Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT
Aviation Research and Analysis Report – AR-2009-033
Final

Factors influencing misaligned take-off occurrences at night

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Postal address: PO Box 967. Civic Square ACT 2608
Office location: 62 Northbourne Ave, Canberra City, Australian Capital Territory, 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

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Factors influencing misaligned take-off occurrences at night

Author(s)

Todd, Melanie A.

Prepared By

Australian Transport Safety Bureau
PO Box 967, Civic Square ACT 2608 Australia
www.atsb.gov.au

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Figure 1– the operator of the 3 July 2009 occurrence
Figure 2 and Figure 4 – Google Earth

Abstract

On 3 July 2009, the Australian Transport Safety Bureau (ATSB) was notified that a SAAB Aircraft Company 340B (SAAB), registered VH-ZLW, had commenced its take-off roll along the runway 25 left edge lights at Sydney Kingsford Smith Airport, New South Wales. This was one of three occurrences over the previous 2 years that involved aircraft commencing takeoff on the runway edge lighting.

In addition, within the previous 2 years the ATSB investigated two other occurrences involving pilot misidentification of runway alignment cues or lack of those cues during takeoff. All five Australian misaligned take-off and landing occurrences involved aircraft with weights greater than 5,700kg and three of the six occurrences involved scheduled regular passenger transport (RPT) operations. The remaining two occurrences involved charter operations.

This research investigation examined each of these occurrences and relevant international occurrences to identify the common factors associated with misaligned take-off and landing occurrences.

After reviewing the Australian and international occurrences, eight common factors were identified that increased the risk of a misaligned take-off or landing occurrence. The factors included: distraction or divided attention of the flight crew; confusing runway layout; displaced threshold or intersection departure; poor visibility or weather; air traffic control clearance/s issued during runway entry; no runway centreline lighting; flight crew fatigue; and recessed runway edge lighting.

To foster safety awareness, knowledge and action, the ATSB developed a pilot information card to help flight crew identify factors that could increase the risk of a misaligned take-off or landing.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory Agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

When safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation, the person, organisation or agency must provide a written response within 90 days. That response must indicate whether the person, organisation or agency accepts the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: The ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

BACKGROUND

When pilots taxi and take off during daylight conditions, they normally have a wide range of visual cues by which they can navigate and verify their location. At night however, the amount of visual information available is markedly reduced. Pilots rely more on the taxiway and runway lighting patterns presented to them and what can be seen in the field of the aircraft's taxi and landing lights.

The Australian Transport Safety Bureau (ATSB), was notified that a SAAB Aircraft Company 340B (SAAB), registered VH-ZLW, had commenced its take-off roll along the runway 25 edge lights at Sydney Kingsford Smith Airport, New South Wales (NSW) on the night of 3 July 2009. This was one of three occurrences over the previous 2 years that involved aircraft commencing takeoff on the runway edge lighting at night.

In addition, within the previous 2 years the ATSB investigated two more occurrences involving pilot misidentification of runway alignment cues or lack of those cues during takeoff. (The ATSB also investigated a serious aircraft landing misalignment occurrence in 2003.)

All five Australian takeoff occurrences involved aircraft with weights greater than 5,700kg and three of the six occurrences involved scheduled regular passenger transport (RPT) operations. The remaining two occurrences involved charter operations.

This report examines these occurrences and other relevant international occurrences where pilots have misperceived their lateral position on runway due to darkness and a combination of individual influences, runway, weather and task conditions. Occurrences have included lining up for takeoff on a taxiway, and taking off without runway lighting being activated. In addition to the Australian data, reports from the United States National Aeronautics and Space Administration's (NASA) Aviation Safety Reporting System (ASRS) database were also reviewed for common trends. These highlight the various factors which, when present, have the potential to increase the likelihood of this type of occurrence.

SUMMARY OF OCCURRENCES

Occurrences involving takeoff on the runway edge lighting

There were three Australian occurrences between 2007 and July 2009 where the crew of aircraft lined up and commenced takeoff on the runway edge lighting instead of the runway centreline. A summary of these occurrences are presented below. Two international occurrences involving takeoffs from the edge of the runway were also reviewed as follows.

In addition, there was an earlier Australian occurrence in 2003 that involved an aircraft misalignment with runway edge lighting during landing. This occurrence is outside the scope of this report as it involved a landing, but is included in Appendix B for information as it shares common themes with the take-off occurrences below.

ATSB Occurrence No: 200903941

On the night of 3 July 2009, the crew of a SAAB 340B aircraft, registered VH-ZLW, was preparing to take off at Sydney Kingsford Smith Airport, New South Wales (NSW), on a scheduled passenger service to Lismore, NSW. The aircraft was taxied onto the runway 25 from the right and lined up with the left edge runway lights for takeoff (Figure 1). Runway 25 does not have centreline lighting.

During the take-off roll, the captain reported that he thought the 'picture looked wrong' and realised the aircraft was incorrectly lined up on the runway edge lights. During this sequence of events, a pilot of another aircraft that was on final approach to the same runway reported a problem with the runway 25 lighting to the tower. As the SAAB moved back to the runway centreline, the aircraft on final approach reported that the lights appeared to be normal again. This confirmed the SAAB captain's thought that the aircraft had not damaged the lights. Moreover, he considered it was unlikely that the aircraft had been damaged because it was handling normally and there were no indications of any problems. Consequently, the captain continued the takeoff and continued the flight to Lismore.

There was no damage to the runway lights or the aircraft during the take-off roll because the runway 25 edge lights were all recessed. The aircraft's movement over the recessed lighting may have given the appearance of the runway edge lights intermittently failing to the aircraft positioned on final approach.

Figure 1: Extra pavement/runway width runway 25 Sydney (looking in the direction of takeoff)

Various factors were identified that influenced the initial misalignment for takeoff:

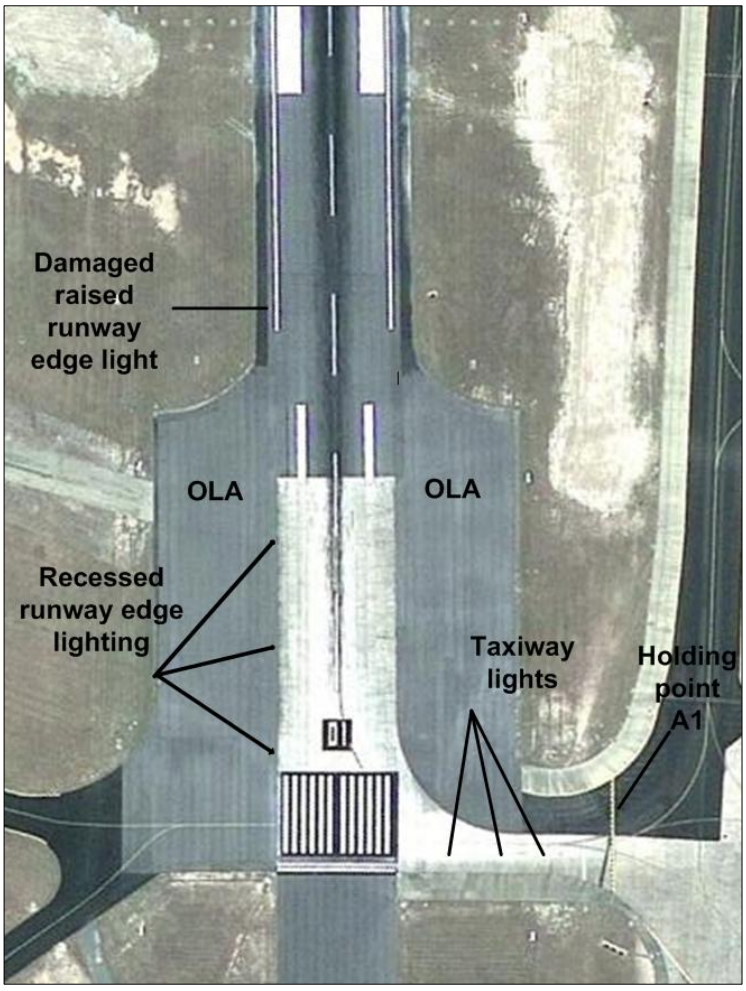
- the runway did not have centreline lighting, but had recessed edge lights
- the runway had extra tarmac width at the point where the aircraft entered the runway for an intersection departure (Figure 1)
- the crew were completing the line up checklist and controls check on the runway as the aircraft's gust locks were in place while holding on the taxiway due to strong winds, resulting in both crew having their eyes mostly inside the cockpit
- the first officer had poor vision of the runway from his seat position.

ATSB Investigation No: AO-2009-007

On 11 February 2009, the crew of a Bombardier Dash-8-315 (Dash-8) aircraft, registered VH-SBW, was preparing for takeoff at Townsville, Queensland (Qld) for a scheduled passenger service to Cairns, Qld. In dark and raining conditions, the aircraft entered runway 01 from the right from holding point A1 and was lined up with the left edge runway lights for takeoff (Figure 2).

During the take-off roll, the captain realised the aircraft was incorrectly lined up and manoeuvred back to the centre of the runway before rejecting the takeoff. The captain taxied the aircraft back to the runway threshold for a second takeoff and the flight proceeded to Cairns without further incident.

Figure 2: Aerial view of Townsville Airport and Runway 01



The investigation is continuing and is considering various factors, including:

- the reduced visibility due to rain
- the additional area of tarmac in the area where the aircraft entered the runway (Figure 2)
- flight crew workload and distractions relating to time pressure and delays throughout the day, and attention given to monitoring the prevailing weather.

