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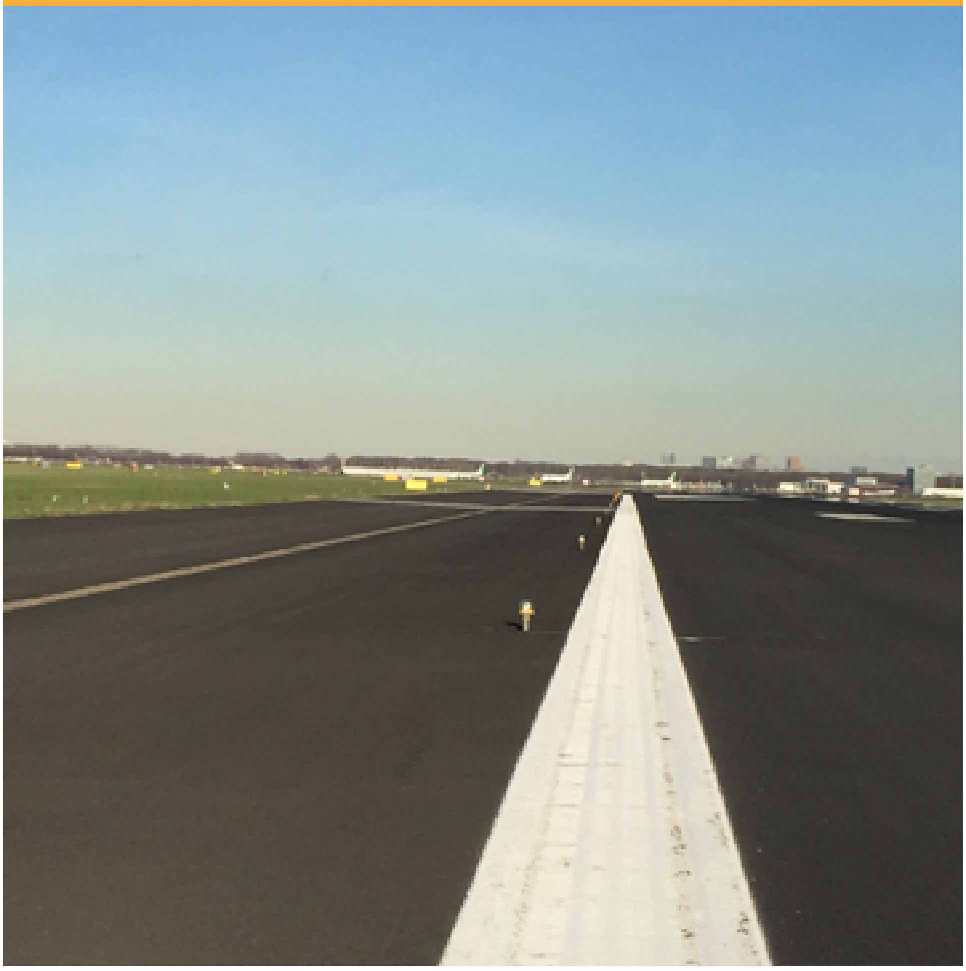
Misaligned take-off from Runway 24, Amsterdam Airport Schiphol



Misaligned take-off from Runway 24, Amsterdam Airport Schiphol

The Hague, November 2018

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The Dutch Safety Board

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N.B. This report is published in the English language with a separate Dutch summary. If there is a difference in interpretation between the report and the summary, the report text wil prevail.

CONTENT

GENERAL OVERVIEW

Identification number:	2016004
Classification:	Serious incident
Date, time of occurrence:	18 January 2016, 17.25 hours[1]
Location of occurrence:	Amsterdam Airport Schiphol
Registration:	EC-JBD
Aircraft type:	Embraer EMB-120ER
Aircraft category:	Commercial – fixed wing
Type of flight:	Scheduled cargo flight
Phase of operation:	Take-off
Damage to aircraft:	Severe damage to the right-hand propeller, multiple fuselage skin puncture marks and damage to nose wheel
Flight crew:	Two
Passengers:	None
Injuries:	None
Other damage:	Runway edge lights
Light conditions:	Night-time

1 All times mentioned in this report are UTC unless stated otherwise. Dutch time at the time of the occurrence was UTC + 1 hour.

On 18 January 2016 an Embraer EMB 120 ER "Brasilia", with registration EC-JBD, performed a cargo flight from Amsterdam Airport Schiphol in the Netherlands to London Stansted Airport in the United Kingdom. On board were two pilots, and at approximately 17.25 hours the take-off was performed from Runway 24. The flight continued towards the destination airport where a landing was performed and at 18.40 hours the aeroplane was parked. After shutdown, the ground crew discovered holes in the right-hand side fuselage. Furthermore, the right-hand propeller blades were damaged and in one propeller blade a metal wire was found embedded in the leading edge. Following this damage the local authorities were notified, including the Air Accidents Investigation Branch (AAIB).

According to the flight crew, nothing out of the ordinary happened during the flight. The London Stansted Airport authority initiated a runway check, however, no irregularities were found. The AAIB notified the Dutch Safety Board (DSB) of the event and provided information on the metal wire found in the propeller blade at London Stansted.

Following this information, the DSB made inquiries at Amsterdam Airport Schiphol about occurrences that night and asked if a check could be performed on Runway 24. Amsterdam Airport Schiphol (AAS) had already performed a runway check the evening before, which revealed that seven runway edge lights were destroyed. From this, it was suspected that the event occurred at Amsterdam Airport Schiphol. The DSB classified it as a serious incident and started an investigation as the State of Occurrence. On behalf of the State of the Operator and State of Registry, the Spanish CIAIAC[2] provided assistance in the investigation. The Brazilian CENIPA[3] represented the State of Design and State of Manufacture.

During the investigation it was determined that the EMB 120 made a misaligned take-off from Runway 24 at Amsterdam Airport Schiphol. Misaligned take-offs occur all over the world and investigations by different authorities have identified several common causal factors. In this investigation it was determined that a combination of operational and infrastructural factors contributed to the event. The large turning angle, required to align the aeroplane with the runway centre line, in combination with the discontinuity of the taxiway S5 centre line and absence of the taxiway centre line lighting has contributed to the misaligned take-off. In addition, the ATC clearance during the turn from taxiway B onto S5 and Runway 24 might have distracted the flight crew.

2 Comisión de Investigación de Accidentes e Incidentes de Aviación Civil, Spain.
3 Centro de Investigação e Prevenção de Acidentes Aeronáuticos, Brazil.

Cooperating and learning
Similar to the report entitled 'Safety of Air Traffic at Amsterdam Airport Schiphol', published by the DSB in April 2017, the Safety Board also investigated how, in this case, the Dutch sector parties dealt with the cooperation and learning aspects of this serious incident.

As a result of the occurrence, both Amsterdam Airport Schiphol (AAS) and Air Traffic Control the Netherlands (Luchtverkeersleiding Nederland, LVNL) conducted investigations into the cause and each wrote a report. LVNL's report states that the investigation was conducted by LVNL in cooperation with AAS.

AAS's report states that no clear conclusions could be drawn and therefore no recommendations can be made. LVNL's report on the other hand, which includes the mutually harmonised results of both AAS and LVNL, reports the immediate cause, underlying causes and makes a recommendation. The recommendation is to bring the investigation results to the attention of the Runway Safety Team (RST) for any further advice. The RST is part of the Schiphol Safety Platform and it has the objective of reducing runway incursions at Schiphol.

LVNL was aware of the risks of intersection take-offs before the incident occurred. However, this did not lead to operational measures by LVNL.

Intersection S5 was also a recommended intersection outside the uniform daylight period despite the fact that the intersection did not have centre line lighting.

The LVNL report does not consider the question of whether intersection S5 is justifiably designated as a 'recommended intersection' in the Operations Manual and if offering the intersection concerned is a wise choice.

After the decision was taken not to install centre line lights on intersection S5, LVNL retained the qualification of intersection S5 as a 'recommended intersection' in the Operations Manual. There was no reconsideration.

The flight

First flight leg: Hannover – Amsterdam
On 18 January 2016 the flight crew was scheduled to fly three legs from Hannover (Germany) to Amsterdam (the Netherlands), to London Stansted (United Kingdom) and back to Hannover.

A pre-flight inspection which included an external check (walk around) was performed at Hannover by the captain and a company engineer prior to departure. No abnormalities were found. Just before take-off the aeroplane was de-iced and departed from Runway 22. The Pilot Flying on this leg was the captain and the first officer was the Pilot Monitoring.

After landing at Amsterdam Airport Schiphol the aeroplane was parked on parking stand B66. As part of the preparation for the next take-off, the captain performed another walk around to check the aeroplane; no abnormalities were found. Next, the flight crew prepared for the second leg from Amsterdam to London Stansted.

Departure from Amsterdam Airport Schiphol
For the second flight leg, from Amsterdam to London, the first officer was Pilot Flying and the captain was Pilot Monitoring. As there is only one steering tiller in this type of aeroplane, located on the left hand side of the cockpit, the captain performed taxiing until the aeroplane was lined up on the runway, ready for take-off. At that time, the controls were handed over to the first officer. During taxiing, the first officer was responsible for radio communication.

At 17.15 hours start-up clearance was requested and approved. At 17.20 hours taxi clearance was obtained and the flight crew was instructed to taxi via taxiway A to taxiway B, using intersection A2 and S7 for take-off from Runway 24. An overview of the intended taxi route is depicted in Figure 1 (blue dashed line).

