Unauthorised takeoffs from taxiways – an in-depth analysis of past occurrences

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By

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Summary

Unauthorised takeoffs from a taxiway by civil aircraft, although very rare, have occurred in the past. In some cases the takeoff was aborted as it was noticed by either the pilot or aircraft traffic controller that the aircraft was not departing from a runway. In some other examples the aircraft continued its takeoff (even when noticed by aircraft traffic control). Any unintentionally takeoff from a taxiway is potentially hazardous if another aircraft or ground vehicle is occupying the same taxiway, the taxiway is not long enough, or obstacles are located near the extended taxiway centreline that the aircraft cannot clear.

In this paper an analysis is presented of reported occurrences in which pilots unintentionally, without authorisation took off from a taxiway. The objective is to get an understanding of the circumstances and causes of these events. This will help accident investigators in the future with their analysis in case they are faced with a similar type of occurrence. The paper describes the human factors related factors to unauthorised takeoffs from a taxiway. Also the contribution of the taxiway configuration, light conditions, and visibility is discussed. The paper also reviews some mitigating measures that can help to prevent these occurrences.

Resume Gerard van Es

A Dutch native, Gerard van Es holds a BSc and MSc in aerospace engineering. He has an extensive background in aviation first with KLM (flight operations), followed by Fokker Aircraft (aerodynamics) and later with the National Aerospace Center (NLR) in Amsterdam, the Netherlands as senior consultant flight operations and flight safety.

His current and past activities encompass a wide variety of aviation related topics on areas such as accident/occurrence investigation, safety assessments, flight data analysis, runway friction, aircraft performance analysis, and aircraft traffic control safety. Gerard is also responsible for the development of the NLR-Air Transport Safety Database (incl. ECCAIRS). Gerard participates in numerous international working groups on aviation safety such as the ICAO Safety Indicator initiative, the FSF runway safety initiative, the Runway excursion prevention working group, the Airlines Risk Management Solutions (ARMS) Working Group and many more.

1 Background

On 6th of September 2019, a Boeing 737-800 was scheduled for a passenger flight from Amsterdam Airport Schiphol to Chania, Greece. It was dark and visibility was good. The aircraft taxied in northerly direction on Taxiway C to Runway 18C when it received takeoff clearance for Runway 18C (see Figure 1). The flight crew then turned left twice, lined up on Taxiway D in a southerly direction and commenced the takeoff. Air traffic control noticed that the aircraft started to depart from the taxiway and instructed the crew to stop immediately. The crew rejected the takeoff and stopped safely on the taxiway.

