On account of the difference in work pressure between the ground and runway controller, the controllers decided to deviate from the specified procedure for traffic crossing an operative take-off runway, causing reduced situational awareness among all crews. The crew awaited take-off clearance and confused this with the clearance intended for another aircraft on another runway. Take-off clearance issued to air traffic on different runways which can be heard on the same frequency may give rise to confusion.

Runway incursion involving a Boeing 737, 8 July 2007, Amsterdam Airport Schiphol
The air traffic controller offered the crew on board a landing Boeing 737 an exit via the end of the runway in order to advance the arrival time at the gate. The aircraft exited the top end of the runway, which the air traffic controller had not anticipated. Because the aircraft had entered the protected area of another landing runway, another Boeing 737 was forced to make a go-around.

The instructions for exiting the runway were ambiguous. The end of the landing runway featured an illuminated stop bar which the crew confused with the runway end lights. The different experiences of the aircraft controller and the pilots with the red lights at the end of the runway may have come into play. The infrastructure physically offered the possibility of taxiing down the runway via the top end of the runway due to the embedded lighting.

APPENDIX L: INCIDENTS AND INVESTIGATIONS IN OTHER COUNTRIES

RUNWAY CONFUSION INCIDENTS INVOLVING PARALLEL TAXIWAYS AND TAKE-OFF RUNWAYS

Several serious aviation incidents similar to the incident involving the PH-BDP have occurred in the past. A number of incidents occurred prior to that of the PH-BDP at Amsterdam Airport Schiphol but the period thereafter also saw two serious incidents.

Accident involving Singapore Airlines flight SQ006, Taipei, October 2000
It was dark and a Boeing 747 was on a taxiway located adjacent to two parallel take-off runways. The aircraft was making its way to the furthest take-off runway. The other take-off runway had been taken out of use for maintenance purposes but was still partially operating as a taxiway. While lining up the crew mistook the take-off runway: instead of passing the take-off runway the aircraft was required to cross, the aircraft entered the inoperative take-off runway. During its take-off run after approximately 1,000 metres the aircraft collided with the construction material and equipment on the runway. As many as 83 of the 179 people on board lost their lives.

The Air Safety Council (ASC) of Taiwan established that among the causal factors, the crew had been under moderate time pressure and their assessment of the taxi route had been poor. While lining up the crew members had not confirmed to each other the runway on which the aircraft was located. The checklist did not include runway checks and the centreline lights on the wrong runway met their expectations leading them to believe that they had arrived at the take-off runway. The lights on this particular runway were said to have been brighter and more visible than the lights on the runway they were to use for take-off. The airfield failed to comply with the applicable international standards and the safety mechanisms of the relevant organisations failed to work. There was also a lack of supervision.

The full investigation report published by the ASC can be downloaded from www.asc.gov.tw.

Serious incident involving Pegasus Airlines flight PGT872, Oslo airport Gardermoen, 23 October 2005
It was dark and a Boeing 737 was on one of the two parallel taxiways en route to intersection A3 on the adjacent take-off runway located parallel to the taxiways. The crew had meanwhile received take-off clearance while on the taxiway. The aircraft was first required to cross the other taxiways and subsequently line up on the take-off runway. The crew took the wrong turn off to the taxiway and started the take-off run. ATC instructed the crew to abort take-off, whereafter the aircraft decelerated.

The Accident Investigation Board Norway (AIBN) regarded the 'Human Factors' relating to the crew as the main cause of the incident. The AIBN was unable to explain why the crew had made an error. Among other things, the AIBN established that the edge lights on the take-off runway were barely visible during good visibility conditions with the light intensity of the runway and runway safety guard lights[78] set at low. The AIBN formulated the following recommendations:

- to air traffic control: issue take-off clearance after ATC has verified whether there no longer is any room for the flight deck crew to make an error in respect of the intended take-off runway.
- to the airport: ensure that the light intensity of the runway guard lights can be operated separately from the runway lights in order to demarcate the entry to the take-off runway more clearly.