Figure 1: Overview of the relevant part of Amsterdam Airport Schiphol with the parking stand, taxiways and Runway 24 together with a rough representation of the intended (blue dashed) and actual taxiing track (blue). (Photo: Google Earth)

During taxiing on taxiway B the ground controller asked if the flight crew would like an intersection take-off. The flight crew accepted this and the ground controller asked if S4 or S5 would be acceptable. The flight crew preferred S5 and the ground controller subsequently cleared the flight to hold short at S5.

As the aeroplane approached S5, the ground controller instructed the flight crew to change radio frequency to the Tower frequency. The Pilot Monitoring contacted the Tower frequency and the runway controller gave take-off clearance for Runway 24 with the instruction to stay on the Tower frequency.

The flight crew completed the before take-off checklist and the captain positioned the aeroplane on Runway 24. Subsequently, the runway controller gave the instruction to make a right-hand turn and steer heading 270 after take-off. The captain handed over the controls to the first officer, who became Pilot Flying. The captain, now the Pilot Monitoring, acknowledged the radio call and read back the tower instructions.

Take-off power was selected by the Pilot Flying and, in effect, the aeroplane's speed increased. During the take-off roll some bumps were felt by the flight crew. According to the flight crew it is not unusual to feel bumps as the nose wheel runs over the runway's centre line lights. The crew heard a "thump" noise as well during the take-off roll. After a brief discussion it was concluded that it might have been a cargo box or the captain's flight bag that fell to the floor. The take-off roll was continued with all aeroplane indications, vibrations and noise being normal.

When the aeroplane reached a velocity of 90 knots, the captain made a speed call out which was crosschecked by the first officer. The decision speed (V_1 = 112 knots) was called out and, three seconds later, V-rotate (V_R = 113 knots) was reached. During rotation, the stall warning light appeared on the Main Annunciator Panel (MAP) and an aural warning sound was activated in the cockpit. The aeroplane was pitched down by the Pilot Flying and the take-off was continued.

The aeroplane became airborne and a few seconds later the stall warning light disappeared. The flight crew interpreted the warning as false. During the climb the captain took over the flight controls to confirm the aeroplane's controllability after which the controls were handed back to the first officer for the rest of the flight. According to the flight crew all indications, including pressurization and vibrations, were normal during the entire flight.

Landing at London Stansted
The aeroplane landed at London Stansted Airport on Runway 22 after which it taxied to stand 205. At approximately 18.40 hours the aircraft was parked and the engines were shut down. At the same time, a ground employee alerted the flight crew, by means of hand signals, that the aeroplane was damaged. First, the flight crew filed all the flight relevant paper work and subsequently went out to inspect the aeroplane. During the walk around, damage to the right-hand fuselage was observed. Also, three propeller blades of the right-hand engine were damaged. A metal wire was found embedded in one of the three damaged propeller blades. The cargo was offloaded; no damage to the cargo was found.

Aircraft, load and equipment
The Embraer EMB-120ER "Brasilia" is a twin-turboprop commuter airliner, produced by Embraer of Brazil. The aeroplane is 20 metres long and has a wingspan of 19.78 metres. The minimum ground clearance distance for the propeller is 0.46 metres. Depending on the configuration, the aeroplane can be used for both passenger and cargo flights. The aircraft involved in this incident was a cargo version with a Maximum Take-off Weight (MTOW) of 11,990 kilograms (Empresa Brasileira de Aeronáutica S.A., 2000).

At Amsterdam Airport Schiphol, the cargo from Hannover was offloaded and, according to the load plan 2,600 kilograms cargo was loaded onto the aeroplane with destination Stansted.

Before departure Jet A-1 fuel was uploaded whereby the total fuel onboard became 1,660 kilograms. The aeroplane take-off weight was approximately 11,500 kilograms (according to the mass & balance sheet). According to the records provided by the operator, no outstanding deficiencies on the aeroplane were open prior to conducting the flight.

On board of the aeroplane were two headsets with passive noise protection (20 dB) and noise-cancelling microphone for communications. These headsets were used by the flight crew during the flight.

Damage to the aircraft
On 19 January 2016, upon request of the Dutch Safety Board (DSB), an Air Accidents Investigation Branch (AAIB) inspector performed a technical inspection at London Stansted Airport to establish the extent of damage caused to the aeroplane. From this inspection it was found that no damage was visible on the left-hand side of the aeroplane fuselage, the left wing and the left-hand engine (Engine #1).

In contrast to the left-hand side, puncture marks were found at several locations on the right-hand side of the fuselage (see Figure 2 left). Around these locations, yellow paint deposits were visible on the white coloured fuselage skin. On one location, near the right-hand wing and body fairing, the fuselage skin was punctured (see Figure 2 right). This punctured hole also exhibited yellow paint marks around it.

Figure 2: Fuselage on the right-hand side of the aeroplane with the hole pattern (left) and a detailed view of the punctured fuselage with visible yellow paint deposits (right). (Photo: AAIB)

In addition to the damage on the aeroplane's fuselage, damage was found on the right-hand side propeller. This damage varied; one blade had a dent and a second blade was damaged on the leading edge with yellow paint scuff marks and a cut in the trailing edge. A third propeller blade was damaged more severely with a large cut in the leading edge with a piece of wire embedded in it (see Figure 3 left).

Figure 3: Right-hand engine propeller with wire embedded on arrival at Stansted airport (left image). Aeroplane nose wheel, as seen from the front side of the aeroplane, with port wheel damaged (right image). (Photo: AAIB)

The left-hand nose wheel (as seen from the front side of the aeroplane in Figure 3 right) exhibited yellow scuff marks and the tyre was cut just on the outside of the wheel extending to approximately halfway of the tyre's circumference. The tyre was found partially deflated and decoupled from its rim. The starboard nose wheel showed damage to the sidewall. In addition, yellow paint deposits were found on the rim and the outside of the tyre.

Flight crew

Both flight crew members held a valid licence and rating for the Embraer EMB 120. All mandatory checks and trainings were performed on time. Both flight crew members held a valid medical certificate at the time of the event and had a rest period of 18 hours before commencing duty. The captain also performed duties as a Line Training Captain (LTC) for the operator.

	Captain	First officer
Experience total	3,653 hours	1,510 hours
On aeroplane type	1,802 hours	1,300 hours
Last 90 days	124 hours	81 hours
Last 28 days	45 hours	39 hours
Last 24 hours	2.42 hours	2.42 hours

Table 1: Pilots' flying experience.

Weather and lighting conditions

The METAR weather conditions at Amsterdam Airport Schiphol were reported to be Ceiling And Visibility OK (CAVOK) with a local barometric pressure of 1017 millibars (QNH). The reported wind condition was 130 degrees at 5 knots with a temperature of -1 degrees Celsius and a dew point temperature of -5 degrees Celsius. On 18 January 2016, sunset was at 17.01 hours with a half-moon (Waxing Gibbous Illumination[4]: 70%). The occurrence flight was therefore conducted under night conditions.

4 Waxing gibbous is a quantification of the sunlit portion of the moon in a period, indicated on a scale of 1-100%, with 100% being full moon.

Investigation

This paragraph starts with the examination of certification specifications for aerodromes. Next, some runway and taxiway markings and lighting at Amsterdam Airport Schiphol and the read out and analysis of the Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) are described. The paragraph ends with the examination of some related occurrences that took place abroad.

Certification Amsterdam Airport Schiphol

Aerodromes in the European Union meeting certain requirements must be certified according to the EASA Basic Regulation and its implementing rules. Currently, Amsterdam Airport Schiphol is certified in accordance with the Certification Specifications CS-ADR-DSN (EASA, 2015).

For this investigation the following regulations of the certification specifications were examined in more detail because of their direct relationship to the investigation presented in this report:

- CS ADR-DSN.L.550 Runway side stripe marking;
- CS ADR-DSN.L.555 Taxiway centre line marking;
- CS ADR-DSN.M.710 (a)(b)(c)(d) Taxiway centre line lights;
- CS ADR-DSN.M.715 Taxiway centre line lights on taxiways, runways, rapid exit taxiways[5], or on other exit taxiways.

The Deviation Acceptance and Action Document (DAAD) describes the deviations from certification specifications and is accepted by the competent authority. According to Schiphol's DAAD, some taxiways at Amsterdam Airport Schiphol used outside Uniform Daylight Period are not equipped with taxiway centre line lights.[6] As specified in CS ADR-DSN.M.710, a deviation from the recommendation (taxiway centre lights) can be made in cases of light traffic density and when adequate guidance is provided by other visual aids, such as taxiway edge lights.

5 Exit taxiways can be used for both entry and exit of runways and is therefore not limited to, as the name suggests, the departure from the runway onto the taxiway.

6 Identification number 2014-032.

Physical characteristics Runway 24

Runway 06/24, also known as the "Kaagbaan", is 3,500 metres long, 45 metres wide and has reference code 4F.[7] On both sides of the runway a 15 metre wide shoulder (strength restricted) is located, extending the total width of the runway, in compliance with CS-ADR-DSN[8], to 75 metres. Runway 06/24 has two exits on the southeast side (S2 and S8) and seven exits on the northwest side (S1 – S7), connecting the runway to, respectively, platform S and taxiway B. From taxiway B, a 90 degree turn must be made for Exit S5 after which a 120 degree turn is required to turn onto the runway. For Exit S6, the final turn onto the runway is 30 degrees.