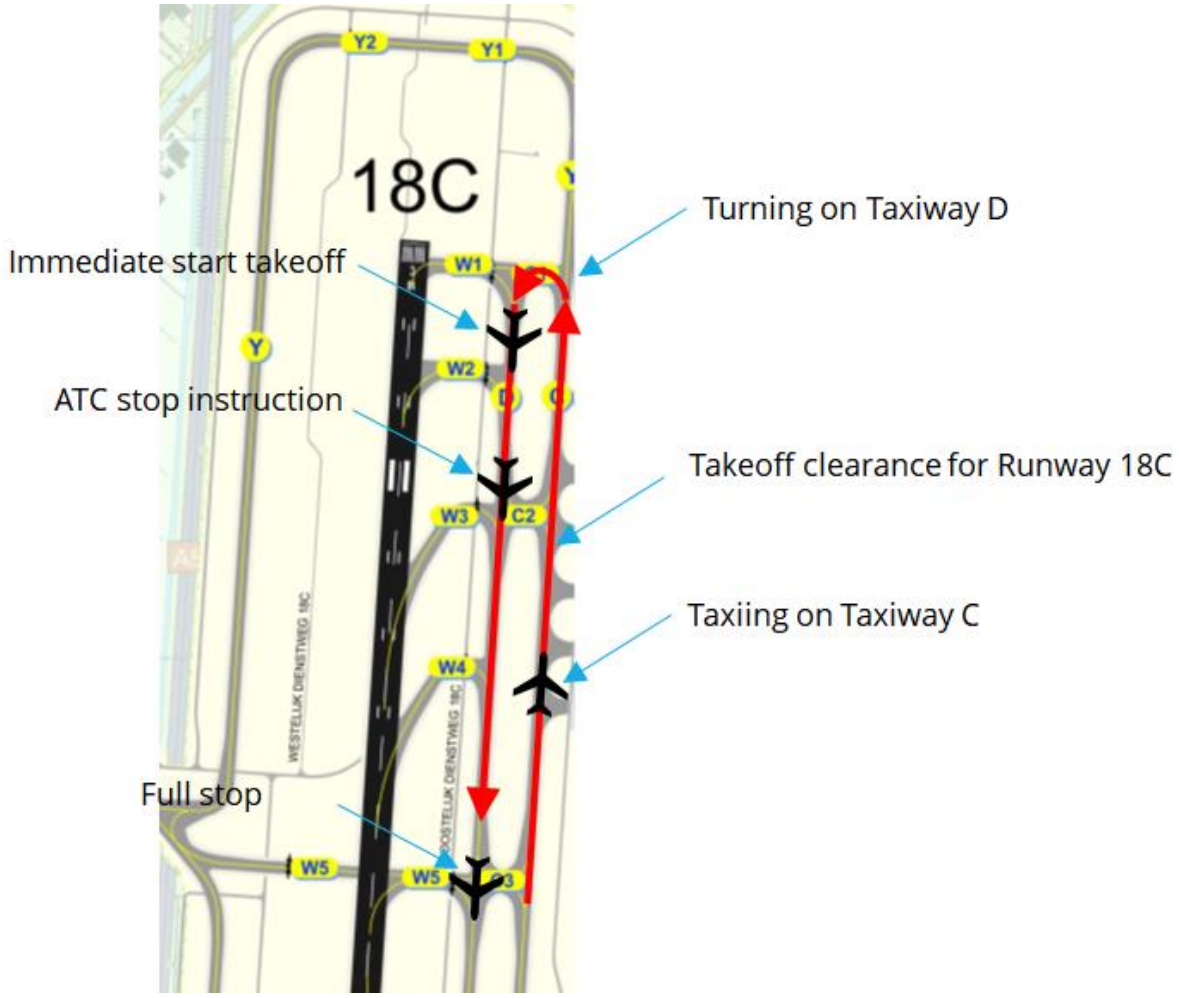

Figure 1: The taxi route and rejected takeoff of the B737-800. (Source: Amsterdam Airport Schiphol, modified by NLR)

Unauthorised takeoffs from a taxiway, although very rare, have occurred in the past. In some cases the takeoff was aborted, as it was noticed by either the pilot or aircraft traffic controller that the aircraft was not departing from a runway. In some other examples the aircraft continued its takeoff. Any unauthorised takeoff from a taxiway is potentially hazardous if another aircraft or ground vehicle is occupying the same taxiway, the taxiway is not long enough, or obstacles are located near the extended taxiway centreline that the aircraft cannot clear. It should be noted that airports sometimes use their taxiways for departures in case a runway is under maintenance and there are no alternative runways available for departures. This is only allowed under strict conditions.

In this paper an analysis is presented of reported occurrences in which pilots attempted to takeoff or took off from a taxiway without authorisation. The objective is to get an understanding of the circumstances and causes of these events. This could help accident investigators in the future with their analysis in case they are faced with a similar type of occurrence.

2 Study approach

The study is based on data sample of reported occurrences in which pilots attempted to takeoff or took from a taxiway without authorisation. These occurrences are analysed for typical common circumstances and causal factors.

Taxiway takeoff occurrences are defined here as those cases in which the aircraft lined-up on a taxiway and the flight crew applied takeoff thrust to start the takeoff roll.

3 Occurrence data sources

The primary data source used in this study was the NLR Air Safety database. For many years National Aerospace Center NLR maintains a large database with aviation safety related data called the NLR Air Safety Database. The NLR Air Safety Database contains detailed information on accidents and incidents of fixed wing aircraft from 1960 and onwards. Besides data on accidents and incidents the NLR Air Safety Database also contains a large collection of non-accident related data. These data include the following: airport data, flight exposure data (hours & flights at the level of airlines, aircraft type, and airports), weather data, fleet data, and more. The NLR Air Safety Database is updated frequently using reliable sources including data from official reporting systems, insurance claims, accident investigation boards, aircraft manufacturers, civil aviation authorities and more.

The queries were conducted for aircraft with a maximum takeoff mass of at least 5,600 kg which were engaged in passenger, cargo or business operations.

