FINAL REPORT

AIRBUS A380-800, REGISTRATION 9V-SKA

PUSHBACK INCIDENT IN SINGAPORE CHANGI AIRPORT

10 JANUARY 2008

AIB/AAI/CAS.046

Air Accident Investigation Bureau of Singapore
Ministry of Transport
Singapore

11 March 2009

The Air Accident Investigation Bureau of Singapore

The Air Accident Investigation Bureau (AAIB) is the air accidents and incidents investigation authority in Singapore responsible to the Ministry of Transport. Its mission is to promote aviation safety through the conduct of independent and objective investigations into air accidents and incidents.

The AAIB conducts the investigations in accordance with the Singapore Air Navigation (Investigation of Accidents and Incidents) Order 2003 and Annex 13 to the Convention on International Civil Aviation, which governs how member States of the International Civil Aviation Organisation (ICAO) conduct aircraft accident investigations internationally.

The investigation process involves the gathering, recording and analysing of all available information on the accidents and incidents; determination of the causes and/or contributing factors; identification of safety issues; issuance of safety recommendations to address these safety issues; and completion of the investigation report.

In carrying out the investigations, the AAIB will adhere to ICAO's stated objective, which is as follows:

> *"The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability."*

CONTENTS

SYNOPSIS

The Airbus A380 was scheduled for a passenger flight to Sydney on 10 January 2008. At 8.46 p.m., the aircraft was pushed back from Bay A4 in Singapore Changi Airport by a Schopf air tug. It was to be positioned on Taxiway WA facing south.

However, during the pushback, the right hand wing landing gear departed from the paved taxiway and went over a concrete airfield lighting transformer box onto the grass verge adjacent to Taxiway WA. Part of the right hand body landing gear also left the paved taxiway. When the air tug driver realised that the aircraft had gone onto the unpaved ground, he tried to pull it back onto the taxiway. During the pulling, the fuse pins attaching the towing pin to the nose gear of the aircraft sheared.

The Air Accident Investigation Bureau of Singapore classified the occurrence as an incident and instituted an investigation.

AIRCRAFT DETAILS

AIRBUS A380

Aircraft Type	: Airbus A380-800
Registration	: 9V-SKA
Number and Type of Engines	: 4 x Rolls Royce Trent 900
Place	: Taxiway WA abeam Bay A4 Singapore Changi Airport
Date & Time (Local Time)	: 10 January 2008 at 8.46 p.m.
Type of Flight	: Scheduled Passenger
Persons on Board	: Crew - 25 Passengers - 424
Point of Departure	: Singapore
Destination	: Sydney, Australia

1 FACTUAL INFORMATION

All times used in this report are Singapore times. Singapore time is eight hours ahead of Coordinated Universal Time (UTC).

1.1 History of the flight

1.1.1 The aircraft was scheduled to operate a passenger flight to Sydney. The aircraft was parked at Bay A4 (**Figure 1**) in the new Terminal 3 which had commenced operation a day earlier.

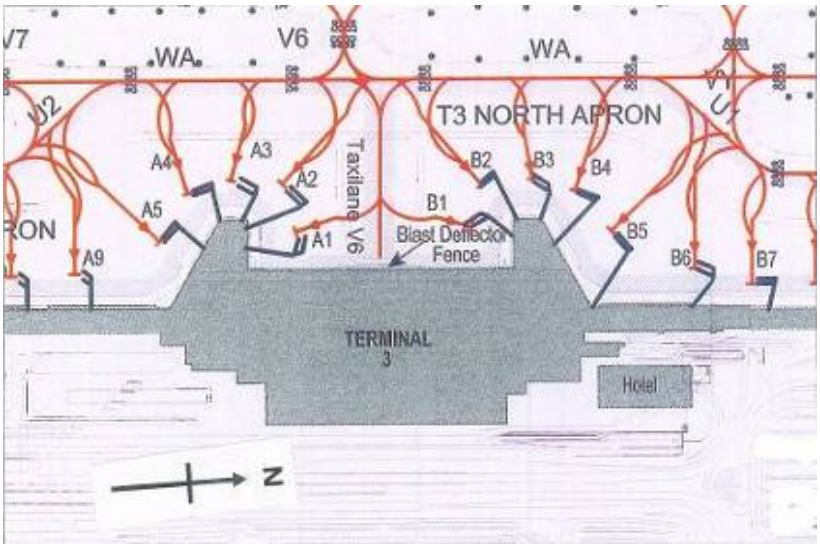


Figure 1. Location of Bay A4

1.1.2 Following clearance by the air traffic control, the aircraft was pushed back by an air tug. It was to be pushed back onto Taxiway WA (Twy WA) facing south. During the pushback, the right wing landing gear and part of the right body landing gear departed from the paved surface of Twy WA. The right wing landing gear rolled over a concrete airfield lighting transformer box onto the grass verge (**Figure 2**). Owing to the weight of the aircraft, the ground under the wing gear wheels sank to about 25 cm below the top of the transformer box. This caused the aircraft to tilt slightly to the right.