Runway and taxiway markings

A marking is defined as a symbol or group of symbols displayed on the surface of the movement area in order to transmit aeronautical information. For a runway, several markings can be distinguished. General conventions for runway and taxiway markings are shown in Table 2 and Figure 4. Note that these markings are in accordance with EASA CS-ADR-DSN (EASA, 2015).

Marking	Colour
Runway edge line	White
Runway centre line	White
Runway threshold	White
Runway designator	White
Runway aiming point	White
Taxiway centre line	Yellow
Taxiway edge line	Yellow

Table 2: Runway and taxiway marking colours.

7 The code letter or number is related to the critical aeroplane characteristics for which the facility is provided (EASA, 2015; ICAO 2013). According to reference code 4F the field length should be larger than 1,800 metres and the runway should be able to support aircraft with a wingspan within the range of 65 metres up to but not including 80 metres and outer main gear wheel span within the range of 14 metres up to but not including 16 metres.

8 EASA recommends the provision of runways shoulders for runways where the code letter is F, such that the overall width of the runway extends to 75 metres or more (EASA, 2015).

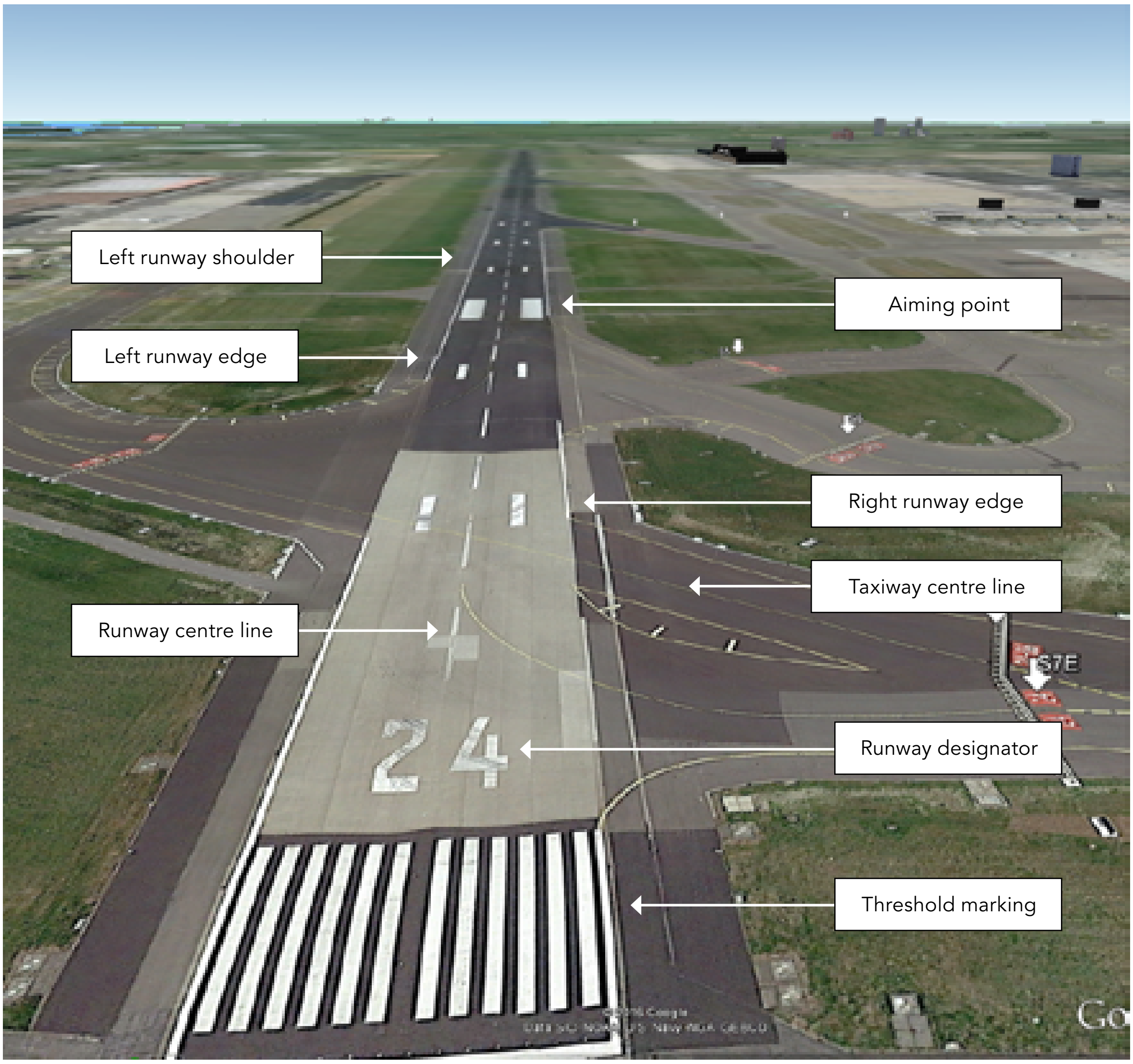

Figure 4: Runway marking definitions. (Photo: Google Earth)

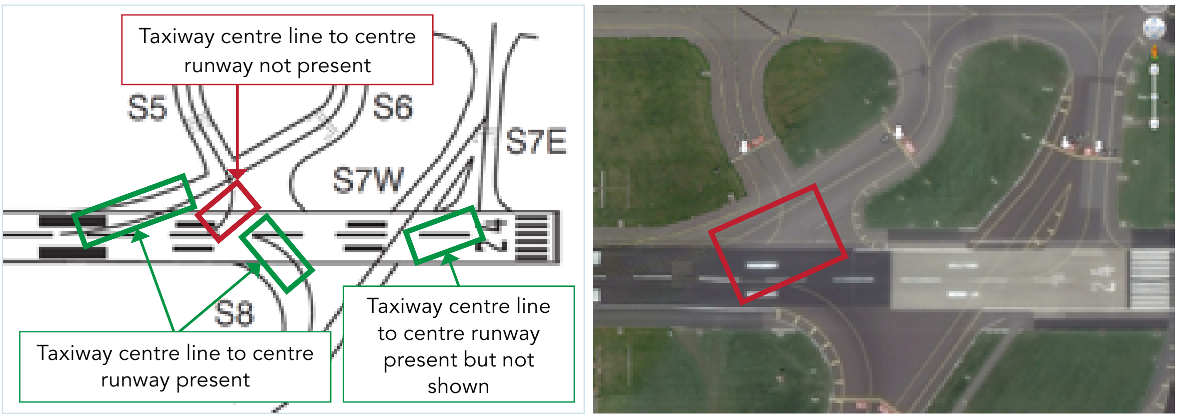

Figure 5: Taxiway B and Runway 24 with Exit S5 - S8 and taxiway centre line marking (reference). (Photo: Google Earth)

In the Integrated Aeronautical Information Package (AIP) for Amsterdam Airport Schiphol, a situation chart is published for runway 06/24. While conducting the investigation, it was found that the situation as depicted on the chart did not correspond with the actual layout of Amsterdam Airport Schiphol. Figure 5 (left) indicates that the taxiway centre line should be continuous and leading towards the runway centre line. However, from Figure 5 (right) it becomes evident that in reality the taxiway centre line is interrupted at the runway side line marking. On 26 April 2016 the investigation team of the DSB informed Air Traffic Control the Netherlands (LVNL) of the discrepancies between the published charts and actual taxiway centre line markings on Runway 24. In response, the relevant maps were updated to be correctly presented in the latest AIP publication.

Runway and taxiway lighting

The centre line runway lights are white and have an interval of approximately 15 metres in the take-off direction. The final 900 metres before the end of the runway, the lights are intermittent red and white. From 300 metres before the end of the runway the centre line lights are red. White lights are located on the runway edges at a 30 metre interval over the total length of the runway. For taxiway marking purposes, blue edge lights are used with green lights indicating the taxiway centre line.