The query was conducted for the period 2000-2022. Although cases of taxiway departures can be found in the period before 2000, it is believed that some of the conditions are less representative for current and future operations. For instance, improvements have been made in aircraft on-board warning systems, in flight crew training (i.e. related to raising the situational awareness on the ground during taxi and in ATC surveillance systems that will help to detect takeoffs from taxiways).

4 Data sample

A query was conducted in the NLR Air Safety Database which resulted in twenty-five cases of (attempted) takeoffs from taxiways.

Table 1 lists the cases identified together with some relevant information. For each occurrence the main causes and contributing factors were also identified for further analysis (not shown in the table). A number of interesting observations can be made from the data sample. These will be discussed in the next sections. It should be kept in mind that the data sample is not very large and any conclusions drawn from it should be taken with some care.

Table 1: Overview of (attempted) takeoffs from taxiways

Date	Airport	Aircraft type	Local operator	Light conditions	Visibility	Taxiway layout*	Error noticed?	RTO speed (Kt GS)	Consequences
24-12-2001	Schiphol	MD82	No	Dark	Good, 4 Km	Dual parallel	By pilot, By ATCo	22	Low speed abort-stopped on taxiway
25-01-2002	Anchorage	A340	No	Dark	Good, >10 km	Other	By ATCo	N/A	Safe takeoff
07-02-2002	Lisbon	A320	No	Daylight	Good, >10 km	Single parallel	By ATCo	133	Medium-high speed abort-stopped on taxiway
12-06-2003	Hong Kong	A340	No	Dark	Good, >10 km	Dual parallel	By pilot	97	Medium-high speed abort-stopped on taxiway
01-09-2003	Phoenix	B737	No	Dark	Good, >10 km	Dual parallel	By pilot	60	Medium-high speed abort-stopped on taxiway
23-10-2005	Oslo	B737-800	No	Dark	Good, >10 km	Dual parallel	By ATCo	80	Medium-high speed abort-stopped on taxiway
05-11-2005	Anchorage	MD11	No	Dark	Good	Single parallel	By ATCo	N/A	Safe takeoff
24-05-2007	Hong Kong	B727	No	Dark	Good, >10 km	Dual parallel	By pilot	20	Low speed abort-stopped on taxiway
11-10-2007	Memphis	C525	No	Twilight	Good, >10 km	Dual parallel	By pilot	N/A	Safe takeoff
25-11-2007	Brisbane	G-IV	No	Dark	Good	Dual parallel	By ATCo	80	Medium-high speed abort-stopped on taxiway
13-09-2008	Hong Kong	B737-800	Yes	Dark	Good, 6-7 km	Dual parallel	By ATCo	63	Medium-high speed abort-stopped on taxiway
10-02-2010	Schiphol	B737-300	Yes	Dark	Good, >10 km	Dual parallel	By ATCo	N/A	Safe takeoff
25-02-2010	Oslo	A320	No	Daylight	Good, >10 km	Dual parallel	By ATCo	N/A	Safe takeoff
27-11-2010	Hong Kong	A340	No	Dark	Good, >10 km	Dual parallel	By ATCo	72	Medium-high speed abort-stopped on taxiway
15-11-2011	Wroclaw	ATR42	Yes	Daylight	Low, RVR 400m	Single parallel	No	N/A	Safe takeoff
16-10-2012	Sofia	A319	No	Dark	Good, 5 Km	Single parallel	By ATCo	37	Low speed abort-stopped on taxiway
23-05-2014	Al Maktoum	Beechcraft 400XP	No	Daylight	Good, >10 km	Dual parallel	By ATCo	50	Medium-high speed abort-stopped on taxiway
12-07-2015	Singapore	B767	No	Dark	Good, >10 km	Dual parallel	By pilot, By ATCo	25	Low speed abort-stopped on taxiway
24-09-2015	Sharjah	B737-400	No	Dark	Good, >10 km	Dual parallel	By ATCo	N/A	Safe takeoff
19-04-2016	Sharjah	A320	?	Dark	Good, >10 km	Dual parallel	By ATCo	20	Low speed abort-stopped on taxiway
06-11-2017	Nice	EMB190	No	Dark	Good, >10 km	Dual parallel	By ATCo	92	Medium-high speed abort-stopped on taxiway
03-08-2018	Riyadh	B737-800	No	Dark	Good, >10 km	Dual parallel	By pilot	100	Overran end of taxiway
06-09-2019	Schiphol	B737-800	Yes	Dark	Good, >10 km	Dual parallel	By ATCo	85 (estimate)	Medium-high speed abort-stopped on taxiway
07-08-2021	Newark	A330	No	Dark	Good, >10 km	Single parallel	By ATCo	90	Medium-high speed abort-stopped on taxiway
01-06-2022	Chicago O'Hare	A320	No	Dark	Good, >10 km	Other	By ATCo	15	Low speed abort-stopped on taxiway

* '*other*' means a taxiway that was parallel to a runway that was not planned for the takeoff.