In addition, the runway edge lights were recessed at the point where the aircraft lined up on the runway, which may have provided the crew with the impression that they were lined up on the centreline lights.

ATSB Investigation No: AO-2007-045

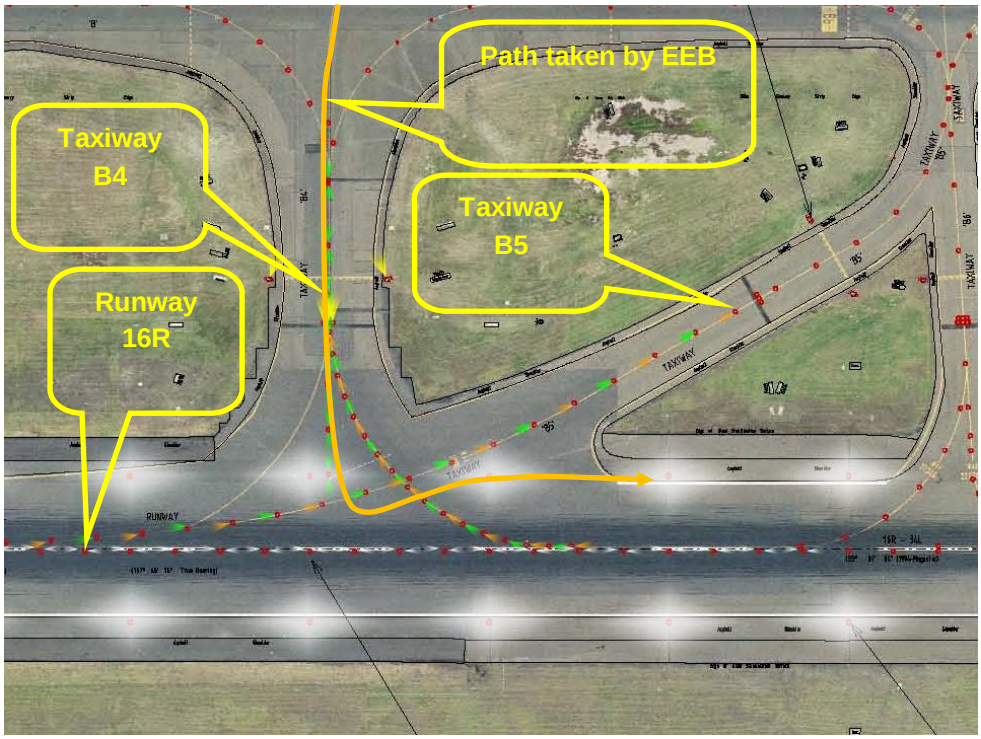
On the evening of 13 October 2007, an Embraer-Empresa Brasilia EMB-120 ER aircraft, registered VH-EEB, was being taxied at Sydney Kingsford Smith Airport, NSW, to take off on a freight charter flight to Melbourne, Victoria (Vic.). The aircraft was taxied onto runway 16R[1] at a double taxiway intersection from the left

[1] R or L after the runway number refers to 'right' or 'left' respectively.

and then lined up with the left edge lighting prior to commencing the takeoff (Figure 3).

Pre-flight checks in Melbourne for the return flight to Sydney revealed damage to the aircraft, which was subsequently found to have been caused by impact with the runway 16R left edge lighting at Sydney.

Figure 3: An overhead photograph depicting runway and taxiway lighting in the area near runway 16R, taxiway B4, taxiway B5 and the path taken by EEB.



The investigation identified various contributing safety factors to the initial misalignment on the runway included the layout of the runway, specifically

- The taxiway B4 left edge marking led onto taxiway B5, instead of runway 16R
- the runway markings leading to taxiway B5
- the absence of runway edge markings at the intersection
- the additional area of tarmac surrounding the area in which the aircraft entered the runway.

In combination with reduced visual cues associated with night operations, these factors probably created the impression that the aircraft had proceeded further into the runway than it actually had.

Air Accidents Investigation Branch (AAIB), UK, Bulletin: 10/2006

On the night of 20 January 2006, an ATR 42-300, registered G-TAWE, was being operated on a scheduled passenger service from Glasgow, UK. In preparation for takeoff, the captain initially lined up the aircraft in a position he thought was just to the left of the runway centreline. The first officer then commented that he did not

think that the 'perspective' looked quite right, so the captain taxied the aircraft to the left until it was lined up exactly over lights. The crew commenced the takeoff lined up with the left runway edge lights. However, almost immediately they were aware of increasingly loud 'bumps' from beneath the aircraft and abandoned the takeoff. Five runway edge lights were damaged.

The AAIB determined that the following issues contributed to the event:

- the crew were conducting an intersection departure from taxiway Q, which had no centreline lights as a lead-in to the runway;
- the captain reported that there had been a heavy rain shower as the aircraft lined up on the runway and that this had distorted his vision; and
- the runway had a hard surface extending a further 23 m from each edge.

The UK Aeronautical Information Publication (AIP) contained a warning about mistaking the runway edge lights for the centreline lights.

Transportation Safety Board, Canada, Aviation Investigation Report A06F0014

On the night of 30 January 2006, an Airbus A319-114, registered C-FYKR, was being operated on a scheduled passenger service from Las Vegas, Nevada, USA to Montreal, Quebec, Canada. Shortly after commencing the takeoff, the flight crew realised that the aircraft was rolling along the runway shoulder instead of the runway centreline. Three runway edge lights were damaged.

The investigation identified various factors that contributed to the occurrence, including:

- that the pilot flying was likely to have been relying on peripheral vision to taxi the aircraft because of the requirement to maintain separation with the aircraft departing ahead
- the flight crew were conducting a rolling takeoff, which reduced the amount of time they had to conduct a visual check of position
- confusing aerodrome markings, especially taxiway lead-in lines that directed aircraft onto the runway edge lights, resulting in the misalignment of the aircraft at the beginning of the take-off roll.

Aviation Safety Reporting System

A review of the US Aviation Safety Reporting System (ASRS) database for the period January 1999 and August 2009 was conducted to identify non-investigated occurrences where aircraft had commenced the take-off roll while lined up on the runway edge lighting. ASRS notifications are confidential and generally provided by flight crew.

Nineteen occurrences were identified during this timeframe, with the majority being passenger carrying operations. Aircraft types ranged from small aircraft and business jets to regular public transport category aircraft. These occurrence reports are reproduced in Appendix A.

Occurrences involving takeoff on a wrong or closed runway or taxiway

A search of ATSB investigations revealed two similar take-off occurrences between February 2003 and March 2008. These involved pilot misidentification of runway cues or lack of cues.

In addition to the Australian occurrences, several international investigations of similar occurrences are also reviewed.

ATSB investigation number: AO-2007-064

On the night of 25 November 2007, a Gulfstream Aerospace Corp G-IV aircraft, registered HB-IKR, was being operated on a passenger charter flight between Brisbane, Qld and Sydney, NSW. The captain inadvertently commenced the takeoff from a taxiway parallel to the runway in use. Air traffic control realised the aircraft was on a taxiway and cancelled the take-off clearance. The aircraft was stopped on the taxiway and manoeuvred to the runway for the subsequent takeoff. The flight proceeded to Sydney without further incident.

Figure 4: Overhead view of intersection[2] with aircraft track highlighted

The investigation identified various factors which contributed to the attempted takeoff on the taxiway, including:

- the captain did not use the available means to assist in guiding the aircraft during taxi after his electronic flight bag display became unserviceable;
- communication between the flight crew was adversely affected by a steep trans-cockpit authority gradient
- the limited rest and jetlag of the captain
- the takeoff being conducted via an intersection departure from taxiway A7, which did not have normal runway threshold markings
- increased workload for the captain and possible self-imposed time pressure.

[2] Courtesy of Google Earth.

ATSB investigation number: AO-2008-020

On the night of 12 March 2008, an Airbus A320-200 aircraft, registered VH-VQY, was being operated on a scheduled passenger service from Launceston, Tasmania (Tas.) to Sydney, NSW. While the crew were preparing for the flight, the control tower closed. Runway lighting activation subsequently reverted to the pilot activated lighting (PAL) system. The aircraft consequently departed without the runway lighting being activated. Several similar occurrences have previously occurred in Australia and overseas.

Contributing safety factors included:

- the flight crew not activating the runway lighting
- not detecting that the runway lights were not on during the taxi
- a reduction in flight crew attention induced by time pressure and various distractions prior to takeoff.

Aviation Safety Council, Chinese Taipei, ASC-AAR-02-04-001

On 31 October 2000, a Boeing Company 747-400 aircraft, registered 9V-SPK, was being operated on a scheduled passenger service from Taipei, Chinese Taipei, to Los Angeles, California, USA. The aircraft commenced takeoff on a partially closed runway during heavy rain and strong winds and collided with construction equipment and runway construction pits. The investigation determined that the crew were aware that a portion of runway 05R was closed due to works in progress and was only available for taxi. There were 83 fatalities and 39 serious injuries.