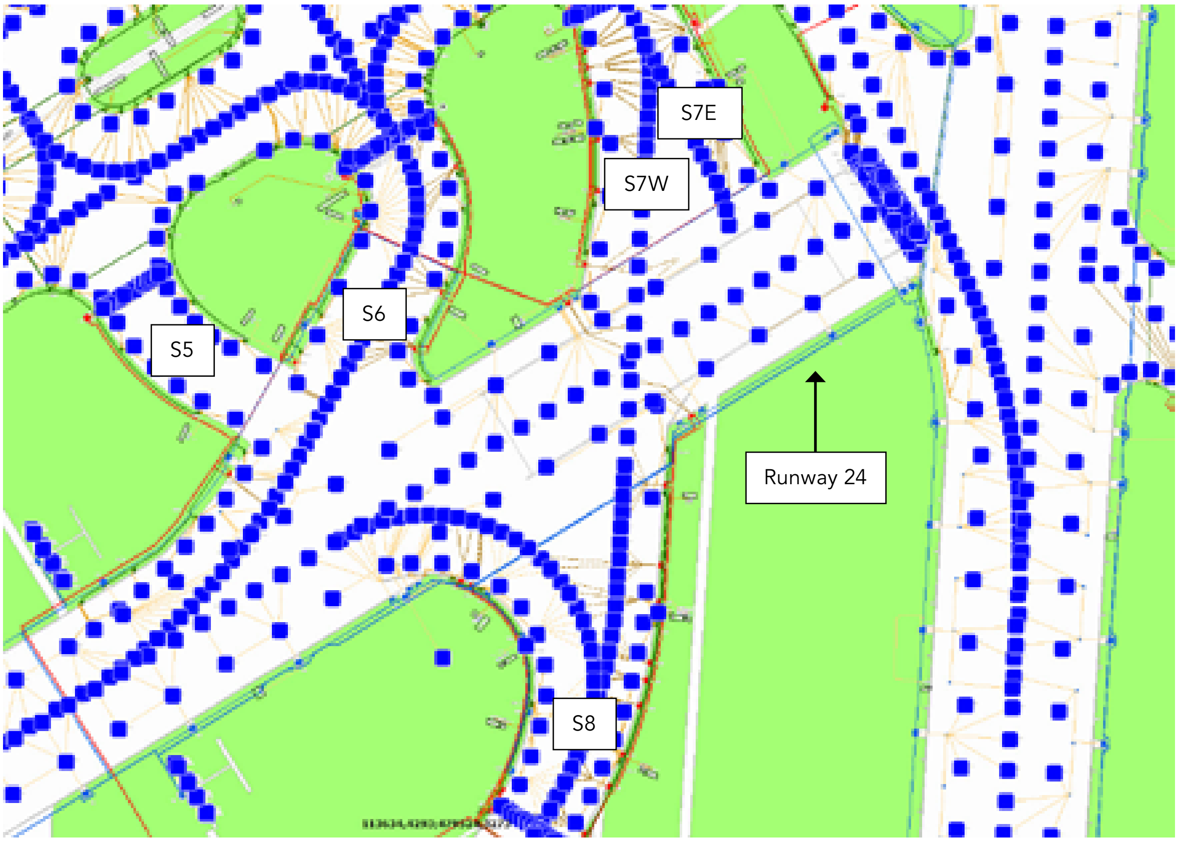

Figure 6: Location of the installed lights (both centre line and edge) on taxiway B and Runway 24 with Exit S5 to S8.

Contrary to the other taxiways leading to runway 06/24, taxiway S5 is equipped with blue edge lights and no green centre line lights are present. Other taxiways serving runway 06/24 are equipped with taxiway centre line lights.

According to the runway controller, the light intensity was set at 3%, in accordance with prescribed procedures. No faults or failures in the lighting system were detected.

Examination broken runway lights

At 20.03 hours, runway 06/24 was inspected by a bird controller. This inspection revealed that three edge lights on the right-hand side near taxiway S5 were destroyed. Just before exit S4, one edge light on the right-hand side was found broken. Between S3 and S4, another three right-hand side edge lights were found broken. This sums up to a total of seven broken edge lights on runway 06/24.

Figure 7: Overview of the positions of the broken edge lights of Runway 24.

Following the event, the DSB requested the damaged lights to be secured for examination. A technical inspection of the broken lights revealed that on at least one of the lights black prints were found. It seems that these traces originate from contact with the tyres of the aeroplane. However, no clear conclusions can be drawn from these traces since the state of the specific edge light before the incident is unknown. An example of a runway edge light as used on Runway 24 is depicted in Figure 8.

Figure 8: Runway edge light as located alongside Runway 06/24 at Amsterdam Airport Schiphol.

Flight recorder and radar data

Following the event, the Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) were read out and analysed successfully. The FDR contained the data of the event flight and recorded 45 individual parameters, which were used for this investigation. The CVR contained recorded data for a duration of 2 hours, with 4 high quality tracks of the last 30 minutes of the flight. The information used in this investigation originated from the tracks recorded by the CVR during the event flight. The FDR data recorded during the take-off phase was analysed and did not show any abnormalities. The recorded airspeed, pitch and flap angle were determined to be normal for the duration of the take-off (for a more detailed overview, consult Appendix A – FDR). During taxiing, a control check was performed which indicated all systems being normal.

By default, the FDR records a propeller imbalance parameter. However, according to the manufacturer, the propeller imbalance parameter is used to determine the vibration effect due to propeller imbalance on the aeroplane fuselage (also measured at the fuselage). Note that, normally, propeller imbalance is measured at the location of the engine, as would be required for propeller imbalance purposes. For this reason the propeller imbalance parameter cannot be used to quantify any imbalance as caused by possible collision of the propeller blades with the runway edge lights.

By examination of the CVR, a transcript of a relevant conversation between the flight crew was obtained. This transcript can be found in Appendix B – ATC Transcript. In addition, a CVR spectral analysis was performed which identified several high frequency components, indicative for impact sounds. Initially, three sound peaks (impact) are recorded around 18.25:03 hours followed by a series of three more (impact) sound peaks during the period running from 18.25:18 to 18.25:20 hours. At 18.25:21 hours, an aural stall warning can be identified on the CVR. No other warnings were identified on the CVR audio recordings. A visual representation of the spectral analysis is depicted in Figure 9.

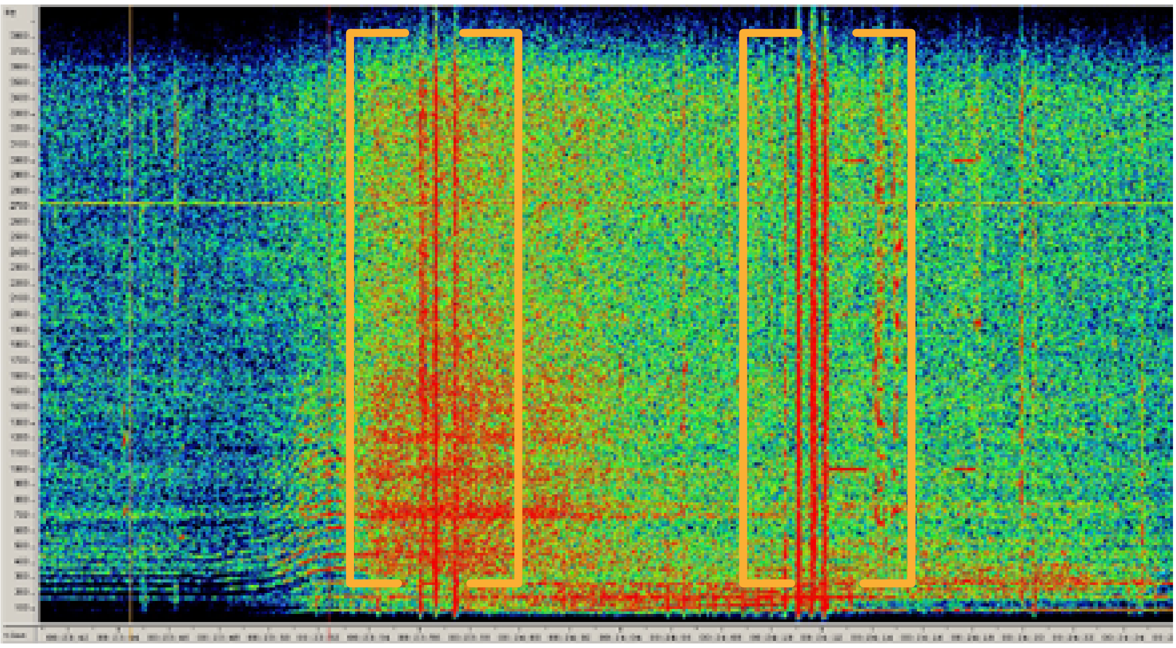

Figure 9: Spectral analysis of the audio track extracted from the CVR for the duration of the take-off. The impact sounds are emphasized by the yellow brackets.

For the investigation, the ground radar data was requested in order to establish the ground track of the aeroplane. Analysis of the radar data confirms earlier findings; the aeroplane left its parking stand B66 and, after taxiing via taxiway A2 and B, a right-hand turn was made onto taxiway S5 (see Figure 10). Subsequently, the aircraft turned towards Runway 06/24. From the ground track it also becomes evident that the aeroplane, upon entering Runway 24, lined up on the right-hand side edge line. The aeroplane took off following the right-hand edge line. Comparison with radar data has confirmed that other aeroplanes, using intersections S5 and S7E, departing between 17.00 and 18.00 hours were correctly aligned with the runway centre line during take-off.

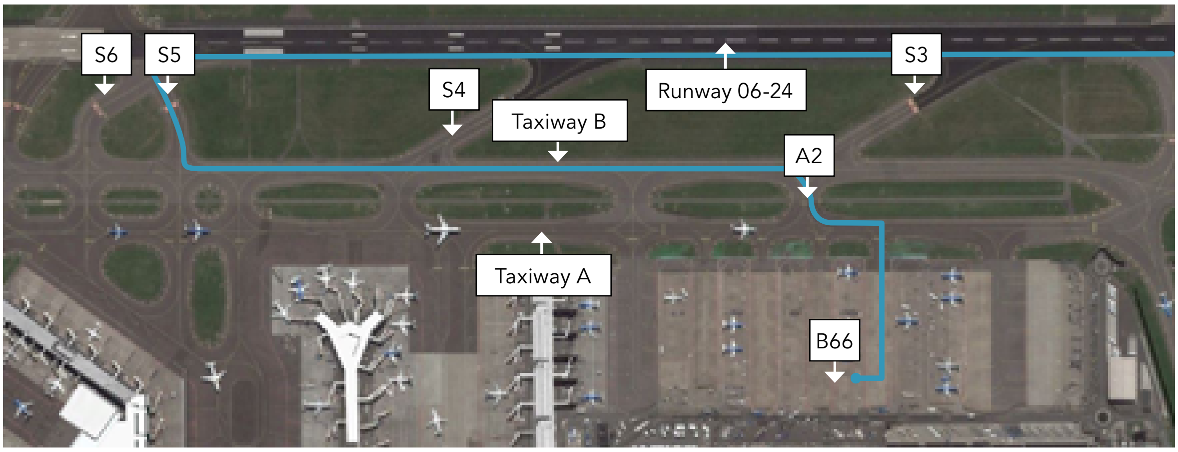

Figure 10: Aeroplane ground track derived from ground radar data. (Photo: Google earth)

ATC procedures at Amsterdam Airport Schiphol

Air Traffic Control (ATC) procedures at Amsterdam Airport Schiphol are described in the LVNL procedural handbook (VDV).[9] According to the VDV, monitoring aeroplanes for a correct alignment with the runway centre line is not part of the responsibilities of the runway controller (LVNL, 2016, p. 1, 7.01).