5 Results

5.1 Light conditions

It follows from

Table 1 that in twenty-one cases (84%) it was dark or twilight conditions existed. As the vast majority of takeoffs are conducted in daylight (around 80%), the actual risk of a taxiway takeoff will be much higher in darkness than during daylight, approximately 18 times higher[1]. There are several explanations for this higher risk in darkness which are discussed next.

During daylight conditions, pilots normally have a wide range of visual cues by which they can navigate to a runway. Flight crews depend on visual aids to achieve the intended taxi route in darkness more than in daylight. However, these visual aids can be less effective in night time conditions. Taxiways feature a continuous yellow line in the centre of the taxiway. During day time there is a clear difference visible between the white broken lines on a runway and the continuous yellow lines on taxiways. When it is dark, however, it has been reported in investigation reports that the yellow taxiway centreline cannot always be clearly distinguished by the beam of an aircraft's taxi or landing lights[2]. The colours white and yellow can be differentiated from each other only when seen in close proximity. At those airports equipped for low visibility operations, taxiways have green centreline lighting, otherwise blue edge lighting or blue edge reflectors are provided. Where green centreline lighting is provided, blue taxiway edge lighting may also be installed as additional guidance. The taxiways of all airports from

Table 1 had either green centreline lighting, blue edge lighting/reflectors or a combination of both (compliant to regulations). This did not prevent the flight crews from properly distinguishing the taxiway from the runway which has different markings and light colours[3]. The beam of an aircraft's taxi or landing lights could make it harder to distinguish the different light colours.

Some airports have a taxiway lighting system on which only the lights required for taxiing traffic are illuminated. Those that do not have this system will have to illuminate all taxiway lights, including those on taxiway route sections aircraft crew are not instructed to follow. It is commonly believed that this could increase the risk of pilots taking the wrong taxi route. However, details on selectable taxiway lighting systems are not available for all occurrences analysed and therefore no conclusions about the absence of a selectable taxiway lighting system can be drawn. In one occurrence with a B767 the airport (Singapore) used a "taxi on the greens" taxi guidance system. The controller switched on the green taxiway centreline lights corresponding to the assigned taxi route and instructed the flight crew to "taxi on the greens". However, this did not prevent the crew from deviating the illuminated taxi route. In this example, according to the investigators, the PF of the occurrence aircraft had an incorrect mental picture of the taxi route. The PF never confirmed his mental picture of taxi route with the cues and aids outside the aircraft.

In darkness air traffic controllers are limited in their ability to visually monitor traffic (even in good visibility). This also depends of the actual location of the tower to the runway and the amount of background lighting. As discussed later in this paper, controllers were often able to detect the error. This was mostly achieved by looking at the ground radar data. However, there are some cases in which the controller visually detected the aircraft departing from the taxiway.

5.2 Visibility

Low visibility could be a factor in pilots loosing position awareness on the airport while taxiing to the runway. However, in twenty-four occurrences out of twenty-five the visibility was good. Only one

[1] The risk is approximately 18 times higher during periods of darkness ([.83/.20]/[.17/.80]=18).
[2] During darkness it is normal practice to use taxi lights when taxiing and landing lights for takeoff. However, it can vary by operator and aircraft type. For instance some use the landing lights "Before Take-Off" or "When Cleared for Take-Off", others leave it up to the captain to decide what to use.
[3] The centre of a runway features a broken white line and the centre and edges of a runway features white lights. Some runways don't have runway centreline lights. As far as known in all cases listed in Table 1 the intended runway for takeoff had runway centre lights.

occurred in low visibility during daylight and contributed to the occurrence. During low visibility operations, pilots will conduct a more thorough briefing for the taxi-out phase. The flight crew will also monitor the taxi chart more closely and focus more on the different markers to identify their position. Air traffic control will also be more focussed during low visibility operations carefully monitoring the ground movements. At very low visibility conditions, ATC will have Surface Movement and Guidance Control Systems to assist them. All these elements will help in reducing the likelihood that pilots depart from a taxiway which could explain the low number of occurrences found during low visibility.