The investigation found the following factors contributed to the accident:

- the flight crew did not review the taxi route in a manner sufficient to ensure they all understood that the route to the runway included the need for the aircraft to pass runway 05R before arriving at the threshold of runway 05L (the intended runway)
- the captain's expectation that he was approaching the departure runway, coupled with the saliency of the lights leading onto runway 05R;
- the crew were probably affected by moderate time pressure to take off before an incoming typhoon closed in on the airport
- it was possible that the green taxiway lights immediately after the runway 05R entry point for taxi to runway 05L were unserviceable and that the following lights were dim. The lights leading onto the runway 05R centreline were reportedly brighter and more visible than the taxiway lights to runway 05L.

National Transportation Safety Board, U.S., NTSB/AAR-07-05

On 27 August 2006, a Bombardier CL-600-2B19 aircraft, registered N431CA, was being operated on a scheduled passenger service from Lexington, Kentucky, USA to Atlanta, Georgia, USA. The investigation determined that the crew were instructed to takeoff from runway 22, but instead lined up on a closed runway (runway 26). The crew noted the lack of lights as being 'weird'. The aircraft took off on that runway but it was too short for the aircraft type and it subsequently ran

off the end of the runway and impacted the airport perimeter fence, trees and associated terrain. There were 49 fatalities.

The investigation found various factors that contributed to the accident, including:

- crew failure to use available cues and aids to identify the aircraft's location on the airport surface during taxi, and their failure to cross-check and verify the aircraft was on the correct runway
- non-pertinent crew conversation during taxi
- lack of positional awareness of the crew
- the Federal Aviation Administration's (FAA's) failure to require all runway crossings to be authorised only by specific air traffic control clearances.

Two post-accident events mirrored this event in that two aircraft ended up on runway 26 when taxiing for runway 22 due to the confusing airport layout and hold lines.

National Transportation Safety Board, U.S., NTSB/AAR-07-05

On 18 April 2007, an Airbus A320 aircraft was on a scheduled passenger service between Miami, Florida, USA and Dulles, Virginia, USA. The aircraft was taxied onto a closed runway (runway 27 instead of runway 30) and commenced its take-off roll.

As the take-off roll commenced, the aircraft's nose-wheel light illuminated a truck flashing its lights on the right side of the runway. The crew rejected the takeoff just as air traffic control queried their position. The crew reported that runway 27 edge lights were on, but an airport engineer said they were not.

Contributed to the development of the occurrence were:

- the confusing layout of the taxiways, including a slight bend in taxiway Q leading to runway 27
- the close proximity of the runways
- air traffic control issuing the crew with a take-off clearance when the aircraft was still on taxiway Q.

National Transportation Safety Board, U.S., NTSB ID: OPS07IA010

On 12 September 2007, a Learjet 35 aircraft, registered N66NJ, entered a closed and unlit runway (runway 19R) and commenced the take-off roll.

The runway was closed for survey work and unlit construction cones had been placed at the departure end of the runway. Air traffic control cleared the aircraft to take off on runway 19R after initially telling them to hold clear of runway 19R. The takeoff and departure were uneventful.

A full moon provided environmental light and the first officer reported the runway lights lumination as low or dimly glowing. The captain did not see the construction cones at the end of the runway.

National Transportation Safety Board, U.S., NTSB ID: ANC02IA011

On 25 January 2002, an Airbus A340-300 aircraft, registered B-18805, was being operated on a scheduled passenger service between Anchorage, Alaska, USA and Taipei, Chinese Taipei when it commenced and completed a takeoff from taxiway K which was parallel to the runway in use. Taxiway K was 75 feet wide and about 480 ft north of the runway. It had blue taxiway edge lights and green centreline lights.

The captain reported that he did not think it was unusual that he did not see any runway threshold markings or a runway number since he believed the threshold for runway 32 was further ahead. He reported the centreline lights as being very bright and he believed this indicated an active runway.

Inspection of the taxi route by investigators indicated that some of the reflective material on each taxiway centreline marking was indistinct, missing, or obscured by patches of ice. Airport signage was present and visible.

Accident Investigation Board Norway, SL Report: 20/2006

On 23 October 2005, a Boeing Company 737-800, registered TC-APH, was being operated on a scheduled passenger service between Oslo, Norway and Antalya, Turkey when the crew commenced the takeoff from a taxiway parallel to the runway in use. During the takeoff roll, air traffic control instructed the crew to reject the takeoff, which they did

The captain stated that she misinterpreted dashed lines across a taxiway and thought she was aligning on the runway centreline. This seemed logical to the captain because the markings seemed to indicate the closed part of the runway, which appeared to be consistent with the NOTAM[3] about the shortened runway distance.

No other aircraft occupied the taxiways or runway, so the crew had no preceding aircraft to follow. The issuing of an air traffic control clearance while the crew were still taxiing was deemed to have impacted the captain's decision to take off.

Other recent occurrences

In addition to the occurrences reviewed above, the ATSB became aware of two separate events that occurred in February 2010. The first event involved a B737-300, registered PH-BDP, being operated on a scheduled passenger service between Schiphol Airport, Amsterdam, Netherlands and Warsaw, Poland on 10 February 2010 which commenced takeoff from a taxiway parallel to the active runway. The second event involved an A320-200, registered VP-BWM, being operated on a scheduled passenger service between Oslo, Norway and Moscow, Russia on 25 February 2010 which also commenced take-off from a taxiway parallel to the active runway.

Investigations into both events are continuing and at the time of publication no further information about the occurrences was available.

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[3] Notice to airmen.

RESULTS: COMMON CONTRIBUTING FACTORS

Australian Transport Safety Bureau and international aviation safety investigation reports and ASRS data identified some common and recurring factors associated with misaligned takeoffs. All of these occurrences involved a takeoff in night visual conditions. Other factors associated with mistakenly taking off on the runway edge lighting are presented in the left column of Table 1, while the common factors for takeoffs on the wrong or closed runway runways or taxiways are shown in the right column. These factors are also presented as a percentage of all occurrences analysed in Figure 5.

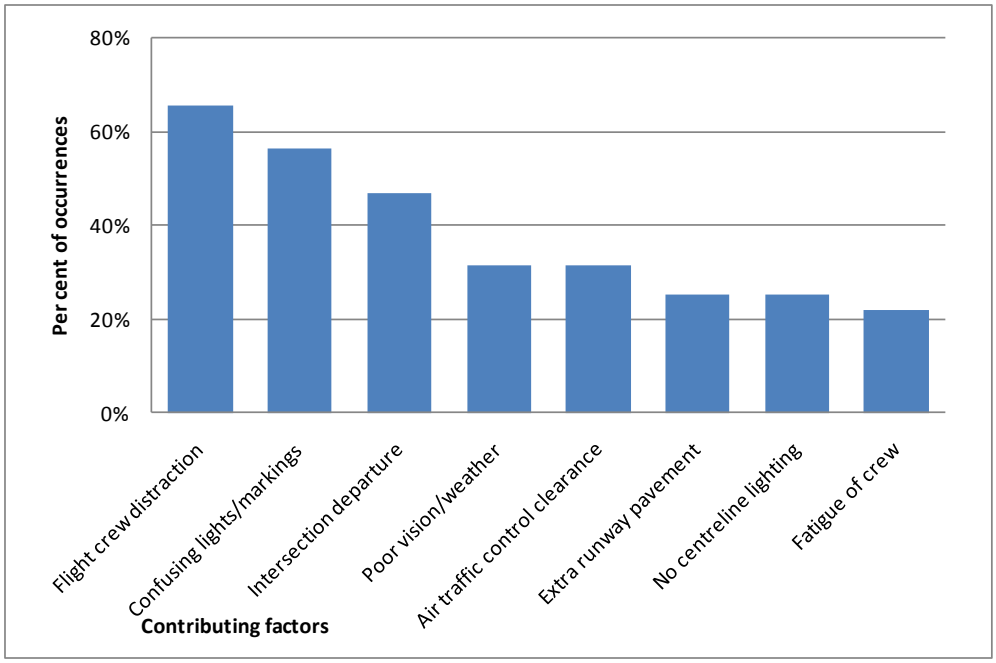
Table 1: All occurrences summarised for contributing factors

	Number of occurrences with this factor	
Factors involved	**Runway edge lighting take-off occurrences (n=24)***	**Closed/wrong runway/ taxiway occurrences (n=8)****
Flight crew divided attention/ distraction/ eyes inside (including due to workload and lack of familiarity with runway or airport)	14	7
Confusing runway/ taxi entry/lighting (lights, markings, signs)	14	4
Displaced threshold (lights and markings start further down runway) or intersection departure	13	2
Poor visibility/vision or bad weather (rain)	8	2
Wide runway/extra pavement near taxiway	8	0
Runway does not have centreline lighting or it is unserviceable or turned off	8	0
Air traffic control clearance when taxiing or entering runway	6	4
Fatigue of crew (self-reported)	6	1
Recessed runway edge lights at taxiways	5	0

* Includes all of the take-off on runway edge occurrences, including ASRS data.

** Includes take-off on the wrong or closed runway or taxiway or on a runway without lights.

Figure 5: Factors contributing to misaligned take-off occurrences



The primary factors that contributed to misaligned takeoffs were environmental factors, such as the physical layout of the runway and/or airport, weather, and/or visibility. For example, physical environmental factors such as a wide runway and/or extra pavement near the runway, or confusing taxiway markings and/or lighting were often prevalent in misaligned take-off occurrences.

The next most common factors were human factors such as flight crew distraction (from within the cockpit), divided attention, workload, fatigue and a lack of familiarity with the runway at night.