The infrastructure surrounding the relevant runway at Gardermoen shows strong similarities with the infrastructure around runway 36C at Schiphol. The full report can be downloaded from AIBN's website: http://www.aibn.no/Aviation/Reports/2006-20-eng.

78 Runway safety guard lights are flashing amber lights indicating the holding position at the entry to a take-off runway.

Serious incident involving Aeroflot flight AFL212, Oslo Airport Gardermoen, 25 February 2010
It was daylight and an Airbus A320 was on one of the two parallel taxiways en route to intersection A3 on the adjacent take-off runway located parallel to the taxiways. The crew had meanwhile received take-off clearance while on the taxiway and were first required to cross the other taxiway in order to subsequently line up on the take-off runway. The crew took the wrong turn off, started the take-off run and lifted off. The crew were unaware that they had taken off from a taxiway.

The AIBN concluded that the procedures were poor and that the crew's attentiveness in the cockpit was poor in combination with inadequate ATC monitoring and inadequate signs. The AIBN formulated the following recommendations:

- to Aeroflot: adjust the standard operating procedure and incorporate this in the checklist to establish the correct runway, heading and intersection before proceeding with take-off.

The AIBN established that the airport had dealt with the improvements to the signs rendering a recommendation superfluous. The previous recommendation submitted to ATC stipulating that take-off clearance should be issued after verification had taken place on the correct runway, had not been adopted. ATC views the Aeroflot incident as an isolated case. The Norwegian Aviation Inspectorate shares this view. The full report can be downloaded from the AIBN website: http://www.aibn.no/Aviation/Reports/2010-18-eng.

Serious incident involving Finnair flight FIN070, Hong Kong International Airport, 26 November 2010
This serious incident is still under investigation. The Accident Investigation Division of the Hong Kong Civil Aviation Department (CAD) published a preliminary report on 23 December 2010.

It was dark and the Airbus A320 was on one of the two parallel taxiways en route to the beginning of the take-off runway. ATC issued take-off clearance when the aircraft - which was taxiing along the taxiway furthest away from the parallel take-off runway - approached the end of the taxiway. The crew, however, made an error in the take-off runway and turned onto the taxiway that they first had to cross and commenced the take-off run. The air traffic controller received a warning from a warning system in the ATC tower, the Advanced Surface Movement Guidance and Control System (A-SMGCS), advising that the aircraft was taking off from a taxiway. He instructed the crew to abort take-off immediately, whereafter the aircraft aborted take-off.

The weather did not play a role and all markings, signs and ground lighting along the taxi route complied with the standards specified in ICAO Annex 14. There were no failures in the radio communication equipment and the taxi and take-off instructions had been issued correctly and confirmed by the parties involved. ATC Hong Kong implemented a temporary safety measure stipulating that take-off clearance should not be issued as long as it has not been established with certainty whether traffic has passed the taxiway that should be crossed.

It emerged from additional information obtained that the FIN070 incident was the fourth such incident at Hong Kong International Airport. Since intersection take-offs are prohibited at Hong Kong International Airport, confusion incidents can only occur at the beginning of taxiways and take-off runways. Following the third incident, a stop bar was also installed in addition to other measures aimed at improving guidance. The incident occurred despite the stop bar having been installed on the taxiway where the aircraft took off.

Another runway confusion incident

Accident involving Comair flight 5191, Lexington (KY), USA, 27 August 2006
The crew had received the instruction to take-off from runway 22 but it was dark and they made an error in respect of the take-off runway. The aircraft took off from the much shorter runway 26 and ran off the runway during the take-off run at high speed and crashed. Forty-nine of the 50 people on board lost their lives.

The National Transportation Safety Board (NTSB) established that the incident was caused because the crew had failed to use the available references and aids to determine their position while taxiing and to verify whether they were on the correct runway prior to take-off.

The contributory factors were found to be the fact that the crew had failed to hold relevant conversations while taxiing and the lack of requirements imposed by the aviation authority of the United States of America stipulating that runways should only be crossed after special clearance from ATC has been issued. The full investigation report can be downloaded from www.ntsb.gov van de NTSB.