Furthermore, after interviews with runway controllers, it can be concluded that the runway controller at Amsterdam Airport Schiphol was unable to determine correct alignment with the runway centre line by either visual inspection (under night conditions) or consultation of the ground radar. During regular operation, the level of detail of the ground radar, as presented to the runway controller, is insufficient to determine correct alignment of the aircraft with the runway centre line.

9 In 2016 the VDV was replaced by the Operations manual.

Related incidents

Following a study conducted beteen 2009 and 2010, the Australian Transport Safety Bureau (ATSB) published a report "*Factors Influencing Misaligned Take-off Occurrences at Night*" in which several risk factors are identified, from several data sources and events, that led to runway misalignments. The ATSB report highlights three cases in Australia in which different types of aeroplanes were involved: an EMB-120 at Sydney in 2007, a Dash 8-300 at Townsville in 2009 and an SF340 at Sydney in 2009. In this study, using the three cases illustrated above, the following risk factors were identified as the most prevalent:

Runway misalignments risk factors (ATSB 2010)

- Night time operations;
- Bad weather or poor/reduced visibility;
- Flight crew distraction (from within the cockpit) or inattention;
- Flight crew fatigue;
- Conducting a displaced threshold or intersection departure;
- Provision of air traffic control clearance when aircraft are entering the runway or still taxiing;
- The runway and taxiway environment, including confusing runway entry markings or lighting, areas of additional pavement on the runway, the absence of runway centre line lighting, and recessed runway edge lighting.

For all occurrences, the ATSB checked presence and contribution of the factors as given above. From this study, the conclusion was drawn that any of these factors may increase the risk leading to a misaligned take-off occurrence.

Following the publication of the study by the ATSB in 2010, several other misaligned take-off occurrences have happened in different places around the world. The DSB performed a search in the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) database. This resulted in fifteen incident reports where the edge lights were interpreted by the flight crew as centre line lights. The results covered a period from 1990 to 2016, involving different aircraft types and different airfields. The DSB examined more similar events.

Analysis

The event

According to the aeroplane documentation, the weight and balance of the aeroplane was within limits and the dangerous goods were packaged according to specifications. Both flight crew members were properly licensed and certified to perform the flight. The aircraft was maintained and did not have any deferred defects prior to the event flight.

According to FDR, CVR and flight crew interviews the following sequence of events was established for the event flight:

1. A pre-flight inspection was conducted by the captain before the event flight which did not reveal any damage to the aeroplane. The flight crew subsequently prepared the fight according to established operator procedures and requested start-up and taxi clearance.

Figure 11: Actual taxi and take-off track of the aeroplane, reconstructed from radar data, together with a transcript of the relevant communication between ATC and the flight crew. (Photo: Google earth)

2. After leaving parking stand B66 at Amsterdam Airport Schiphol, the flight crew followed the taxi clearance instructions as given by the ground controller. While taxiing on taxiway B, the ground controller offered an intersection take-off, either from S4 or S5. The crew accepted the ground controller's offer and elected S5 whereafter the ground controller approved this and gave a hold short instruction for S5.

3. Take-off clearance was given by the runway controller just before turning onto intersection S5 while the aeroplane was taxiing. Apart from the take-off clearance the flight crew was also instructed to stay on the frequency. The runway controller call was read back by the first officer and the CVR transcript reveals that the instruction to stay on the frequency was a surprise for the flight crew and the take-off clearance was discussed. In the meantime the aeroplane continued to taxi on S5 and the flight crew performed final checklist items.

4. Heading instructions after departure were given by the runway controller while the aeroplane was leaving exit S5 and turning onto runway 24. At this time the controls were handed over to the first officer and as a consequence the ATC call read back was done by the captain. Given the ground radar accuracy it is evident that at this time the aeroplane was on the right runway edge line and was misaligned for take-off. There is a 20 seconds time delay between the moment that heading instructions were given and take-off power was selected. Apart from the take-off checklist items no other conversation was made between the two flight crew members.

ATC clearances
By merging the ground radar track and ATC transcript, it was established that the take-off clearance by ATC was given to the flight crew before the aeroplane turned onto taxiway S5. A heading instruction was given while the aeroplane was turning onto the runway. For an overview of the actual taxi and take-off track, together with a transcript of the relevant communication between ATC and the flight crew shown at the location of occurrence, see Figure 11.

A common factor that was identified by the ATSB in the misaligned take-off study is the provision of the take-off clearance by ATC while the aeroplane is still entering the runway or even taxiing towards the runway. This factor might also have played a role at the Amsterdam Airport Schiphol event. In the interest of expediting traffic, a clearance for immediate take-off may be issued to an aircraft before it enters the runway. On acceptance of such clearance the aircraft shall taxi out to the runway and take off in one continuous movement (ICAO, 2016). Taxiing is a phase of flight that requires full flight crew attention. Radio communication, including proactive clearances occur regularly during all phases of flight, including taxiing.

Meteorological conditions
Given the date and time it is clear that the event occurred during night time conditions. Examination of the meteorological data at Amsterdam Airport Schiphol reveals that the visual range was not decreased by any weather phenomenon. From this it is concluded that the weather, at time of the event, did not affect the visibility. Hence, it can be stated that weather is not considered as a contributing factor. Under these conditions, taxiway and runway markings must have been visible to the flight crew by making use of the aeroplane's taxi and take-off lights.

Exit taxiway S5 – centre line lights
Examination of CS ADR-DSN Certification *Specification and Guidance Material for Aerodromes Design* has indicated that, according to CS ADR-DSN.M.710 (b2), taxiway centre line lights should be provided on a taxiway intended for use at night in runway visual range conditions of 350 metres or greater, and particularly on complex taxiway intersections and exit taxiways. However, the same document also states that these guidance lights do not need to be provided on exit taxiways where the traffic density is light and taxiway edge lights and centre line marking provide adequate guidance.

In December 2011, the DSB published a report about an incident at Schiphol airport where an airplane took off from a taxiway. In the DSB report, AAS and LVNL were recommended to carry out a risk inventory for taxi traffic near runways. The study that was conducted by the Safety Platform Schiphol (VPS)[10] states as a risk factor that lines are poorly visible at night and during reduced visibility conditions.

10 Eindrapport Risico-inventarisatie voor taxiënd verkeer nabij start- en landingsbanen op Schiphol. Datum: 21-12-2012 Rapport nr : 12-RA-MD-060; Versie: v1.00.

Taxiway S5 is not equipped with green centre line lights. This deviation from the standards is justified by Amsterdam Airport Schiphol (AAS) in the Deviation Acceptance and Action Document (DAAD). In the document AAS states that this deviation is according to the specifications in CS ADR-DSN.M.710 in cases of a light traffic density and sufficient guidance by other visual aids. However, the Dutch Human Environment and Transport Inspectorate (ILT) does not share Schiphol's interpretation; the ILT has indicated that Amsterdam Airport Schiphol, in its entirety, is a heavy density traffic zone. This is based on the definition of aerodrome traffic density, as used in Annex 14 to the Convention on International Civil Aviation, Aerodromes[11] (see box on the next page). This definition is not used in the CS-ADR-DSN.[12]

Aerodrome traffic density

a. Light. Where the number of movements in the mean busy hour is not greater than 15 per runway or typically less than 20 total aerodrome movements.
b. Medium. Where the number of movements in the mean busy hour is of the order of 16 to 25 per runway or typically between 20 to 35 total aerodrome movements.
c. Heavy. Where the number of movements in the mean busy hour is of the order of 26 or more per runway or typically more than 35 total aerodrome movements.

Note 1. The number of movements in the mean busy hour is the arithmetic mean over the year of the number of movements in the daily busiest hour.
Note 2. Either a take-off or a landing constitutes a movement.

Based on the traffic intensity and the complexity of the airport, it is the opinion of the DSB that the airport as a whole should be considered as a heavy traffic density zone. The DSB report "*Schiphol air traffic safety*" (April 2017) mentions that Schiphol is a complex airport, both in terms of its infrastructure and in terms of how air traffic is handled.[13] This complexity entails certain risks for air traffic. Schiphol's rapid growth is increasing that complexity further. The increase in air traffic since 2014 has coincided with an increase in the number of significant incidents.

Finding

The absence of centre line lighting on taxiway S5 is not in correspondence with the specifications set in CS ADR-DSN.M.710.