5.3 Taxiway layout

The runway on which the aircraft should have taken off had a dual parallel taxiway layout next to it in eighteen occurrences (72%), including partial dual parallel taxiway (see example in Figure 2). In all these cases the aircraft was taxiing via the outer taxiway and took off from the inner taxiway. Eleven of these occurrences took place on 4 airports. Five aircraft took off from a single parallel taxiway and two aircraft departed from a taxiway that was not parallel to the intended runway. The data clearly show that dual parallel taxiways are a very common factor in taxiway takeoffs and increase the risk. This is not a real surprise as the taxiway has the same direction as the runway[4]. So when making a wrong turn, the crew could have the erroneous expectation to have entered the runway.

Flight crews of the occurrence flights sometimes reported that they were not surprised not seeing runway threshold markings or a runway number since they believed the threshold was further ahead (in case of a displaced threshold). The arrow marking on the runway that should be normally visible in such as case were not missed either. In a number of occurrences a takeoff clearance was already given early during taxiing, so the flight crews did not pay much attention looking for holding lines as they could go directly onto the runway. Therefore the absence of holding lines when turning on to the taxiway did not alarm the flight crew that they were not on the runway. This issue will be discussed in some detail later in the paper. Also stop bars were sometimes already deactivated by the controller after given the early takeoff clearance as no other traffic was near the departure runway. In those cases the flight crew were not alerted by an illuminated stop bar which could be visible to them before turning onto the parallel taxiway.

[4] Some operators require that a heading check is made prior to commencing the takeoff. This can give the crew an incorrect confirmation that they are on the runway where they are actually on the parallel taxiway.

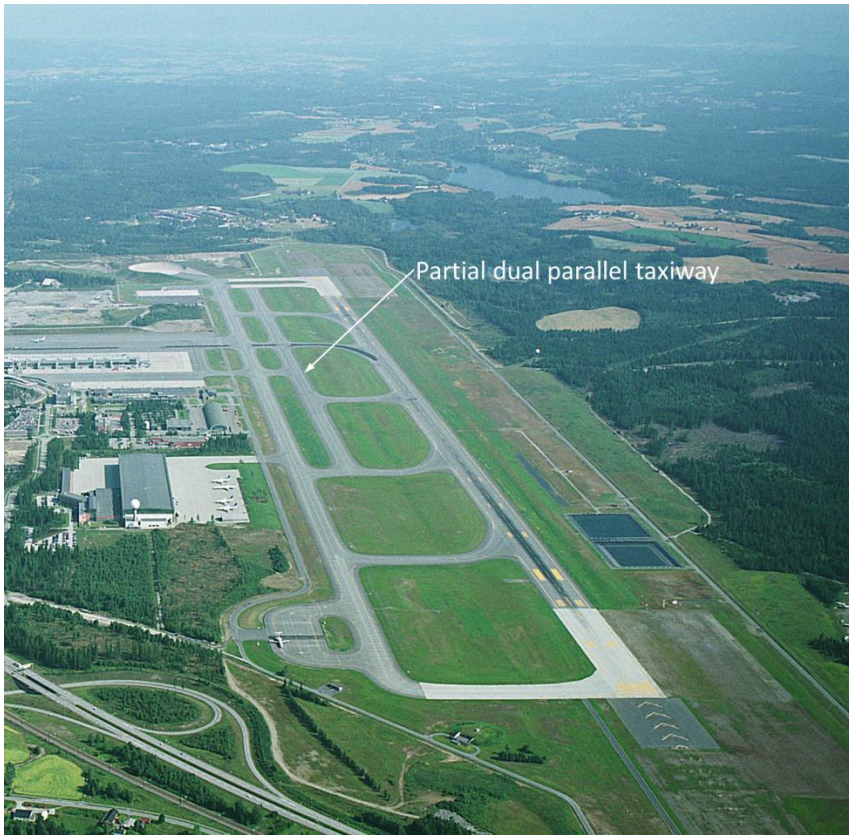

Figure 2: Example of an airport with a partial dual parallel taxiway (Photo: Oslo Lufthavn AS)