Investigation report entitled 'factors influencing misaligned take-off occurrences at night', ATSB', june 2010

Background information
In daylight pilots have a wide range of visual references to help them determine their position or find their way around during take-off or while taxiing. When it is dark there is considerably less visual information. Pilots rely more on the light patterns of taxiway and take-off runway lights and whatever else they can see with the beam of the taxi and landing lights on their aircraft. This report demonstrates incidents in which pilots wrongly interpreted their position on the take-off runway because it was dark and a combination of personal factors, the take-off runway, the weather and activities they were required to carry out.

The Australian Transport Safety Bureau (ATSB) identified eight Human Factors that contributed to the occurrence of the incidents during take-offs at night. The incidents involved flight deck crews mistaking the edge lights on the take-off runway as the centreline lights and take-offs from the incorrect take-off runway or taxiway. Six of the eight factors notably occurred in the PH-BDP incident in either the same or slightly varying circumstances. The corresponding graph can be found in section 3.1.3. The report explains a number of factors; the most common factor is crew distraction and/or inattentiveness just before the aircraft taxies onto the runway. This occurs in part because the focus of the crew's divided attention is mainly on cockpit activities, which adversely affects the crew's ability to thoroughly assess the outside environment.

The weather conditions, the lights and markings on take-off runways and taxiways and the layout of the latter likewise serve to illustrate that these aspects can cause confusion among pilots. The difference in the colour of the take-off and landing runway lights has not always proved to be effective. During night-time conditions, pilots rely heavily on taxiway and runway lights in order to determine their position.

The report identifies two operational factors:
Take-off clearance timing: this may affect the work pressure or give the crew the idea that they have already reached the runway whereas they are in fact still travelling on a taxiway.
Intersection take-offs: reduced visual guidance for determining the aircraft's position on the runway, and in some cases no taxiway lighting (lead-in lights as active guidance).

Erasing Confusion, Flight Safety Foundation/ Aerosafety World, May 2010
Part of the article is summarised below. Pilot best practices and updating the equipment on board aircraft corresponds with reducing the number of take-offs from and landings on the incorrect runways, including taxiways.

Runway confusion incidents are often precursors to runway incursions and potentially the foreboding of a collision. The risk factors are but rarely unique and can be mitigated by the same safety programmes as runway incursions.

Proportions of 1,429 Accidents, Air Carriers Wordlwide, 1995-2008		
Type of Event	**Number of Events**	**Percentage of Total**
Runway incursion	10	0.7
Runway confusion	4	0.3
Source: Flight Safety Foundation Runway Safety Initiative, 2009		

Table 4: Breakdown of incidents based on incursion and confusion characteristics

Runway confusion and runway incursions

According to airline statistics, 14 accidents occurred in the period 1995-2008, see table 4. Ten of the incidents were attributable to runway incursions and four to runway confusions. However, figures from the past five years show that while the number of fatal runway confusion incidents is far less than fatal runway incursion incidents, the number of casualties, however, is much higher. There is a reservation in that the small number says little, albeit that this may be attributable to runway confusion being a relatively new phenomenon which has not yet been adequately identified in the current reporting system. Nonetheless their weight should not be underestimated because this threat is becoming increasingly manifest across the globe. See tables 5 and 6 for the statistics.

Fatal Runway Safety Events, Air Carriers Worldwide, 2002-2006				
Type of Event	**Number of Events**	**Number of Fatalities**	**Percentage of Events**	**Percentage of Fatilities**
Runway incursion	3	17	0.6	0.4
Runway confusion	1	49	0.2	1.2
Source: Flight Safety Foundation Runway Safety Initiative, 2007				

Table 5: Breakdown of fatal accidents based on runway incursion and runway confusion characteristics

Findings resulting from the incidents investigated

In addition to the quality and use of NOTAMs, an adequate taxi briefing, distraction and the cockpit workload, a last-minute change in the Flight Management System (FMS) often played a role in the incidents investigated. The golden rule that a pilot must continue to look outside at all times cannot always be maintained. The loss of situational awareness by pilots proved to be a generally recognised factor in numerous incidents.