11 Volume 1, Aerodrome Design and Operations, 1.1 Definitions.
12 Not used in the CS ADR-DSN – Issue 2 (effective date: 25 January 2015). The definition of traffic density is included in issue 3 of the CS ADR-DSN (effective date: 8 December 2016).
13 https://www.onderzoeksraad.nl/en/onderzoek/2211/investigation-into-air-traffic-safety-at-amsterdam-airport-schiphol?s=5288F6C1D984D3ADAA11262CC010A1302333B561

Exit taxiway S5 – centre line marking
As can be seen from Figure 5, a centre line marking leading from taxiway S6 to the centre line of Runway 24 is present. In contrast to S6, S5 does not have a centre line marking leading to the centre line of Runway 24. The centre line marking that is present on S5 is discontinued at the right-hand edge line of Runway 24.

According to CS ADR-DSN.L.555 (a1) taxiway centre line marking should be provided on a taxiway, de-icing/anti-icing facility and apron in such a way as to provide continuous guidance between the runway centre line and aircraft stands. The absence of a (continuous) centre line marking on exit taxiway S5, connecting S5 to the runway centre line is a deviation from this specification.

Finding

The absence of a continuous centre line marking on taxiway S5 leading to the centre line of Runway 06/24 is not in correspondence with the specifications set in CS-ADR-DSN.L.555.

In June 2017, AAS stated that as a result of the occurrence the centre line marking of S5 has been extended to close by the centre line marking of Runway 24. By this the centre line marking of S5 gives guidance to aircraft when lining up on Runway 24.

Fatigue
During interviews with the flight crew, no statements about any fatigue were given. Examination of the schedule indicated that both crew members started their shift in the afternoon of the same day after having a rest period of two days. From this it can be concluded that it will be unlikely that the crew suffered from fatigue at the time of the event.

Impact sounds during take-off roll
CVR analysis revealed that several impact sounds were recorded by the cockpit area microphone during the take-off run. Following the first impact, it can be heard that the flight crew did discuss hearing a sound but attributed this to a falling pilot briefcase. During the interviews the flight crew acknowledged that some bumps were felt during the take-off run. At the time, the crew was not sure if this was coming from either the nose wheel or the main wheels. However, experiencing such sounds was not unusual for the flight crew because of its resemblance with the sound caused by the front gear running over the runway centre line lights. Hence, the flight crew did not have any indication for the severity of the incident.

In addition to the explanation as presented above, the impact sounds that were recorded by the CVR did, in some cases, coincide with the flight crew call outs (speed alive, V_1, V_{rotate}). This, in combination with noise-cancelling headsets could cancel out the impact noises that would have been heard otherwise. Hence, again this indicates that the flight crew was unaware of the impacts during the take-off roll.

Ground radar analysis shows that, at several instances in time, the actual aeroplane take-off track is located on the right-hand side with respect to the right-hand side runway edge line. These time instances coincide with the time of the impact sounds obtained from spectral analysis of the CVR recordings. The ground speed obtained from the aeroplane's FDR matches the speed derived from the time difference between the impacts as obtained from CVR spectral analysis.

The port nose wheel sustained damage and yellow paint residue was found during visual inspection of the damage caused to the aeroplane. Again, this confirms that the runway edge lights were hit by the aeroplane; more specifically, the edge lights were hit by the nose gear.

Altogether, based on the information presented by the CVR, ground radar and yellow paint deposits that were found on the front gear, it is therefore concluded that the runway edge lights at the right-hand side of Runway 06/24 were hit by the aeroplane's nose wheel during the take-off roll.

Propeller and fuselage damage
Since the height of the runway edge light is insufficient to be hit by the blades of the propeller (propeller ground clearance is 0.46 metres; runway edge light height is 0.29 metres), another scenario must be considered to explain the damage that was caused to the propeller and fuselage.

In order to explain the damage of the propeller and fuselage the following scenario was considered. After the lights were run over by the nose wheel of the aeroplane, parts of the runway edge lights were ejected to the right-hand side. Subsequently, some parts of the disintegrated lights hit the right-hand propeller. The latter is indicated by the yellow paint deposits that were found on the propeller blades. While being hit by the propeller blades, some parts of the edge lights were catapulted towards the fuselage due to the propeller's rotational velocity, leading to penetration of the fuselage skin. This explains the impact marks and punctured holes as found on the right-hand side of the fuselage skin. The yellow residue around the puncture marks on the fuselage matches the colour of the runway edge lights.

In addition to the statements presented above, the hypothesis can be supported by the fact that a metal wire, originating from one of the runway edge lights, was found embedded in the leading edge of one of the propeller blades. Despite the embedded wire and other damage to the propeller blades, the propeller imbalance parameter extracted from the FDR, did not show any deviation from its nominal value.

Stall warning
By considering the CVR analysis, a stall warning aural message was activated after the aeroplane pitched up for take-off. At that time, the crew determined that the stall warning was false and the take-off was continued. According to the FDR data, the pitch angle and speed were sufficient for climbing flight when the warning became active. As described in the Operations Manual (Empresa Brasileira de Aeronáutica S.A., 2000), the "STALL WARN" light located on the Multiple Alarm Panel (MAP) and the aural message stall warning are both associated with a failure of the stall warning system. A miscompare

between the two angle-of-attack vanes will trigger the above mentioned failure indications. Alerts to the pilots of impending aerodynamic stall conditions, in contrast to a failure of the stall warning system, are provided by the control column stick shaker function and stick pusher.

Except for the stall warning, examination of the FDR data has indicated that no other parameters showed discrepancies from their nominal values. Therefore, the following scenario is assumed to have occurred: during the take-off roll the aeroplane hit several runway edge lights. After collision with the front gear, some parts of the runway edge lights were launched into the propeller which, subsequently, catapulted parts of the edge lights into the fuselage and other parts of the aeroplane. A possible explanation for the momentary stall warning failure indication could be that parts of the runway edge lights could have been catapulted against the right-hand angle-of-attack vane, affecting its position and resulting in a discrepant value compared to the left-hand angle-of-attack vane. Consequently, the stall warning system detected this momentary mismatch in angle-of-attack vane position.

Similar events
As shown by the ATSB study (ATBS, 2009), several factors have been identified as contributing to misaligned take-offs. In the context of this investigation, five common factors between the incident and earlier findings by the ATSB study were found. These factors are:

- The event occurred at night (dark);
- Air traffic control clearance was given while the aeroplane was taxiing and entering the runway;
- An intersection departure was conducted;
- Exit S5 has extra pavement near the runway (and a discontinued taxiway centre line);
- Flight crew distraction and divided attention occurred in the cockpit (hand over controls).

On 24 March 2016 the New Zealand Transport Accident Investigation Commission (TAIC) released a report involving an Airbus A340, which performed a misaligned take-off from Auckland Airport. In the TAIC report is stated that the ATC clearance was given while the aeroplane was turning onto the taxiway and take-off runway. This event shows similarities with the event at Amsterdam Airport Schiphol.

From the TAIC report it was concluded that last-minute checks performed by the flight crew just before take-off led to a reduction of situational awareness. In effect, the aeroplane lined up with the runway edge line instead of the runway centre line.

The large turning angle, required to align the aeroplane with the runway centre line, in combination with the discontinuity of the taxiway S5 centre line and absence of the taxiway centre line lighting has contributed to the misaligned take-off at Amsterdam Airport Schiphol.

Identification of runway edge lights

Although visual cues might be available, due to workload and/or other flight crew attention the determination if the aeroplane is lined up correctly might be difficult to make. A runway heading check is not sufficient to establish if the aeroplane is also laterally lined up correctly on the runway. It takes some time to observe and distinguish between the lights and (colour) patterns to establish the lateral position of the aeroplane.

Figure 12: View of Runway 24 from a position aligned with the centre line lights (left) and the runway edge lights (right).

As noted in the Biggin Hill report of the AAIB (AAIB, 2015), the dominant common factor between misaligned take-offs is that a visually compelling line of edge lights was visible to the crew. This edge line with lights was assumed to be the centre line by the crew. There is nothing inherent in an individual edge light that distinguishes it from a centre line light when viewed along the axis, as both have a white colour. It is the pattern of edge lights, and the relationship of this pattern with other lights and visual cues, which identifies them as edge lights. If this complex relationship becomes disrupted or misinterpreted, pilots can lose situational awareness.

If individual edge lights could be identified as such directly, rather than through a process of interpretation, a crew would notice their error more easily in case they are lined up incorrectly. Modern lighting technology offers more options to identify lights directly than the tungsten lighting technology on which the current standards are based.[14]

14 Global aerodrome lighting standards are, in general, derived from ICAO Annex 14, Volume 1, 'Aerodrome Design and Operations'.

COOPERATING AND LEARNING

Similar to the report entitled 'Safety of Air Traffic at Amsterdam Airport Schiphol'[15], published by the Dutch Safety Board (DSB) in April 2017, the Safety Board also investigated how, in this case, the Dutch sector parties dealt with the cooperation and learning aspects of this serious incident.

As a result of the occurrence, both Amsterdam Airport Schiphol (AAS) and Air Traffic Control the Netherlands (*Luchtverkeersleiding Nederland*, LVNL) conducted investigations into the cause and each wrote a report. LVNL's report states that the investigation was conducted by LVNL in cooperation with AAS. Factual information and part of the analysis from the AAS report and the mutually harmonised results of the investigation are included in the LVNL report. The DSB has analysed both reports.