Operational factors, such as air traffic control clearances and intersection departures, were also relatively common, particularly in occurrences overseas, and in some cases they contributed to, precipitated, and/or exacerbated the presence or impact of other factors such as workload, distraction, or a lack of visual cues to assist the crew in lining up the aircraft along the correct runway's centreline. Air traffic control clearances given while taxiing were present in half of the occurrences involving take-offs on the wrong or closed runway or taxiway.

DISCUSSION

The most common factors contributing to misaligned take-off occurrences identified in Table 1 are discussed below.

Human factors

The most common human factors identified were flight crew distraction and/or inattention to external surroundings (sometimes as a function of the workload entering the runway), (self-reported) fatigue and a lack of familiarity with the runway at night.

Flight crew distraction upon entering the runway or just before entering the runway was a frequently cited factor in the events examined. Distraction refers to drawing away or diverting attention, or an action that divides attention (ATSB, 2005). This definition of distraction needs to be considered within the context of attention. Broadly, the issue of distraction comes about when multiple stimuli or tasks make simultaneous demands for attention. Generally, distraction results from one of these competing stimuli or tasks interfering with or diverting attention from the original task or focus of an individual.

Distraction was reported to occur in the events analysed for a number of reasons including:

- flight crew dealing with an unusual event or problem
- flight crew performing checklist items or setting power/checking instruments/readings.

Some of these items, such as completing checklists, are a normal and necessary part of the departure phase of flight. However, they may act as a distraction to flight crew if conducted out of sequence, such as during the line-up[4] phase.

Part of the problem with distraction is the resulting divided attention of the flight crew, with a focus on tasks inside the cockpit being at the expense of accurately assessing the external environment. This often occurs during taxi, when flight crew need to be 'eyes inside' the cockpit for significant periods of time. That is, instead of maintaining a visual look out from when they enter the runway, their attention is drawn inside for some reason such as checking instruments, confirming aircraft configuration or performing checklist items. While multi-crew operations partially mitigate this risk by articulating and dividing aircraft handling and monitoring roles between the pilots, there are still times when both crew members may not be processing the external environmental cues accurately. This divided attention is often a necessary part of lining up or beginning the take-off roll, but occasionally the attention of the flight crew will be diverted for longer than normal in response to an unusual event or problem. It is often attention to this non-standard action or item that contributes to line-up error events.

The workload of flight crew during the entry to the runway is another factor that may act to distract the crew as they are lining the aircraft up for takeoff. In the case of the SAAB occurrence at Sydney, NSW, the additional workload of completing a checklist and commencing an immediate departure, instead of the expected line-up

[4] Line up refers to position aircraft on downwind end of runway pointing along centreline.

and wait, could have further eroded the amount of time the captain had to verify the visual cues presented to him. In addition, a lack of familiarity with the airport or the runway in use, especially at night, presented an additional demand on the pilots during the taxi and line-up phase of flight. A lack of familiarity requires a heavy reliance upon charts, which will bring crews' attention inside the cockpit. The surface navigation task in unfamiliar locations and/or at night will increase crew workload by requiring more of their attentional resources to be deployed specifically to that task at the expense of other tasks and/or accuracy. When crews are required to complete other functions, such as checklists and lining up on the runway, their attention will be diverted from the surface navigation task to these critical pre-take off tasks.

Fatigue is a complex subject and has physical, mental and task-related elements. Fatigue may be acute or chronic and may be due to sleep deprivation, circadian disruption or excessive activity. In relation to lack of sleep, fatigue is 'often underappreciated' and 'compared to people who are well-rested, people who are sleep-deprived think and move more slowly, make more mistakes and have memory difficulties' (Caldwell et al, 2009). It is therefore probable that fatigue will increase the likelihood of flight crew making a misalignment error on the runway.

Environmental factors

Environmental factors include both the weather at the time of the occurrence and the physical environment or infrastructure of the airport, such as runway/taxiway lighting and markings, including those associated with airport works such as closed runways/ taxiways or displaced thresholds.

Bad weather, specifically rain, featured in several events. In at least one occurrence the rain was heavy enough to obscure the line markings on the runway and decrease visibility enough to reduce the available visual cues during line up. This was an issue during the misaligned take-off in Glasgow in 2006.

Confusing runway entry, lighting or taxiway layout/lighting was the most frequent environmental factor identified in the occurrences analysed. Also common was the layout of taxiways, runways and airport aprons; the area around the entry to the runway and beyond the edge of the runway (e.g. extra pavement in that area); and the width of the runway and the lighting layout, colour and intensity.

Areas of additional pavement around the taxiway entry and runway threshold area can provide erroneous visual cues for pilots at night. Pilots operating from a runway with a greater width (or additional paved areas at taxiway entry) than most standard runways can believe that they are in the centre of the runway when they are actually lined up on the edge. This particular problem was highlighted in the misaligned takeoffs involving a Dash 8 at Townsville, Qld in 2009 and an EMB-120 at Sydney, NSW in 2007.

Recessed lighting, particularly at the taxiway entry to the runway, was often quoted as an influencing factor in US Aviation Safety Reporting System (ASRS) reports relating to lining up incorrectly. Centreline lighting, when it was present, was always recessed in order to allow aircraft to safely travel over the centreline during takeoff. Some runways (such as runway 25 at Sydney, NSW) have recessed runway edge lighting running the whole length of the strip. If the lights are not recessed,

they are normally raised and frangible[5]. Often runways will have recessed lights at the runway edge where the taxiway meets the runway (such as runway 01 at Townsville, Qld). Recessed runway edge lighting can therefore act as confirmation that the flight crew have lined up on the centreline, when this is not actually the case.

The importance of the colour, positioning and intensity of taxiway and runway lighting was highlighted in the events reviewed. During night operations, flight crew rely heavily on taxiway lead-in lights and available runway lights to position the aircraft correctly for takeoff. If the taxiway lights lead to the runway edge lighting instead of the centre of the runway (such as the occurrence involving a A319 at Las Vegas, Nevada in 2006), or the lights lead onto a closed runway (such as the B747 accident at Chinese Taipei in 2000), then flight crew are more likely to misalign the aircraft for takeoff. In some cases, the difference in colour between taxiway lights and normal runway lights was either not noted by flight crew, or they believed the lights were the correct colour when they were not, as was the case in the A340 occurrence at Anchorage, Alaska in 2002.

In Australia, the Manual of Standards (MOS) for Civil Aviation Safety Regulation 139 outlines the standards in place to reduce the possibility that flight crew line up on a closed runway for take-off. The standards include ensuring all aerodrome lighting on a closed runway or taxiway is extinguished and electronically isolated to prevent in advertent activation of the lights. In addition, when a closed runway, taxiway or portion thereof, is intercepted by a useable runway or taxiway, red unserviceability lights are to be placed across the entrance to the closed area at night at intervals not exceeding 3m.

Airport markings include signage and painted lines on the taxiway/runway. Any degradation or obstruction of the painted lines can lead to confusion for pilots, as was the case in the A340 occurrence at Anchorage, Alaska in 2002 and the A320 at Miami, Florida in 2007.

Aircraft using a displaced threshold[6] will not be able to see the normal threshold markings, such as the runway number or ‘piano keys', which provide important cues during the line up phase of flight. If the runway does not have centreline lighting, it may be less evident to the pilots that the aircraft is lined up on the edge lighting given the limited cues available from the displaced threshold.

Operational factors

Two operational factors that featured in the occurrences reviewed were the timing of air traffic control clearances and intersection departures.

The timing of delivery of air traffic control clearances contributed to the events in different ways, depending on the type of occurrence. For takeoff on runway edge lighting events, the provision of an air traffic control clearance typically influenced the occurrence by providing a distraction or adding to the workload of the flight crew. In similar events involving taking off from a taxiway or closed runway, the provision of a clearance typically misled the crew into thinking they were positioned on or near the runway, when they were either still on a taxiway or on a

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[5] Frangible refers to lights that are designed to, or likely to, shatter on impact.

[6] A displaced threshold refers to one not at the downwind end of a full-strength runway pavement.

closed runway, such as the event involving a B737 at Oslo, Norway in 2003, the Learjet at Dulles, Washington in 2007 and the Gulfstream in Brisbane, Qld in 2007.

In Australia, a take-off clearance will not be given until the flight crew have reported that they are ready to receive a clearance. As a result, most occurrences involving the timing of air traffic control clearances were from outside of Australia. However, one occurrence did occur within Australia which also involved internal time pressure, which may have influenced the time the clearance was received.

The issue relating to intersection departures is similar to displaced thresholds, in that the aircraft is entering the runway at a point along the runway rather than a point associated with a normal runway threshold. Because of this, there are no specific runway identification markings or threshold markings to give the pilot visual cues as to their position on the runway. This was the case for the SAAB occurrence at Sydney, NSW in 2009, the EMB-120 occurrence at Sydney, NSW in 2007 and the ATR-42 occurrence at Glasgow, Scotland in 2006.

While most runway entry points used for an intersection departure have lead in lights and lines, not all have both. In some cases, pilots will 'square off' the entry to the runway. The practice of 'squaring off' refers to a practice where the crew taxi the aircraft straight onto the runway and turn through 90 degrees to line up for takeoff, instead of following the curved lead-in line or lights to the centreline. This technique is often used to minimise the amount of runway length utilised for the line up phase.

The occurrences reviewed identified the necessity for following any available lead-in lines and lights to maximise the opportunity for the flight crew to correctly align the aircraft on the runway for takeoff.

CONCLUSIONS

From the evidence available, the following conclusions are made with respect to misaligned take-off accidents and should not be read as apportioning blame or liability to any particular organisation or individual.