100 Confusion Events by World Region, Air Carriers	
Region	**Percentage of Events**
Africa	4
Asia Pacific	13
Europe	28
Latin America	7
Middle East	7
North America	41
Source: Michel Trémaud	

Table 6: Breakdown of confusion incidents by region

In the area of ATC, the following factors came into play: deviating from a standard taxi route, no procedures for intersection take-offs and inadequate monitoring of traffic on account of which confusion could not be prevented on time. Another factor that occurred was issuing take-off clearance without establishing the aircraft's position. There are a number of cases where clearance was issued at times when the aircraft had not yet reached the intended runway or still had to cross runways/taxiways.

In terms of infrastructure, the layout played a role in respect of situational awareness, distraction and confusion. The removal of snow from a taxiway and partially removing snow from the take-off runway involved a difference in contrast and the risk of making an error. The taxiway lights put the crews on the wrong track if the lights were brighter than the take-off runway lights.

A few of the risk management action points stipulate that when a taxi instruction is issued both pilots are required to consult the route on a ground movement chart and to agree with the route that should be followed, the hold positions and where the aircraft should cross other runways/ taxiways. In this context operators are required to incorporate best practice to support flight deck crews in maintaining situational awareness.

APPENDIX M: INTERNAL SAFETY INVESTIGATIONS CONDUCTED BY KLM

Introduction

Each year KLM's Flight Safety and Quality Assurance Department conducts 10 to 20 internal safety investigations into KLM incidents. The department investigates the incidents involving safety issues, encompassing a lesson that is expected to be learned.

airsafety report (asr)

The department receives 2,000 pilot reports (ASRs) each year including incident reports, a selected number of which are investigated in detail each year. The information in the ASRs is entered in a database. The incident information collected is analysed in detail based on criteria subdivided into various levels of risk. The trend currently seen is that the number of observations involving the biggest breach is declining in respect of the standard. The relevant reports are those in which 'human factors' also contribute. KLM stated that the trend showed a further decline following the incident involving the PH-BDP. KLM's explanation is that this is the result of increased awareness among KLM pilots. These effects ebb away over the course of time.

KLM provides the air traffic controllers feedback if the airline detects hazardous situations on the basis of the ASRs. KLM furthermore shares information with LVNL and vice versa. From a safety management perspective they share information on the incidents and endeavour to learn from each other.

Flight data monitoring and global trends

The Investigation Department also analyses current flight information. By pro-actively monitoring flight data (FDM) KLM aims to prevent accidents from actually occurring.
KLM also monitors global trends which are disclosed in an international context. Points requiring attention encompass warnings for mid-aircollisions associated with the increasing congestion of airspace. Another point requiring attention are the incidents involving aircraft running off the runway as a consequence of the weather conditions or high-speed approaches.

The incident involving the ph-bdp and measures

The incident involving a KLM aircraft taking off from taxiway Bravo at Amsterdam Airport Schiphol was a new, unique incident for KLM. The incident in fact could not be predicted via the usual proactive monitoring of flight data on account of the fact that the human factor contributed strongly. The most important lesson KLM has learned from the incident is that this can also happen to KLM pilots at Amsterdam Airport Schiphol. All KLM pilots should realise just how precarious the balance is in terms of safety and they each must accept their own responsibility for safety.

In respect of flight safety, KLM requires that the KLM organisation focuses on performing the procedures correctly. During proficiency-checks crews undergo assessment on how they deal with these procedures. Following the incident involving the PH-BDP, KLM used the incident in order to improve safety awareness. Moreover KLM has introduced a new term to pilot training programmes: 'threat and error management'.

Threat and error management means that the pilots seated in the cockpit must jointly decide on their work method. During briefing sessions pilots highlight possible threats to their flight and circumstances to make each other aware of the possible risks as well as for the purpose of managing these risks.

KLM had already been considering whether or not to implement RAAS[79] before the incident involving the PH-BDP. In March 2011 KLM Flight Operations took a decision in principle to incorporate RAAS in its fleet. The decision was accelerated as a result of the incident involving the PH-BDP.