The objective of AAS's investigation, namely to determine the extent to which the infrastructure, the current procedures at Schiphol Airport and the actions of the airport party or parties involved played a role in the occurrence, was not achieved. AAS's report states that no clear conclusions could be drawn and they could not, therefore, make any recommendations. LVNL's report on the other hand, which thus includes the mutually harmonised results, reports the immediate cause, underlying causes and makes a recommendation. The recommendation is to bring the investigation results to the attention of the Runway Safety Team (RST)[16] for any further advice.

Intersection take-off
In LVNL's Operations Manual, intersection S5 is a 'recommended intersection'[17] when using dependent take-off and landing runways, despite that this intersection has a centre line that stops at the runway edge marking and does not have centre line lighting.

It is not clear from the AAS and LVNL reports whether or not the ground controller or the runway controller were aware that S5 is an intersection without centre line lighting. The question of whether it is generally known amongst the ground controllers and runway controllers that intersection S5 does not have centre line lighting was not asked. Questions put to the runway controller by the DSB revealed that at the time of the incident he was not aware of the fact that intersection S5 did not have centre line lighting. LVNL believes it is not relevant for air traffic controllers to know exactly which entries and what lighting is available given that the Operations Manual indicates which entries may be used in what conditions.

15 Dutch Safety Board report titled 'Safety of Air Traffic at Amsterdam Airport Schiphol', published 6 April 2017.
16 The Runway Safety Team is part of the Schiphol Safety Platform and it has the objective of reducing runway incursions at Schiphol.
17 Ops Manual 7.01, p 2.

Known risks associated with intersection take-offs
From the previously cited Australian investigation, among other things, it is known that there are additional risks associated with intersection take-offs.

Irrespective of whether or not the absence of centre line lighting was known to the ground controller and runway controller concerned, the DSB believes that if an intersection take-off is offered outside of the uniform daylight period it should not be up to the pilot to choose between intersection S4 or S5 but in this situation a single intersection should be offered. A choice causes additional and unnecessary communication in the cockpit at the time shortly before take-off. This requires attention, creates a risk of confusion and thereby generates additional risks.

LVNL's procedural handbook states that the runway controller must only allow jet aircraft to take off via an intersection if there is an operational reason to do so.[18] Operational reasons for taking off via an intersection could be:

- changing the order of departure with the aim of achieving a higher take-off capacity;
- avoiding jet blast nuisance to traffic on a different take-off or landing runway;
- being able to comply with an ATFCM[19] measures;
- avoiding crossings of a runway that is in use as far as possible.

In this occurrence, LVNL states that the operational reasons for offering an intersection take-off was changing the order of departure with the aim of achieving a higher take-off capacity. The Operations Manual does not include reasons for offering an intersection to non jet aircraft such as the EMB-120R.

The Operations Manual did not include any stipulations focusing on reducing known risks that exist when offering or permitting intersection take-offs, nor has this point been changed in the Operations Manual after this occurrence.

Schiphol Safety Platform (Veiligheidsplatform Schiphol, VpS) risk assessment
In 2012, the Schiphol Safety Platform[20] conducted a risk assessment for taxiing traffic near take off and landing runways at Amsterdam Airport Schiphol. At the time, this was the follow-up of a recommendation made by the DSB in 2011 in the final report of the investigation into the cause of a take-off from a taxiway.[21] The experts consulted by the VpS for this risk assessment mentioned requesting/offering an intersection take-off as one of the top five risks at Amsterdam Airport Schiphol during the pushback, start up and taxiing phase. There were no further conclusions, actions or proposals for mitigating measures associated with this risk assessment.

18 VDV, 4.01 Gebruik van banen, Starten van intersecties.
19 Air Traffic Flow and Capacity Management.
20 The VpS is a partnership of companies that play a role in the aviation process at Amsterdam Airport Schiphol. The objective of their collaboration is to guarantee safety at Schiphol and to continuously and integrally improve it.
21 Took off from taxiway, Boeing 737-306, 10 February 2010 Amsterdam Airport Schiphol, Amsterdam.

Investigation entitled 'Air Traffic Safety at Amsterdam Airport Schiphol'
The investigation entitled 'Air Traffic Safety at Amsterdam Airport Schiphol' published by the DSB after the subject incident concludes, among other things, that the parties at Schiphol lack a clear working method for dealing with recommendations, which ensures that parties take action jointly. An Integrated Safety Management System (ISMS) was taken into use within the sector at the start of 2018. The mutual harmonisation of the investigation results by AAS and LVNL led to a recommendation, which is mentioned in the LVNL report (as mentioned before).

Objective of LVNL's investigation
Although the LVNL investigation report states that the investigation was focused on what LVNL could possibly do to prevent any repetition of this kind of incident, the report limits itself to bringing the results of the investigation to the attention of the RST. The report does not consider the question of whether the intersection concerned is correctly designated as a 'recommended intersection' in the Operations Manual and if offering the intersection concerned is a wise choice.

Similar incident
The LVNL report includes mention of an incident that occurred in October 2014 when an aircraft also lined-up with the edge of the runway, just as via intersection S5. Because the pilot of another aircraft saw this and reported it, it was possible to correct the situation. This occurrence did not lead to action by LVNL. There was also a short remark in the report that the RST discussed the confusion that occurs with some pilots as a result of the positioning of the edge lights at intersection S5.

The analysis in the report by AAS explains that the yellow centre line of the taxi track stops at the runway edge marking and the crew therefore confused the runway edge marking with the centre line. In addition, in its analysis the AAS reports that all taxiway lighting at Schiphol is illuminated, including on the route that an aircraft must not follow and which can therefore result in a crew making a mistake. The likelihood of mistakes occurring increases especially, according to the report, if the route that the crew must follow as in this incident is not illuminated.

Handling of the occurrence in the Runway Safety Team meeting
The report of the RST meeting[22] on 14 December 2016 reveals that only extending the yellow taxi lines from S5 to the centre of Runway 24 was adopted as a point for action. Providing green centre line lighting for intersection S5 was not implemented. Questions put to the AAS by the DSB revealed that intersection S5 does not have centre line lighting to avoid there being lighting that could cause confusion for traffic landing on runway 06 under restricted visibility conditions.

22 Draft RST Report No. 128 dated 14 December 2016. The next meeting of the RST designated this report is final.

Other possible action points arising from both internal reports were not discussed by the RST. This is why the RST did not consider the risks of an intersection take off and how to reduce them. In addition, LVNL did not reconsider reviewing what changes in the procedures were considered to be necessary after it was decided not to install centre line lights on intersection S5.

CONCLUSIONS

Given the factual information it is concluded that the EMB-120 aeroplane made a misaligned take-off from Runway 24 at Amsterdam Airport Schiphol, at night. During take-off, the crew interpreted the right-hand side runway edge lights as the runway centre line lights. Evidently, visual cues provided in the form of taxiway markings and lighting turned out to be insufficient for a correct guidance of the aeroplane from the taxiway to the runway centre line. The large turning angle, required to align the aeroplane with the runway centre line, in combination with the discontinuity of the taxiway S5 centre line and absence of the taxiway centre line lighting have contributed to the misaligned take-off. In addition, the ATC clearance during the turn from taxiway B onto S5 and Runway 24 might have distracted the flight crew.

During the take-off roll several runway edge lights were struck by the nose landing gear of which the pilots were unaware. It is suspected that, on several occasions, the edge lights were catapulted leading to damage to the aeroplane. Despite the sustained damage, the aeroplane was able to take off and reach its destination airport. No other damage occurred.

The absence of centre line lighting on taxiway S5 is not in correspondence with the specifications set in CS ADR-DSN.M.710.

The absence of a continuous centre line marking on taxiway S5 leading to the centre line of Runway 06/24 is not in correspondence with the specifications set in CS-ADR-DSN.L.555. This was corrected after the occurrence had taken place.

LVNL was aware of the risks of intersection take-offs before the incident occurred. However, this did not lead to operational measures by LVNL.

Intersection S5 was also a recommended intersection outside the uniform daylight period despite the fact that the intersection did not have centre line lighting.

The LVNL report does not consider the question of whether intersection S5 is justifiably designated as a 'recommended intersection' in the Operations Manual and if offering the intersection concerned is a wise choice.

After the decision was taken not to install centre line lights on intersection S5, LVNL retained the qualification of intersection S5 as a 'recommended intersection' in the Operations Manual. There was no reconsideration.

To International Civil Aviation Organization (ICAO):
It is recommended to initiate the process to develop, within Annex 14 Volume 1 'Aerodrome Design and Operations', a standard for runway edge lights that would allow pilots to identify them, specifically, without reference to other lights or other airfield features.

To Amsterdam Airport Schiphol:
It is recommended to proactively take measures, in line with the above recommendation to ICAO, which prevent pilots from interpreting the runway edge lights as the runway centre line lights.

To Air Traffic Control the Netherlands:
Outside the uniform daylight period, allow air traffic access to the runway for take-off only when intersections are used that are equipped with centre line lighting.

Worldwide safety investigations of similar occurrences revealed coincident contributing factors like summed up in the ATSB report. The above recommendation to the International Civil Aviation Organization was issued by the British Air Accidents Investigation Branch (AAIB) on 3 December 2015. The AAIB motivation for the issue of their safety recommendation (GB-SIA-2015-0038) is described on page 28 of this report.