The following were identified as the most prevalent safety factors in the data reviewed. In all occurrences, one or more of these factors were present and contributed to the event. Each of these factors may increase the risk of a misaligned take-off occurrence.

- night time operations
- the runway and taxiway environment, including confusing runway entry markings or lighting, areas of additional pavement on the runway, the absence of runway centreline lighting, and recessed runway edge lighting.
- flight crew distraction (from within the cockpit) or inattention
- bad weather or poor/reduced visibility
- conducting a displaced threshold or intersection departure
- provision of air traffic control clearance when aircraft are entering the runway or still taxiing
- flight crew fatigue.

SAFETY ACTION

Australian Transport Safety Bureau

To foster safety awareness, knowledge and action, the ATSB had developed a Pilot Information Card to help flight crew identify factors that could increase the risk of a misaligned take-off. An example is presented below.

Figure 6: The Pilot information card

Side 1

Side 2

Civil Aviation Safety Authority

The Civil Aviation Safety Authority has indicated to the ATSB that it

> ... can assist the ATSB by distributing the suggested pilot information card with an issue of Flight Safety Australia (FSA), and write an article in FSA about this report.

APPENDIX A: ASRS REPORTS

Appendix A documents reports from pilots that involved take-off occurrences on the edge of a runway to the United States National Aeronautics and Space Administration's (NASA) Aviation Safety Reporting System (ASRS) database for the period January 1999 and August 2009

Small Transport, Low Wing, 2 Turboprop Eng.

When I took off in the plane from Marathon, FL (MTH), I had unfortunately ran over 4 of the R runway sidelights. It appears there was minimal and repairable damage to the plane. There were a couple small dings in the R prop that appear to be small enough to be blended/smoothed out. The dings were from the broken glass from the lights. The lights are designed to be low enough to the GND so that the prop will not hit them. The sidelights are also designed to break off to minimize any damage to aircraft that run over them. The only other minor damage was to the brake deice manifold, which was slightly bent. I will replace it. How did it happen? During the night TKOF from Marathon, I did not pick up the initial aircraft drift to the R side of the runway where the runway sidelights are located. I was scanning the power gauges to ensure the correct power was set as I was increasing the power levers to reach TKOF pwr. I stopped the drift but it was not in time to avoid the sidelights. The R tires are about 10 ft to the R from where I sit and the aircraft nose and R eng blocked my downward view so I did not realize I was going to hit the sidelights. Drift on TKOF is caused by increasing power, which increases the eng torque on the plane during power adjustment, especially while moving the power lever from idle to TKOF power during the TKOF roll. Another reason I did not recognize the R drift and put in an immediate correction back to centreline was that for a few seconds the R sidelights appeared to be a lighted centreline and was momentarily confusing. Once I had the power set and my complete focus was outside the window for the TKOF, it appeared like I was just L of a lighted centreline -- it was actually the white R runway sideline and sidelights. Unlike the L side of the Marathon runway where the sidelights are at the edge of the runway, the R sidelights are placed on the runway approx 50 ft in from the true side of the runway (where the runway pavement stops). So looking outside, in the darkness of night, for those few moments it appeared as if I had 60 ft more paved runway to my R side. This momentary confusion caused me to delay the correction back to centreline and, therefore, run over the sidelights.

DC-10

When cleared to take off by ZZZ tower, as I was entering the runway for TKOF, I looked away from the taxi line to search for helicopter traffic what had been reported by tower in conjunction with the TKOF clearance. When I looked back at the runway, I was aware of lights embedded in the pavement below me. Thinking they were the centreline lights, I lined up on them. (Turns out, this airport has no centreline lights. I know that, as I had been there before. But, no matter). As I began to apply power, the FO aggressively informed me that I was lined up on the runway edge lights. I immediately corrected to the (unlit) centreline, and continued a normal TKOF. Supplemental info from ACN 784985: after TKOF we were concerned the aircraft may have damaged some of the L edge lights.

B767-300

We were cleared into position on runway XXR at ZZZ and as I completed the turn onto the runway, I lined the aircraft up on what I thought was the runway centreline, confirmed by what I perceived to be the runway centreline lights. When we were lined up, the relief pilot said that we were not lined up correctly. While my line-up was not perfect, the FO and I both thought that the relief pilot was being very particular since, according to my perspective, that the centreline was no more than 1 - 1.5 ft R of the nose. I don't recall my exact words, but I said something to the effect that '(name) (the PF) will fix it on the TKOF roll,' meaning that he would manoeuvre to the exact centreline as soon as we started to roll. At some point very early in the TKOF roll and below 60 kts, I realized that we were on the R side of the runway and that what I thought were the centreline lights were in fact the runway edge lights. Once realized, I immediately called 'abort,' took control of the airplane, and simultaneously steered to the centreline and slowed the aircraft. We advised tower of the abort and exited the runway to assess the situation. I did not feel anything unusual or any bumps either before or during the abort. Since there was the possibility that we had hit some runway lights, we advised the tower of this and requested an inspection of the edge lights. A ground vehicle initially reported there was no damage, but an aircraft taxiing behind us said that he saw 2 lights damaged. We taxied back to the gate for a maintenance inspection which discovered 1 R main landing gear tire damaged and in need of replacement. After inspecting the aircraft and replacing the tire, maintenance signed off the logbook item and we departed. We departed on runway XYL which did not, unfortunately, afford us the chance to re-examine the runway XXR TKOF area to see what visual cues could have prompted me to line up on the R side. In rethinking this event over numerous times, 1 factor could have been the fact that with the displaced threshold the white runway edge lights did not begin until about 2500 ft down the rwy. At this distance I could have mistaken the edge for the centre. Supplemental info from ACN 783158: taxi from the gate to runway XXR was uneventful as the before TKOF checklist was completed, we were given clearance to taxi into pos and hold on runway XXR. As we were given the previous clearance, I closed my taxi diagram and placed it on top of my kit bag and checked that it would not slide during TKOF. When I looked back out of the forward windows, I noticed we were lined up on the R side of the runway, with the nose wheel a few ft L of the R side runway edge lights. I stated to the crew that we were not lined up right. The FO looked back and said it's ok. We were given TKOF clearance soon after that and started to roll. I fully anticipated the FO to start correcting towards the centreline. However, this did not occur and I stated again we were not lined up right. The captain recognized this, corrected us back towards the centreline and immediately aborted the TKOF.

Citation X

Cleared to position and hold, I followed what I thought was yellow taxi line onto runway. Thought I was lined up just L of centreline lights -- maybe a little L of centreline. When cleared for TKOF corrected just a little R, thought I was hitting runway centreline lights but it seemed rougher. FO said correct L, which I did. Roughness stopped and we rotated. Landing was smooth but got rougher on rollout. It turns out that I had lined up just L of runway edge lights at San Diego and we struck some. On landing we lost both R main tires but did no other damage as far as I know. Called company, asked them to call SAN tower and sent safety report into company. Supplemental info from ACN 713512: during TKOF roll runway 27 SAN, the PIC let the airplane veer too far to the R hitting runway edge lights. I think part of the problem was that the runway centreline lights were notamed OTS. It can be confusing at the runway entry point on the N side of runway 27 because of the large amount of pavement and lighting in that area.

Beechcraft

Flt taxied via taxiway C to runway 10L, intersection R. Weather was moderate rain requiring use of windshield wipers for taxi. Pavement and markings were partially obscured by standing water. Upon receiving TKOF clearance, line-up checklist was completed and flight followed green taxiway centreline lights through 135 deg turn on taxiway R onto runway 10L. At end of taxiway centreline lights, yellow taxi line was no longer visible due to darkness and water on pavement. Pilot aligned aircraft with what appeared to be runway centreline lights and held in position. Upon receiving TKOF clearance, final eng checks (underspeed governor, hp limiters, NTS check valve) were completed and TKOF roll commenced. At approx 30-40 kts, pilot heard a 'clunk' from L side of aircraft and aborted TKOF. Aircraft remained under control throughout with no perception of swerving and no abnormal eng sounds or vibrations. Aircraft was taxied back to ramp via taxiways K and C. Inspection showed scratch marks on aft surface of one blade of #1 (L) prop. No other damage was found. SFO airport ops found one edge light on L edge of runway 10L broken, but advised pilot that it may have been broken prior to this event. Airport ops also found metallic debris unrelated to the broken light near the centre of runway 10L at approx the same location. Inspection revealed that this debris did not come from our aircraft. It is inconclusive whether the prop strike was on a runway edge light or on debris near the centre of the rwy. After discussion with maintenance, the aircraft was flown back to its home base without incident. Contributing factors: while general area visibility was adequate, visibility immediately around the aircraft was compromised by rain. In particular, rain on the windshield and side windows impaired visibility. The pilot's side windshield wiper was relatively ineffective. Much of the pavement presented a 'black hole' appearance due to reflections and standing water obscuring taxi lines and other markings. While I was convinced that I had lined up the aircraft on the runway centreline, it is possible that I inadvertently lined up on the L edge lights, believing them to be the runway centreline lights due to reduced visibility through the rain-covered windshield. It is also possible that I lined up between the L edge and centreline, believing the centreline lights to be the R edge lights. In addition, I feel that the optical illusion caused by rain beginning to flow diagonally upward on the windshield at the beginning of the TKOF roll may have contributed to this incident, if, in fact, the prop strike was on an edge light rather than on runway debris.