At the same time, however, KLM feels that RAAS generates too many warnings for runway incursions, which pilots may judge as being irrelevant. The risk involved is that if a 'genuine' warning is sounded, the pilots will have become insensitive to the warnings issued by the system.

KLM and other parties

The Amsterdam Airport Schiphol terrain feature several hot spots. The hot spots are complex junctions, sometimes comprising as many as five taxiways, which meet from different directions which contain curves. It emerged from statements that it would be desirable to simplify the current Schiphol infrastructure of taxi routes, intersections, curves, markings, etcetera.

As regards air traffic control (ATC), KLM believes that ATC is solely responsible for the separation of aircraft so as to ensure that separation poses no safety risk. The airline sees its role as that of the organisation responsible for the safety of KLM aircraft. The captain and his crew must ensure that the risks associated with each flight are managed to ensure that they are reduced to an acceptable level. It is appreciated that air traffic controllers contribute as far as possible and provide information to pilots. Air traffic controllers, however, should refrain from doing the pilot's thinking. The pilot in command will decide whether he will accept an offer to take an intersection from air traffic control (LVNL). By the same token, it is up to the pilot in command to request support from the air traffic controllers if he requires support. This is the pilot in command's duty.

The KLM had instituted an internal investigation into the facts relating to the incident involving the PH-BDP. The Transport, Public Works and Water Management Inspectorate (IVW) sent special investigating officers to KLM and according to KLM, IVW threatened to impose sanctions on specific individuals. KLM found IVW's approach detrimental and discontinued its own investigation.[80] In KLM's experience, nowadays IVW is only too eager to apply enforcement without IVW having any reason to do so. KLM has established that the initial distinction between IVW's role as a supervisory body (oversight) and that of an enforcement body is becoming more obscure. KLM is of the opinion that IVW consequently forms a threat to the reporting culture at KLM. KLM's safety management system is based on independent reports.

79 RAAS is a runway awareness and advisory system, an electronic system on an aircraft that helps pilots to maintain positional awareness. The system can therefore contribute to preventing runway incursions and taxiway take-offs.

80 European legislation permits discontinuation of an internal incident investigation.

APPENDIX N: BACKGROUND INFORMATION ON FLIGHT OPERATIONS

The KLM organisation regularly makes crews aware that its customers take centre stage. At the end of the day, KLM derives its income from its customers and must ensure that it has satisfied customers. Customer awareness is also addressed in education and training programmes. Pilots in command in particular are educated to maintain customer focus.

The cost index for each flight has been fixed precisely. The flight plan states the costs resulting from a delay as a function of the number of minutes of delay. Flight operations have changed over the course of the years and there is an increasing emphasis on fuel efficiency and on-time performance. According to statements made by pilots, the impression that has emerged is that the balance between safety and economy has shifted towards the latter. The fleet of Boeing 737s forms an important part of the airline's total route network and is susceptible to the above balance. Punctuality strongly affects the total operations of the KLM organisation. This is because many passengers transfer to other intercontinental KLM flights or that of its partners at Amsterdam Airport Schiphol. The extent to which observing punctuality recurs in flight operations differs per crew because one pilot in command will be more sensitive to customer needs and time pressure than another pilot in command.

It is not unusual to accept an intersection take-off, for which the crew are not prepared. If sufficient time is available a new take-off calculation can be made but it takes several minutes to make such a calculation. This consequently negates any time gained in making an intersection take-off. If possible, maximum take-off power can be entered in the FMS, but the ability to estimate the feasibility of the take-off will depend on the crew's experience. This modus operandi is frequently used but is not covered by any KLM procedure. A late change in the intersection that should be used will increase work pressure. It emerged from interviews that such a risk can be accepted in a well-considered way if this only involves a slight increase in work pressure. Pilots derive a certain amount of satisfaction if they are able to achieve time gains on behalf of their passengers. In this context professional pride is not an insignificant aspect by any means.