5.4 Taxiway width

Although not listed in

Table 1, the width of the taxiways was mostly between 22 and 29m and narrower than that of the runway (45m). In two occurrences the taxiway was formerly a runway so these were much wider. It remains unclear why pilots have not recognised that they were departing from a surface which was about half the width of a normal runway. Paved shoulders, when added to the width of a standard taxiway, can make the taxiway appear much wider than it actually is. However, studies on misaligned takeoffs suggest the contrary[5]. In all occurrences the taxiway had a shoulder varying between 8.5 and 19m on either side of the taxiway. This could mislead the flight crew believing that they are on the runway. For example a pilot view on a 23m wide taxiway with 11m wide paved shoulders is compared to the same view on 45m wide runway in Figure 3 during daylight conditions. During night time the effect of the paved shoulders could be less of an issue if the taxiway edges are well lit. If this is not the case the taxiway can look much wider as illustrated in Figure 4. Still in all occurrences there was some form of taxiway lighting (green centre and or blue edge lights/reflector) available. The pilot eye—to wheel height does not seem to play a significant role. The occurrences listed in

[5] ATSB. (2009). Factors influencing misaligned take-off occurrences at night. Canberra: Australian. Transport Safety Bureau.

Table 1 are for a variety of aircraft with variable pilot eye—to wheel heights ranging from 2 to 6m. Although 44% of all occurrences B737/A320 type of aircraft were involved. This proportion reflects the worldwide utilisation of these aircraft[6].

Figure 3: Example pilot view on a taxiway and a runway (source: YouTube)

[6] About 40% of all takeoffs are conducted with B737/A320 series of aircraft (Source: NLR air safety database)

Figure 4: Example of an unlit taxiway edge (source: YouTube)

5.5 Airport familiarity

In only four cases (16%) the involved operator had its home base at the occurrence airport. Flight crews that are familiar with an airport could be less focussed to their position on the airport while taxiing. For instance they may not pay much attention to a ground movement chart which helps them to verify their position. However, the vast majority of occurrences in the data sample concerned infrequent users of the airport. These flight crews were not (very) familiar with the layout of the airport as they would not come to the airport on a regular basis. Complex layouts and parallel taxiways can add to loss of situational or positional awareness of pilots which are unfamiliar with the airport layout, especially during operations during darkness. Interesting is the fact a number of airports (Schiphol, Hong Kong, Sharjah, Oslo and Anchorage) experienced multiple taxiway takeoffs even with flight crews that were familiar with the airport. Deviation from the normal taxi-route were a factor in a number of these cases.

5.6 Error detection

In the vast majority of the occurrences either the air traffic controller (68%), the pilot (20%), or both pilot and controller at the same time (8%), detected the takeoff initiation on the taxiway. There is only one case reported to be undetected (only afterwards when the aircraft had departed).

In eighteen cases (72%) the pilot aborted the takeoff, whereas in seven cases (28%) the aircraft continued. In only one of these seven cases the pilot realised the mistake. However, the involved aircraft was near its rotation speed, and the decision was taken by the pilot to continue the takeoff. In five cases the air traffic controller noticed the error but decided not to take action. Different reasons were given by the controllers for not intervening, such as: the aircraft was at a too high a speed, the aircraft speed was unknown and the taxiway was not occupied at the time. In hindsight these reasons are understandable. However, it remains very difficult for a controller to make a good judgement on the capabilities of an aircraft to stop or continue the takeoff safely.

5.7 Consequences

In seventeen occurrences (68%) the pilots managed to stop the aircraft safely on the taxiway. In seven cases (28%) the pilots continued their takeoff without further consequences. In one case the pilot rejected the takeoff but was unable to stop on the taxiway[7]. This aircraft ended on the runway safety strip without any damage. The speed at which the pilots started to abort their takeoff varied between 15 and 133 knots (GS). These speeds are randomly distributed[8]. The abort speeds depend on the time the error was noticed and how long it took for the pilot to start the abort. All aborts were conducted below V1, the maximum speed at which the crew can decide to reject the takeoff.

In only one case it was reported that another aircraft was occupying the taxiway from which the takeoff was attempted. In this occurrence (MD82, at Schiphol, 2001), the other aircraft was at some distance from the departing aircraft. The flight crew of occurrence aircraft (MD82) actually noticed the other aircraft and safely stopped at low speed at about 2,200m from each other.

5.8 Causal and contributing factors

Although the data sample is relatively small to draw hard conclusions on common causal and contributing factors, some general observations can still be made. These are based on the official findings of the investigators.