Citation X

I was the PIC on a Cessna citation v (c560), far 91, CPR flight from ASW to IND. We departed ASW and arrived at IND 30 mins later. Our pax returned a few hrs later and we began taxiing. IND tower instructed us to taxi to runway 5R for departure. After we entered the parallel taxiway for runway 5R, we requested an intersection departure since runway 5R is 10000 ft long. Ground control approved an intersection departure from the C7 taxiway. As we rounded the corner onto taxiway C7, IND tower cleared us for TKOF on runway 5R. I was starting a turn to line up with the runway heading as I entered the runway surface and began adding power for TKOF. I glanced down at the N1 power gauges to set TKOF power, called for TKOF power to be set by the SIC and then looked back outside. At first, the picture I saw did not look right and seemed slightly confusing. Ahead and slightly L were white lights that I did not expect to see on my L. I then mistook those lights to be the runway centreline lights, so I began a slight steering correction to the L to centre the aircraft on the centreline lights. Just as I made this correction, I saw a runway edge line next to the white lights that I was steering for and was shocked to realize that I was trying to line up with the runway edge lights, not the centreline. I immediately began a R correction to get back to the runway centreline when I felt a slight thump from the vicinity of the L main landing gear and saw a yellow object propelled forward and L of the nose of the aircraft. Since there was no vibration or other indication of problems, I continued the TKOF and had an uneventful 25 min flight back to ASW. After landing, we inspected the L gear, wing and flap area for damage. We found a small amount of sheet metal damage to the main gear door along with fragments of blue grass, a slightly bent landing gear door connecting rod and a broken landing light. Maintenance and the dept mgr/chief pilot were notified immediately. Conclusions: both pilots were type rated captains in this aircraft and qualified for the flight. Duty time was well within company specified limits. Weather was not a factor. The cause of the incident was the Capt's (my) in attn to our location on the departure runway surface while beginning the TKOF roll. Contributing factors: night departure using a reverse high speed connecting taxiway requiring a longer taxi distance than usual to enter the runway surface. My being distracted when setting the power and not paying attention to aircraft location on the runway. This normally is not a problem except, in this case, where I began my turn to line up on the runway prematurely causing me to line up near the L side of the runway, not the centreline. When I looked up from the engine gauges, I momentarily mistook the runway edge lighting for runway centreline lighting. Prevention: when something doesn't look right, it probably isn't. Stop or delay what you're doing, if possible, until you can resolve the discrepancy. Always confirm your position on the runway by the appropriate markings, although this was harder to do at night due to limited illumination from the landing lights on this aircraft. Don't be in a hurry to apply TKOF power until lined up with the runway centreline.

Citation jet, C525/C526

We taxied out of FBO at XA28 local time for the return flight to INT. Our taxi clearance was to runway 31C via K and F taxiways. Shortly after reaching runway 31C, we were cleared for TKOF with a L turn out. I lined up in the displaced threshold area and centred myself (or so I thought) in the middle of the distant red threshold lights. There were no other lights that I saw to indicate that I was anywhere, but centred up. This was my leg (the Capt's), and I pushed up power as the FO completed the TKOF checklist. Just as we reached the red threshold lights at approx 60 kts, the FO said that I was on the R side of the runway. Immediately we felt a vibration and the FO said we'd blown a tire. I immediately rejected the TKOF, and the airplane began to pull heavily to the R. I stood on the l rudder pedal to hold the airplane on the runway and was successful in doing so. Late in the rejected TKOF, I was able to get my feet up on the brakes, but the aircraft skewed to the L, and I had to let off the brakes. As our speed reduced, we were able to exit at taxiway A and stop clear of the rwy. Visual examination after shutdown revealed a shredded R main tire, R brake lines torn loose and leaking, R anti-skid wiring ripped apart, R main gear door missing and some flap damage. At this point, we did not know that we had hit anything, because we never felt or heard an impact at any point in the TKOF run. The sole pax was transported back to FBO and then ground personnel put the R main gear on a dolly and the aircraft was towed back to FBO. The next day, city ops took us out to runway 31C, where we saw what caused the R main tire to blow. We had inadvertently lined up on the R runway edge line and had taken out 5 runway edge lights with the R main gear.

Citation V

We were cleared to taxi to runway31C at Midway airport. The co-pilot, having the airport diagram, directed me to the runway. The windshield was slightly fogged up from the moist conditions. Upon reaching the runway, we were cleared for TKOF on runway31C. The aircraft was taxied onto the runway as the co-pilot pointed out the centreline lighting. The aircraft was positioned slightly L of the assumed centreline lighting position and held there while the cabin was checked to see if pax were buckled in and ready to go. The windshield was still slightly fogged up due to the moist atmospheric conditions at the time. Brakes were held as power was increased to TKOF power, allowing for improvement in defogging windshield. Brakes were released as per procedure. Co-pilot was called to make any adjustments to power. As aircraft headed down runway and accelerated for TKOF, co-pilot called for airspeed crosscheck at 60 kts. Shortly thereafter, we heard a single thump, sounding similar to a tire rolling over a recessed centreline light. Aircraft instruments, annunciator panel were fine, as was the directional control of the aircraft. Thinking an aircraft tire rolled over a centreline light was the cause of the noise, we continued the TKOF and I positioned aircraft between the lights L and R of us to prevent running over the recessed lights again. The rest of the flight proceeded normally to destination. Post flight inspection found a hole on the underside of the inboard R flap, another small hole in R outboard flap. Midway airport was called immediately to inspect the runway we departed on. After inspection of the runway, Midway tower called back and indicated a runway light and the top of a sign were knocked down. Upon studying the airport diagram, we found that there wasn't centreline lighting on runway31C. We concluded that aircraft must have been lined up on R side of runway, which had a paved entrance the entire width of the displaced threshold. The problem was caused by lack of aircraft situational awareness by the crew. Given the complex and confusing environment we were in, a better familiarization of the airport layout should have been understood. Furthermore, I should have crosschecked co-pilot's directions and paid extra attention due to the slight fatigue of the crew.

PA-34-200T Turbo Seneca II

On my TKOF roll from PDX, I had a prop strike. That night I was flying for a FAR part 135 cargo operator. The prop strike occurred on TKOF roll for my return flight to BFI, WA. Once cleared to take off from runway 28R, the tower instructed me to turn R direct btg VOR, climb and maintain 6000 ft. I set my instruments for these instructors, while taxiing towards the runway centreline. After setting up on what I believed to be the centreline, I applied full brakes and advanced the throttles to 30 inches manifold pressure, at which time I checked my eng instruments. All instruments indicated in the green arc. I then advanced the throttles towards 39 inches manifold pressure which was TKOF power setting while releasing the brakes. Immediately after releasing the brakes, the L eng sputtered/partial power loss. For some reason unknown to me, I looked down at my l eng oil pressure, which was in the green arc. I then turned my attention back outside and saw a white line which I thought was the runway centreline. My eyes once again turned to the eng instruments at which time I heard 2 or 3 thumps outside the aircraft. After figuring out where I really was, in the lights, I positioned the aircraft back on the runway centreline and announced to the tower that I was aborting my TKOF. I estimated the aircraft speed to have been 20-40 kias at the time of impact with the runway edge lights. I'm not sure why I looked down at the instruments instead of maintaining positive control of the aircraft or when I retarded the throttles. Reviewing the situation after the fact, it makes sense to me that I confused the runway edge line for the centreline. I'm not exactly sure when the throttles were retarded, but I think I did it as I looked down at the oil pressure gauge. I think there were many factors that led to the situation that occurred that night. I was extremely fatigued from lack of sleep and studying for an interview that I was supposed to fly out to that day. Additionally, I might have been complacent because the weather was so nice. The weather on the earlier flight from Seattle was poor with winds of approx 180-220 degrees at 20 kts gusting to 25-30 kts and 4000 ft broken to overcast. While at PDX, the weather was calm winds, unrestricted visibility with clear skies.

Learjet 45

We taxied to runway 31C at MDW and held short of the runway on the W side. A B737 landed, and we were instructed to, 'taxi into position and hold.' There was another aircraft holding short of runway 31C opposite of us. The Capt had the taxi lights off as a courtesy to the opposite airplane facing us. He left the lights off until we had turned on to the runway apron/displaced threshold. The Capt lined up with what he thought was the runway centreline lights. We were given clearance to take off runway 31C. The Capt advanced the power levers and the aircraft began to accelerate. As we began to move forward, closer to what we thought were centreline lights, I noticed that the lights were actually the runway edge lights, sticking out of the ground. I yelled, 'left' to urge the Capt to manoeuvre the airplane away from the R side of the rwy. The plane swerved to the L and the lights were passed and we remained on the runway. At the same time, the Capt reduced power to idle and came to a stop. I called tower over the radio and reported an aborted TKOF. We then taxied clear of the active runway. After we were clear of the runway, tower asked what our intentions were. Both of us were sure that we did not hit anything, but I suggested that we taxi back to the FBO and visually inspect the aircraft to be certain. We taxied back to the FBO where I got out of the airplane to look at the R side of the airplane. I carefully inspected the R wing, R tires, R wheel well, and the R wheel assembly. There was no evidence of any damage. I got back into the airplane and told the Capt. We decided we would taxi back out for TKOF. I think there were a few factors that led to misalignment with the rwy. I think that due to the size and lighting the runway 31C's apron/displaced threshold area, it is easy to mistake the R side edge light with the centreline lighting that you see at many airports. Combined with the fact that the Capt had the taxi lights off, we probably thought that the space to our R was the R side of the runway. We had also been on duty at this time for over 9 hrs. I think fatigue with all of the other factors led to misalignment with the runway. Even when we lined up for TKOF the second time and paid special attention to our position on the runway, it was still evident how someone could have misinterpreted the runway alignment. Supplemental info from ACN 537818: the TKOF was aborted from a speed of less than approx 20 kts. We held off with turning on our lights as not to blind another aircraft holding short on the other side. Doing this, we may have missed a taxi line that goes from the hold short point to runway centre. Both pilots had dismissed an 'odd feeling' of this being a wide runway or 'a something different feeling.' About the time we turned to line up, the PNF remarked 'there's centreline' (actually runway edge markings) and the tower cleared us for TKOF. Poor lighting or marking/lighting for the rwy. The r edge lights may appear further up the runway making you think that's centreline.