The KLM organisation does not stipulate a procedure for lining up on the take-off runway, involving crew members confirming with each other on which runway and at which intersection the aircraft is located. There are airlines that have incorporated such procedures and checks in the 'Before take-off checklist'. A KLM Boeing 737 crew uses a ground movement chart mainly at other airports. They usually do not use such a chart at Amsterdam Airport Schiphol because they know the airfield well and use their common sense to determine what is and is not necessary. This could take place during the taxi briefing in which the take-off and departure procedure (SID), derated take-off and the procedure in the event of engine failure, including the taxi route, is discussed.

APPENDIX O: BACKGROUND INFORMATION ON AIR TRAFFIC CONTROL

Field of tension between safety and efficiency

During interviews with LVNL officers it emerged that the trade-off between safety and efficiency is an ongoing issue in the day-to-day activities of air traffic controllers and supervisors. Because the efficient handling of air traffic would be seriously affected, they are deterred from constantly directing all traffic to the beginning of a runway. intersection take-offs are necessary in order handle air traffic efficiently. Abandoning the compulsory direction of travel, for which the air traffic control Regulations Manual (VDV) offers leeway, enables the air traffic controllers to push the flow of traffic along the taxi routes, entries and exits that most efficiently serve this purpose. The interviews with the LVNL officers brought to light that they do not immediately feel that this increases the risk of incidents. In terms of the procedure for transferring an aircraft from the ground to the runway controller, from an operational point of view it is impossible to detain all aircraft until the hold lines on the entries. According to the LNVL officers, handling outbound traffic would consequently grind to a halt. It was stated that as a result of the incident, LVNL would need to take a critical look at the procedure.

It emerged from the interviews with the air traffic controllers that ATC regularly relies on a pilot's assumed familiarity with the airport terrain. This primarily applies to home-based pilots, including KLM pilots. Air traffic controllers themselves often offer an intersection take-off but particularly home-based pilots frequently request such take-offs. Depending on the position of the relevant aircraft and the take-off runway, this may encourage the ground controller to already transfer the aircraft to the runway controller in the meantime. Observing the transfer procedure specified in the VDV implies that the procedure would considerably undermine the efficient flow of traffic. The specified transfer procedure is unworkable from the point of view of efficiency.

The context in which air traffic controllers perform their work is acceptable according to some parties, but is often not necessarily optimal in terms of safety. Handling more traffic per hour per runway is a choice that affects the level of safety but that is just the way it is. However, aside from the above, in respect of the environmental standards air traffic controllers, particularly the supervisors, are responsible for ensuring compliance with the noise abatement standards. This frequently means that air traffic controllers operate parallel take-off runways (runways 36L and 36C), as was the case on the night of the incident. This modus operandi requires that air traffic controllers must make certain that the first turn made by an aircraft taking off does indeed correspond with the assigned SID. A possible conflict could possibly arise with traffic taking off from the other parallel runway. This will involve the air traffic controller possibly having little focus left for traffic lining up, particularly if he has already issued take-off clearance.

The management

In principle every air traffic controller should individually determine where the line should be drawn between safety and efficiency, or service provision. This modus operandi is a conscious organisational decision. Air traffic control the Netherlands (LVNL) has previously stated that individual independence is a trait fostered in the practice of the air traffic controller's profession. A great deal of value is attached to the ability to operate independently when performing activities. An air traffic controller will, of course, observe the rules but within these rules there should be room to operate independently and weigh up the options in an operational context. In a report published in July 2011 concerning a near mid-air collision between an Air France Airbus A319 and a KLM Boeing 737, the Board concluded that this can only be achieved safely if the relevant frameworks have been clearly defined. In the above report, air traffic control the Netherlands (LVNL) acknowledged the lack of a clear distinction between strict guidelines and a general framework.

The Dutch Safety Board
telephone +31(0)70 333 70 00 • **e-mail** info@safetyboard.nl • **website** www.safetyboard.nl
visiting address Anna van Saksenlaan 50 • 2593 HT The Hague
postal address PO Box 95404 • 2509 CK The Hague • The Netherlands