A common causal factor mentioned in the investigation reports is that the flight crew did not monitor, verify and/or confirm the position of the aircraft during taxiing and/or at start of the takeoff. Multiple factors were mentioned that could explain this. Most of them were unique to one or two occurrences like a late runway change, pilot fatigue, high workload, pilot's distraction, crew not using a ground movement chart or moving map, rushed flight crew, inadequate monitoring of aircraft movement by tower air traffic control and inadequate airline operator's procedures.

Interesting is that high workload (of flight crew or air traffic controller) and rushed flight crews are not very common to taxiway takeoffs. In fact most occurrences occurred during low traffic hours at the airport. This does not always mean that the flight crew cannot be rushed. When they for instance need to catch up delays, they could be rushed irrespectively of the traffic situation.

A factor mentioned a number of times by the investigators was the presence of a dual parallel taxiway on which the aircraft was taxiing via outer taxiway and took off from inner taxiway. Especially during darkness this layout was a large contributing factor in the occurrences analysed.

A factor that was very common amongst the occurrences was that an early takeoff clearance was given by the controller. At times of low traffic this is a normal procedure. There were eleven occurrences (48%) where a clearance was issued at times when the aircraft had not yet reached the intended runway. In most of these cases there was no need to speed things up because of other traffic or delays. An air traffic controller can instruct the flight crew to either stop before entering the takeoff runway or to line up the aircraft on the runway (aircraft has not yet received clearance for takeoff). It is also possible that the crew may already receive permission to depart while the aircraft is still moving on a taxiway. The crew may then takeoff as soon as the aircraft enters the

[7] The taxiway did not run parallel over the full length of the runway (taxiway 1,400m long, runway length 4,000m).
[8] The data follow a normal distribution (P>0.20).

runway[9]. In this last case the crew is likely to take less time to check if they are on the runway and visual cues that they are not on a runway can be easily missed. (i.e. absence of holding lines, or runway entry lights). Therefore some airports have introduced the procedure that a take-off clearance should be issued after verification has taken place that the aircraft is on the correct runway. Others require runway controllers to continuously monitor an aircraft when an early take-off clearance is issued.

Darkness was mentioned in the vast majority of occurrences as factor that contributed to the occurrence. As already discussed darkness can make it more difficult to the pilot to identify visual cues like markings and lights of taxiways and runways. Background lights surrounding an airport (e.g. from building or roads) can also contribute to a reduce situational awareness of the pilots while taxiing. Finally it is also more difficult for air traffic controllers to visually monitor the aircraft in darkness.

6 Mitigations

6.1 Taxiway takeoff warning systems

Avionic and aircraft manufacturers have developed on-board warning systems that could help to avoid an unintentional takeoff from a taxiway.

Since 2007 an on-board system is available called Runway Awareness Advisory System RAAS. This system is an optional extension of the well-known and commonly used EGPWS system manufactured by Honeywell. RAAS provides pilots position awareness advisories relative to runways during ground operations and approach to land. A feature in RAAS is called Taxiway Takeoff advisory which is relevant to the occurrences studied in this paper. The purpose of the Taxiway Takeoff advisory is to enhance crew awareness of excessive taxi speeds or an inadvertent takeoff on a taxiway. The advisory is generated if: the ground speed of the aircraft exceeds 40 kts., and the aircraft is not aligned with the runway. RAAS functions are based on a database of runway locations, aircraft position (GPS) and ground speed. The system does not have knowledge of the locations of taxiways[10]. The aural message string "*On Taxiway, On Taxiway*" is annunciated each time the advisory is generated. At least one of the aircraft listed in

Table 1 was equipped with RAAS (before 2007 the system was not certified). This was the occurrence with the Air France A319 at Sofia (2012). However, the aircraft never reached the speed of 40 knots for the RAAS system to issue a caution. RAAS will also notify the crew if they are approaching a runway and will call out the runway when lined-up. This is an additional confirmation to the crew that they are indeed on a runway. Currently a number of aircraft operators have installed RAAS into their aircraft or on any newly acquired aircraft.

Other warning systems onboard aircraft are also available. On a number of Boeing manufactured aircraft the selected departure runway is cross--checked with the GPS position. The FMC will issue the alert level message "*RUNWAY DISAGREE*" if the selected runway disagrees with the FMC position and a takeoff is attempted and the speed is below 80 kts. A takeoff attempt may be indicated when the thrust levers are placed in the takeoff position or when ground speed is greater than a typical

[9] This is often called "a rolling takeoff" by air traffic controllers. However, a rolling takeoff can also be conducted after the aircraft has lined-up on the runway.