MD-80 Super 80

Upon aircraft post inspection, noticed small lacerations on front of #3 tire. On TKOF, noticed rudder pedal vibration approx 1/3 into TKOF roll. TKOF was from runway 25R LAS. Overrun was used for TKOF. In peripheral vision at brake release, noticed a couple of open items on mechanical checklist. Did quick visual verification to ensure items were complete. Remembered performing and completing the checklist. 80 kt speed check missed. I made 100 kt call, looked up, and aligned with rwy. Remember distinctly thinking overrun area was darker than normal. About 1/3 into TKOF roll, noticed slight vibration of rudder pedals not that much different than some other runways used in the sys. No comments made by flight attendants or pax or tower about anything unusual. It is possible that aircraft drifted R and hit runway edge lights before liftoff. Verified all aircraft sys were normal shortly after TKOF and proceeded to destination. Possible contributing factors: pilot fatigue, poor visibility in TKOF overrun, last second initial TKOF pilot distraction for a couple of seconds. Cognizant of seriousness of distractors. Discussed at length with FO to prevent such a chain of actions in the future. Supplemental info from ACN 473356: during post flight in COS, noted damage to #3 tire, R main. Capt wrote up tire condition in logbook. Began to wonder how tire may have been damaged. Concluded circumstances during TKOF roll in LAS may have been suspect. In LAS, tower cleared us for TKOF on runway 25R and we had just completed R eng start, so last 5 or 6 items remained on mechanical checklist when we received TKOF clearance. Fairly rushed completion of checklist. Capt made entry onto runway and he set 1.4 EPR and then asked for auto-throttles. I complied and then observed engine instruments wind up. It was fairly warm in LAS, so I carefully monitored EGT's as the l eng slowly crept higher. I missed the 80 kt callout as a result and Capt called 100 kts. I recall fairly dark overrun area, but nothing exceptional during TKOF. Remainder of flight uneventful. Suspect tire damage may have taken place during TKOF in LAS from overrun surface or other FOD. I realize that 100% of both pilots' attention should have been outside cockpit during line-up and we should have requested a short delay to complete checklists. Fatigue coupled with delays throughout the day and a very quick turn in LAS also may have been a factor.

Learjet 31

After dark on Jan/XA/00, we taxied our Lear 31 from Las Vegas executive terminal at LAS airport to runway 1L. We held short at taxiway B1. It was quite busy and we had waited at least 10 mins before the tower cleared us. There are green taxiway centreline lights at that intersection that continue across the runway and on toward the main terminal. I looked L and R making sure it was clear and as we finished up the final items on the line-up checklist, I looked ahead again and turned L to line up on the runway centreline lighting. On the TKOF roll, I aligned the aircraft so that the nose wheel was offset slightly to the L of the lighting to keep the nose wheel from rolling across the flush mounted lights. After approx 1/2 dozen lights went by, I saw that the next light was not flush, but mounted on a stanchion about 1 ft high. (The runway edge lighting is flush mounted exactly like centreline lighting on the R-hand side of runway 1L in this area. This is apparently to allow aircraft access to the runway from a large ramp area, not just a taxiway, and I had mistaken the edge lights for centreline lights.) I swerved l because I couldn't judge quickly enough whether we could straddle the light. It wasn't enough and we ran over the light with the R main gear at about 30-40 kts. I discontinued the TKOF and notified the tower that we needed to return to executive. I told them we had hit a light and asked that someone check it out by vehicle. We returned to the ramp and I informed the pax we had run over something and needed to inspect the tires. After shutdown and with a flashlight, I carefully inspected both tires and found only a superficial cut and scrapes on the outboard main. I inspected the gear doors, hinge, and actuator, main strut, brake lines, antiskid wiring, wheel well and wing flap and discovered no damage. We continued the flight uneventfully. Upon termination of the flight, I wrote up the tire cut for maintenance to check an inoperative landing light. The next day, maintenance personnel decided to change the tire even though it was still serviceable. They also discovered FOD to the R engine -- a possibility I had not even considered. Apparently, as the light stanchion broke over, a piece was thrown forward and bounced off the runway high enough to be ingested. Prevention: 1) as the pilot, check lighting available on the runways to be used. I could have found out from the charts there is no centreline lighting on this rwy. 2) this intersection is used for departures often because of runway 25/7. Full length departures would interfere, so the TKOF roll begins right about where landing jets obliterate runway markings with tire rubber. The painted markings are dimly visible still, however, and can be seen if you pay close attention. 3) install centreline lighting on this runway for the first 500-1000 ft to prevent the edge lighting from being confused with centreline lighting.

Regional Jet 700 ER&LR

It was my first time to take off at night from SAN. We taxied out to runway 27 and were cleared to taxi into pos and hold. It was not obvious where the runway started and the taxiway ended, so I was being very cautious. I taxied slowly and turned the landing lights on to better see where we were going. Being unfamiliar, I asked the FO if this was the centreline that we had lined up on, and he said it was. I didn't know it at the time, but I lined up on the runway edge lights. We sat there for 1 min or so, and were then cleared for TKOF. Immediately after starting our TKOF roll, we could see we were not on the runway centreline. There was plenty of room to manoeuvre on the displaced threshold, so the FO, who was flying, steered the aircraft back to the centreline while continuing the TKOF. The markings and lighting on this area of the airport are (to me) not very straight forward like they should be. I believe this is what caused the prob. Increased awareness and better vigilance would help prevent this prob. I would like to see my company address this issue at a recurrent training session since I believe it has probably happened before and will probably happen again.

Baron 58/58TC

On TKOF roll at LCK on runway 23R intersection departure from intersection D at XA57, pilot misjudged L borderline of runway to be centreline, struck 3 runway edge lights with l prop and aborted TKOF. Causes include pilot fatigue, loss of situational awareness due to keeping attn inside of cockpit for the runway, checklist too long and confusion to precise location on runway from sitting too low in seat to see properly, and poor aircraft lighting. Corrective actions taken by the company include remedial fatigue training and situational awareness training.

MD-80 Series (DC-9-80)

Taxi out of international terminal at LAS. One follows the green taxi centreline lights, for about 20 mins, till at the departure end of runway 25r. When turning onto runway 25r, I lined up on the runway edge lights, thinking I was on the centreline lights of runway 25r. Started TKOF roll. After 30 ft of movement, I realized I was not aligned on the runway and turned to centre of runway and continued the TKOF. This is the first time I have seen an optical illusion or heard of one like this. The centreline lights at runway 25r were off. The long taxi on taxi centreline lights, then turning onto runway causes an optical illusion that makes you line up on the runway edge lights, thinking you are on the runway centreline lights. The runway centreline lights should be on at night at all times. No conflict or event occurred. Call back conversation with reporter revealed the following info: the reporter said that the extended time taxiing with only ref to taxi lights in the centre of the taxiway led them to assume they would be led onto the runway by centreline lights. The illusion was that the green taxiway centreline lights led to the expected white runway centreline lights. There are no blue taxiway edge lights at LAS. He, as the taxiing pilot, lined up on the white lights that were in fact the edge lights. The FO, as the PF, noticed the shadows created when the landing lights were turned on for TKOF, aborted the TKOF and realigned the aircraft with the painted centreline.