On 26 January 2016, ICAO responded to the recommendation:

ICAO states that Safety Recommendation 2015-038 will be referred to the Aerodrome Design and Operations Panel (ADOP) within ICAO for further study. In reviewing the recommendation, the ADOP, including its various specialized working groups, will take into account possible contributing factors such as additional pavement width at the beginning of the runway and the need for appropriate fog dispersal at aerodromes. The next meeting of the relevant ADOP Working Group is scheduled for the first quarter of 2016.

The AAIB initial assessment of the response of ICAO was that it is not adequate.

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FDR DATA

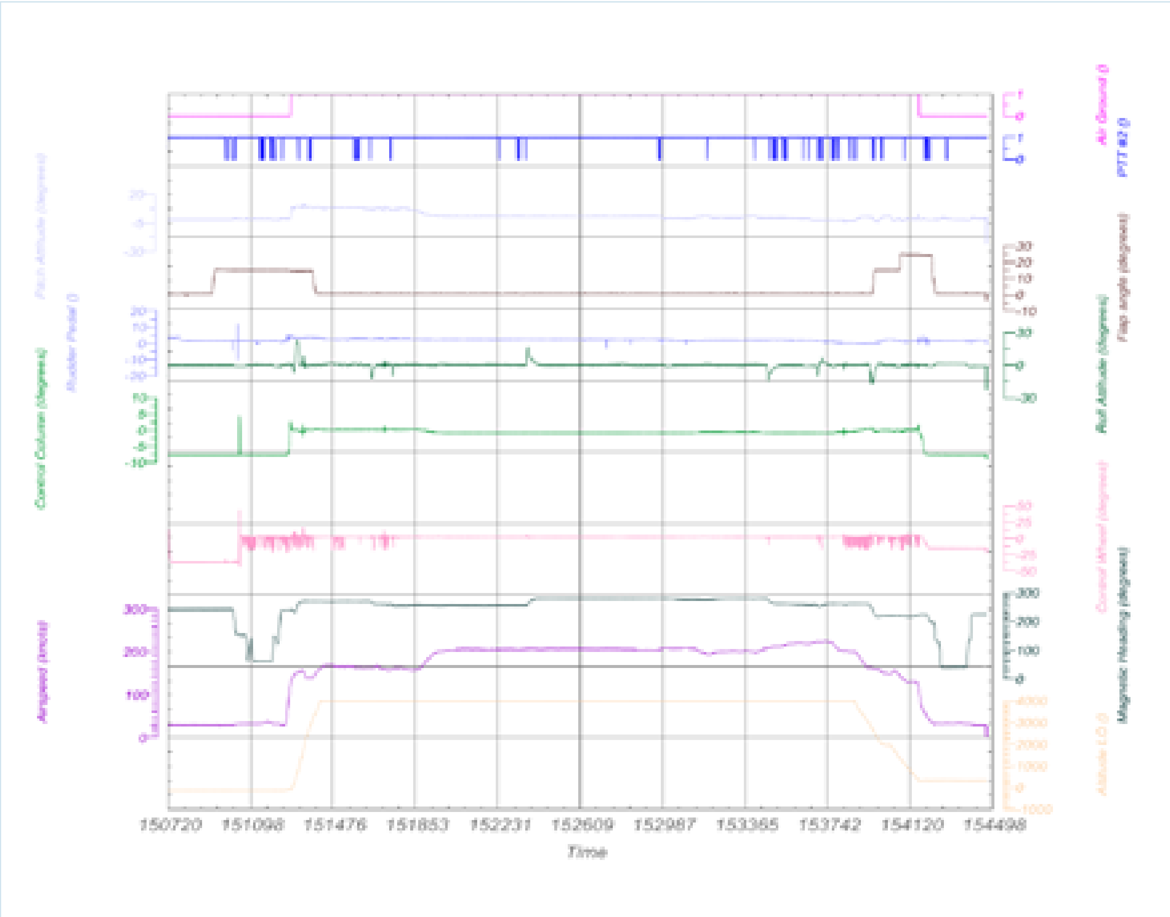

Figure A1: Overview of the Euler angles, aircraft state and control related parameters for the duration of the flight.

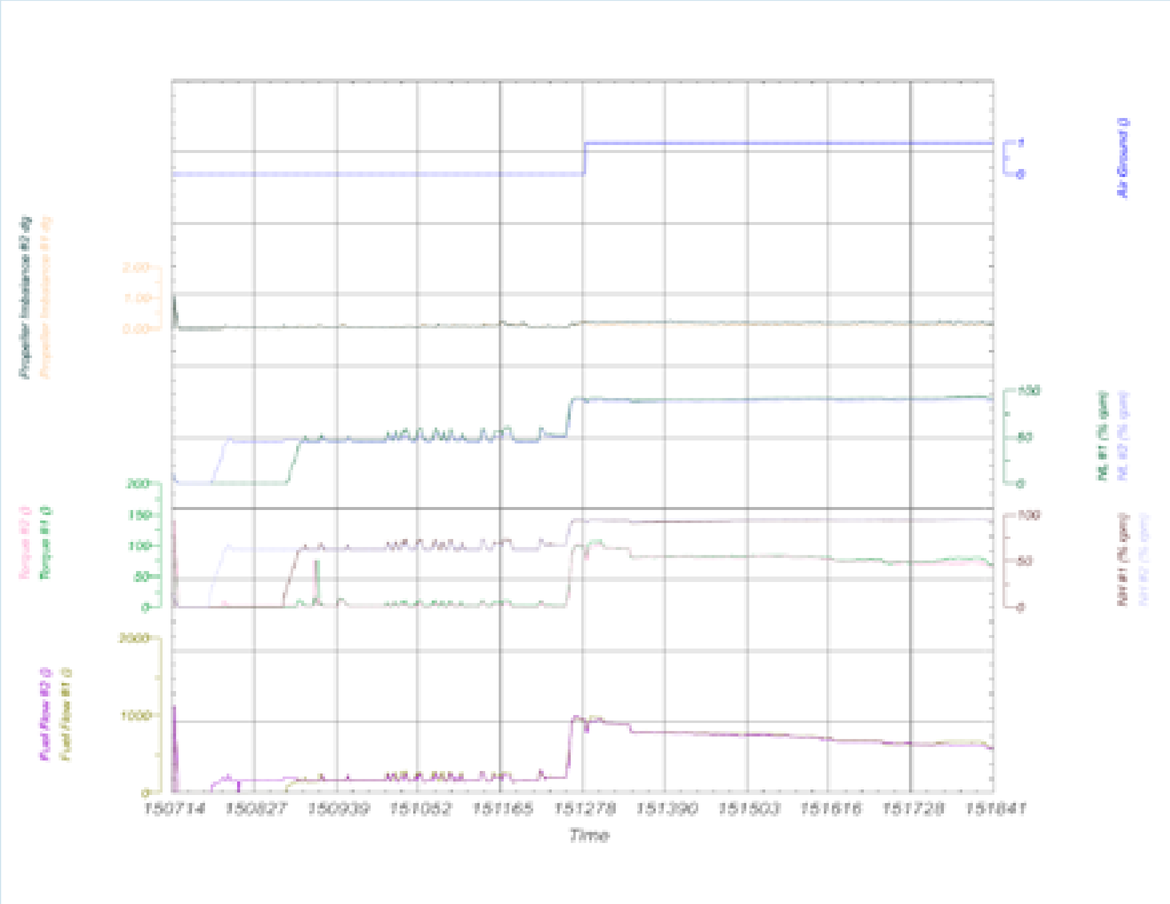

Figure A2: Overview of engine related parameters during take-off.

APPENDIX B

ATC TRANSCRIPT

UTC time	Source	Radio transcript	Note
17:20:21	FO	Ground Hello Swiftair 7016 stand 66 request taxi	Radio contact using ATC ground Frequency
17:20:26	GND	Swiftair 7016 taxi A2 and then B. Taxi runway 24 S7	Taxi clearance is given to the flight crew
17:20:34	FO	A2 B A runway 24, Swiftair 7016.	
17:20:58	FO	Ground Swiftair 7016. Do you confirm is via B runway 24?	
17:21:04	GND	A2 and then B.	
17:21:06	FO	A2 and then B Swiftair 7016	
17:22:56	GND	Swiftair 7016, How long will you be ready for departure	
17:23:01	FO	Will be ready Swiftair 7016	
17:23:04	GND	OK. Would you like an intersection departure?	
17:23:06	FO	Affirm Swiftair 7016	
17:23:09	GND	S5 or S4?	
17:23:13	FO	S5 is OK, Swift 7016	
17:23:16	GND	Swift 7016 Taxi to holding short S5	
17:23:44	GND	Swiftair 7016 contact TWR 119.9	
17:23:48	FO	119.9 Swift 7016. Thank you. Bye	
17:23:56	FO	Tower hello Swift 7016	Radio contact using ATC Tower Frequency
17:23:58	TWR	Hello Swift7016 stay on this frequency Runway 24 Cleared take-off. Wind is 130 at 5	Take-off clearance
17:24:06	FO	Cleared for take-off runway two… four and stay on your frequency Swift 7016	
17:24:36	TWR	Swift 7016 after departure make a right turn to 270	Departure clearance
17:24:41	CAP	After departure heading 270, Swift7016	

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