[10] Accurate survey data as regards to airport taxiways are unavailable or prohibitively expensive. The EGPWS airport database that RAAS uses therefore may lack complete and accurate taxiway survey data. The RAAS advisory annunciation algorithm designates as taxiway all airport terrain that is not identified as runway in the airport database. Therefore, the RAAS advisory annunciation algorithms result in an on-taxiway advisory during operation of the aircraft that satisfies the groundspeed conditions, unless the runway selection algorithms determine the aircraft is both on a runway and aligned with it.

taxi speed, for example, around 30 knots. A similar system was developed by Airbus for their fly-by-wire aircraft models and is part of the so-called Take-Off Surveillance 2 (TOS 2) functionality. It aims at avoiding a take-off on a taxiway by checking the aircraft position with regards to the runways available on the current airport as soon as the thrust levers are set at a position equal to or higher than the FLEX/MCT. This check is performed up to 80 kts. If the flight crew applies takeoff thrust when the aircraft is on a taxiway and outside the runway area, a red ECAM warning "*NAV ON TAXIWAY*" is given.

There are also systems that warn air traffic control when aircraft are taxiing along a taxiway at too high a speed. These are normally part of the Advanced Surface Movement Guidance and Control System (A-SMGCS). In the 2010 Hong Kong occurrence the controller was able to intervene because the system sounded a warning.

All the warnings systems described here depend on the proper and timely actions taken by the flight crew and air traffic controller. These systems cannot prevent that flight crews initiate a takeoff from the taxiway. However, they can make sure the flight crew's perception is altered so that they can timely abort the takeoff roll at a low speed.

6.2 Miscellaneous mitigations

A common factor mentioned is that the flight crew did not monitor, verify and/or confirm the position of the aircraft during taxiing. Airport moving maps can be a great help in improving pilot positional and situational awareness while taxiing on complex layouts during darkness. An airport moving map shows an aircraft's position relative to the airport surface while taxiing. It can be installed on certified hardware and on mobile devices such as iPads.

Some airports have introduced the procedure that a take-off clearance should be issued after verification has taken place that the aircraft is on the correct runway. Others require runway controllers to continuously monitor an aircraft when an early take-off clearance is issued.

7 Final remarks

Unauthorised takeoffs from taxiways do occur occasionally. In this paper twenty-five cases of (attempted) takeoffs from taxiways that have occurred in the period from 2000 to 2022 were analysed. Several interesting observations can be made regarding the circumstances and causal factors that were related to this events.

The risk of a (attempted) takeoff from a taxiway is much higher during darkness with runways having dual parallel taxiways. In all occurrences involving a dual parallel taxiways the aircraft was taxiing via the outer taxiway and took off from the inner one. The risk is about 18 times higher during darkness.

Low visibility did not play a role in takeoffs from taxiways. In only one case (4%) the visibility was poor contributed to the occurrence. During low visibility both flight crew and ATC are focussed on the position of the aircraft which could explain the low share.

Flight crews who are unfamiliar with the airport are more often involved in taxiway takeoffs. This could be related to a complex airport layout and parallel taxiways which they are not very familiar with.

A common causal factor of the analysed events is that the flight crew did not monitor, verify and/or confirm the position of the aircraft during taxiing and/or at start of the takeoff. A variety of contributing factors to this cause were found. A factor that was most frequently reported was that flight crews were given a takeoff clearance while still taxiing to the runway and well before arriving at the intended takeoff position. This led to crews paying less attention to markings that would normally indicate that they had entered a runway. Another factor is that taxi and landing lights could make it harder to distinguish green taxiway centre lights and yellow taxiway centre lines from the white runway centre lights and lines.

In all analysed occurrences the taxiways had wide paved shoulders. These paved shoulders could make the taxiway look wider which could give a false impression to the flight crew that the aircraft is on the runway.

Avionic and aircraft manufacturers have developed on-board warning and positional awareness systems that could help to reduce the risk of an unintentional takeoff from a taxiway. Still recent examples of such events showed that these systems have not yet resolved the problem completely.

ATC procedures can help to prevent unauthorised takeoffs from taxiways. Examples are the procedure that a take-off clearance should be issued after verification has taken place that the aircraft is on the correct runway or that runway controllers should continuously monitor an aircraft when an early take-off clearance is issued.