B737-300

My flight was departing LAS en-route to SFO. Due to aircraft performance limitations with the local conditions, we were required to perform a flaps 1 deg improved TKOF on the full length runway 7l. From the hold short pos we were cleared for TKOF. The lighting is confusing in this area, due to the intersection of runways 7L, 1L and taxiways H and F. As we taxied onto the runway, both the Capt and I were watching closely to ensure we had the runway environment in sight for the proper rwy. The Capt and I both believed we were on runway centreline when we began the TKOF roll. Shortly thereafter, the Capt and I both suddenly realized we were lined up on the r side runway edge lights for runway 7L. The Capt immediately steered for centreline and we continued the TKOF. When the landing gear was retracted after TKOF, the R main landing gear disagreement light was on indicating the landing gear was not up and locked. Placing the landing gear handle to off, caused the R main landing gear down and locked light to illuminate. Discussing the problem with the crew, dispatch and maintenance we decided to land in San Francisco. We needed to reduce weight and preferred a lower ground speed for landing. We then conferred with first flight attendant #1 and agreed to prepare the cabin for evacuation for the possibility of a gear collapse or fire from a damaged tire. We had normal landing gear indications on approach into SFO. The landing touchdown and rollout felt normal. We kept the pax in their seats, cleared the runway and stopped for a visual check before taxiing to the gate. The crash truck driver indicated the landing gear appeared normal. At the gate we discovered the landing gear door was damaged and appeared to cause subsequent damage to the tire. We later found out a runway edge light had been damaged in Las Vegas on runway 7L. Call back conversation with FO revealed the following info: the FO stated that, due to their improved TKOF as a result of the high LAS temps, they were using the full length of runway 7L, which is not typical. The crew was dependent on lighting, as this was a night time departure. He described the runway as not having any lighting until the intersection with taxiway A8. Thus, as they were lining up on what they perceived as the centreline, they were receiving their cues from lighting that began approx 1000 ft further down the rwy. He reported that the FAA required that he and the Capt take extra training in the company's simulator in order to satisfy their concerns about this crew. Call back conversation with Capt revealed the following info: the Capt recalled that he and the same FO made the exact same departure the day before during daylight hrs. Even then, the area was confusing to the Capt and he described it as being 'a mass of concrete.' during the day he could barely make out a small, yellow lead in line to runway 7L. However, in the dark he could not see the lead in line. Further, he described the hold short area as being totally dark and situated in such a way that a 90 deg turn was required in order to line up with the rwy. Therefore, the runway lights were impossible to see from the hold short area. The FO noted that the hold short area appeared to sit lower than the runway, further preventing visibility of the runway lights. The Capt stated that normal ops occur at the intersection of taxiway A8 and runway 7L where the normal runway lighting is clearly visible and that ops requiring the full length only happen during unusually hot days. The Capt stated that he and the FO were not rushing, they had no disagreement, and they both thought everything appeared normal. As they started their TKOF roll, both simultaneously realized they were off to the R of the runway and the Capt corrected to the centre. Both stated that the runway is a non precision runway, therefore, it has no white centreline lights. Yet, they both remembered being in between what appeared to be a set of white runway edge lights. The Capt reported that the FAA and NTSB are very interested in this event and that the pilot group attorney contacted him immediately. As

word of this event spread, the Capt recalled that other company pilots contacted him and stated that they, too, had trouble with this area of LAS. Both stated that the company will be amending their airport page for LAS, warning of possible visual illusions at this end of runway 7L.

Small Aircraft, Low Wing, 2 Eng, Retractable Gear

I was taxiing out to, and cleared to depart from, runway 31C by tower control while still on the taxiway. A B737 had begun its TKOF roll approx 10 seconds prior to my TKOF clearance, so I elected to use max available runway so as to minimize wake turbulence exposure on climb out. I followed the yellow taxiway centreline stripe out to the beginning of the displaced threshold to initiate my TKOF roll. Here's where I believe the mistake occurred. When I followed the yellow taxiway centreline stripe out to the white runway markings, I thought I was aligning with the 'tail' of a displaced threshold arrow. Instead, the yellow stripe led me to the runway edge markings, and continued onto a taxiway on the other side of the rwy. Believing I was aligned on the runway centreline, I looked forward and saw a row of white lights that I believed to be runway centreline lights. I completed my runway checklist, applied full power, and approx 5 seconds later heard the 'popping' noises of the nose gear going through elevated runway lights. Still not realizing the mistake I had made, I applied l rudder pressure to offset the airplane from what I perceived as merely a louder than normal noise of the nose gear going over centreline lighting. When I did this, the r prop contacted the runway edge lights, severely damaging the prop. I immediately shut both engines down and aborted TKOF. Radio contact with the tower was lost due to antenna damage. After the aircraft was removed from the runway, an airport official pulled me aside and told me 2 aircraft (the first being a pax jet!) were involved in similar incidents on the same runway in the previous month. He believed a marking problem existed at the departure end of runway 31C coming off the taxiways, and he drove me in an airport vehicle along the route I had taken in my aircraft from the taxiway to runway 31C to show what he believed could be the prob. Until this point, I was completely bewildered as to how the aircraft had just mysteriously 'gone off the runway.' once we followed the taxiway centreline stripe out to the runway, however, it became evident that I was partially led to/partially mistaken the runway edge for the centre of the displaced threshold. Therefore, I appear to have been perfectly aligned with the r edge of runway 31c. An interesting note is that the following Friday night i heard airport vehicles communicating with ATC, operating with a painting crew in the displaced threshold area of runway 31C. I have not yet seen the changes.

B737-200

Capt lined up for TKOF on R edge of runway, thinking the runway edge lights were centreline lights. The Capt was flying this leg, initiated TKOF while I (FO) was completing the checklist, asked me to set TKOF thrust and we immediately heard a loud bang. I called for abort. Capt aborted and we taxied back to the gate. The loud bang was the B737 running over a taxiway sign, then numerous lights. We never got above 40 kts on speed. Only damage to plane was to the R main tires. The Capt forgot to turn on lights and rushed the TKOF. My eyes were in the cockpit accomplishing the checklist and setting power.

Pilatus

While departing at night I rolled directly onto the runway from intersection after TKOF clearance from tower. As I made my turn onto the runway I aligned the aircraft with what I believed was the runway centreline lighting sys. I applied TKOF power and utilized an inside/outside scan in order to check my gauges for eng performance/limits and to monitor my TKOF outside the aircraft. Prior to lift-off I heard/felt 2 small thumps. I was concerned but not alarmed and continued my TKOF due to the fact that I was close to rotation spd and that there were no other indications of a prob. Once airborne I asked ATC for a downwind turn in order to return to the field for landing. I was cleared for a visual approach. The approach, landing, rollout, taxi, and shutdown were all normal. Post flight inspection revealed damage to the l main landing gear door and the l flap. I called the tower from our office and advised them of the incident and requested a runway check by ops. An ops representative came to my hangar and reported 3 runway lights damaged. This confirmed my suspicion that I had not properly aligned myself with the runway centreline but rather the L side edge. I learned from tower that the runway centreline lights were not illuminated. The intersection of runways XX and YY plus the displaced threshold on runway XX leads to a confusing situation as one takes the runway for TKOF at night (and day!). I believe I followed the taxiway stripe leading to runway YY and then aligned the TKOF track with the l edge lights believing that I was on the runway XX centreline. There is significant runway material l of the edge lights. It appeared to be a normal TKOF. I recommend that the centreline lights always be utilized at night for all ops in order to avoid the situation I was involved in. Call back conversation with reporter revealed the following info: reporter stated that he has operated from the airport for over 8 yrs with the same company and is familiar with the airport. He stated that it was late night/early morning and fatigue may have been a factor in the incident. He felt that he had a false sense of positional awareness when he took the runway and the lead in line he followed was for runway YY vice runway XX which caused him to line up on the edge lights for runway XX. Without the centreline lighting being illuminated he lost positional awareness. He noted that the airport auth had indicated that one other aircraft had a similar event several yrs ago. When questioned, the reporter indicated that he felt it was his mistake and that safety of flight was not an issue.

APPENDIX B: LANDING OCCURRENCE EXAMPLE

ATSB investigation number: 200300418

On 19 February 2003, a Boeing Company 737-376 aircraft, registered VH-TJB, was being operated on a scheduled passenger service from Adelaide, South Australia (SA) to Darwin, Northern Territory (NT). During the landing on runway 29, the aircraft touched down close to the right edge of the runway and ran off the sealed runway surface. The aircraft was returned to the runway during the landing roll. There were no injuries to crew or passengers, but the aircraft sustained minor damage.

The approach was conducted at night and in conditions of reduced visibility due to heavy rain, with the windscreen wipers set to 'high'. Immediately after touchdown, the captain saw that the runway edge lights were tracking down the windscreen centre frame and heard the aircraft wheels strike runway lights.

Figure 7: Lateral touchdown position of the left main landing gear

The investigation identified several factors which reduced the captain's ability to detect the aircraft's displacement from the runway centreline. These included:

- painted runway markings that were less conspicuous on a wet runway at night;
- a lack of touchdown zone lighting/centreline lighting on a runway that was wider than the standard runway width; and
- the possibility that the High Intensity Runway Lighting was glaring on the wet windscreen.

The investigation concluded that the presence of runway centreline lighting would have increased the visual cues available to the pilot and assisted with his recognition of the developing sideslip and lateral deviation from the centreline.

APPENDIX C: SOURCES AND SUBMISSIONS

Sources of Information

The sources of information during the investigation included the:

- flight crew of the 3 July 2009 occurrence aircraft
- operator of the 3 July 2009 occurrence aircraft
- Sydney Airport Corporation Limited
- US National Aeronautics and Space Administration's (NASA) Aviation Safety Reporting System (ASRS) database
- US National Transportation Safety Board (NTSB)
- UK Air Accident Investigation Branch (AAIB)
- Transportation Safety Board of Canada (TSB)
- Accident Investigation Board, Norway
- Aviation Safety Council, Chinese Taipei
- Australian Transport Safety Bureau (ATSB) database and research reports.

References

ATSB (2005). *Dangerous Distraction: An examination of accidents and incidents involving pilot distraction in Australia between 1997 and 2004*. (Report B2004/0324). Author: Canberra, ACT.

Caldwell, J.A., Mallis, M. M., Caldwell, J.L., Paul, M. A., Miller, J. C., & Neri, D. F. (2009). Fatigue countermeasures in aviation. *Aviation, Space, and Environmental Medicine, 80(1), 29-59.*

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the flight crew and operator of the 3 July 2009 occurrence aircraft, the Civil Aviation Safety Authority, Airservices Australia and the Sydney Airport Corporation Limited.

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Factors influencing misaligned take-off occurrences at night