Figure 2. Right wing landing gear and the concrete airfield lighting transformer box

1.1.3 The driver tried to pull the aircraft out of the unpaved ground. During the pulling, the fuse pins attaching the towing pin[1] to the towing fitting on the aircraft nose landing gear (NLG) sheared (**Figures 3**, **4** and **5**). Together with the tow bar, the towing pin was detached from the NLG and the aircraft was thus separated from the air tug. The aircraft was otherwise not damaged. Damage to the air tug is described in paragraph 1.2.

Figure 3. Nose gear towing fitting with the towing pin missing

[1] The towing pin was part of the nose landing gear system. One end of the tow bar was hooked up to the towing pin, and the other end was hooked up to the air tug.

Figure 4. Nose gear towing fitting with fuse pins and towing pin in place

Figure 5. Sheared fuse pins of the towing fitting

1.1.4 The pushback team comprised one air tug driver, one headset man, one wing walker on the left, one wing walker on the right and one tail walker behind the aircraft. The leader of the pushback team was the headset man, who was a licensed aircraft engineer. Below are their accounts of the incident.

1.1.5 Air tug driver's account of the incident

1.1.5.1 This was the first time the air tug driver pushed back an A380 aircraft, and his first time pushing back an aircraft from Bay A4. His main concerns regarding the pushback of the A380 were the weight of the aircraft and the up and down slopes of the pushback path. The driver felt that the manoeuvring space for the pushback was quite tight for an A380.

1.1.5.2 During the pushback, the driver was in the driver's seat on the left, facing the aircraft, and the headset man was in the right hand seat. The driver said that his first concern was for the aircraft to clear the obstacles (the aerobridges of Bay A4 and a B777 aircraft parked in Bay A3). To ensure the aircraft was clear of the obstacles, he pushed the aircraft beyond the red apron safety line (which marked the bay's boundary). He commenced to push the aircraft towards Twy WA after the wing walkers had signalled that the wingtips were clear of the obstacles. After ensuring the left wing's clearance from the obstacles, the left wing walker boarded the air tug and stood behind the headset man.

1.1.5.3 The driver was unable to see the taxiway centreline owing to the up slope of the ground and to the fact that the taxiway was not illuminated. Besides having to be wary of the weight of the aircraft and the up slope of the apron area, he had to pay attention to the turning angle of the NLG to ensure that he did not exceed the steering angle limits, to avoid structural damage to the NLG. As a result, he did not maintain the aircraft's body gears close to the yellow lead-in line to Bay A4.

1.1.5.4 The driver said he did not realise that he had pushed the aircraft onto the grass verge as the taxiway was not illuminated. (The distance from the driver's position to the right wing gear was about 32 m.) When he realised the aircraft was on the grass verge he stopped the pushback and told the headset man that he would tow the aircraft forward. He engaged the reverse gear to pull the aircraft forward and, soon after, realised that the tow bar had separated from the aircraft.

1.1.5.5 The Twy WA's green taxiway centreline lights were not switched on. The driver said that such lights were not switched on for SIA aircraft during pushback although they were switched on for foreign airlines like Qantas and Japan Airlines[2]. His opinion was that such lights would provide very useful guidance for the air tug driver.

1.1.6 Headset man's account of the incident

1.1.6.1 During the pushback, the headset man was seated on the right of the air tug driver, facing the aircraft. He said that the aircraft was clear of the obstacles on the left side of the aircraft before the driver began to turn the aircraft onto Twy WA, facing south. After the aircraft was clear of the apron safety line, he noticed that the aircraft was off the yellow lead-in line and he alerted the driver. He did not notice any attempt on the driver's part to steer the aircraft back to the lead-in line. However, he did not pursue the matter with the

[2] According to the air traffic services provider, the green centreline lights are not switched on for any airline for pushback guidance as the lights would cause confusion to other taxiway users.

driver as he felt he should leave it to the driver's judgment because before the pushback commenced from Bay A4, the driver's two supervisors assured him that the driver could do the job safely[3]. He then focused his attention on ensuring that the limits of the NLG steering angle were not exceeded during the pushback manoeuvre. He said that at no time did the steering angle approach the limits. He said he saw, as the driver was turning the aircraft onto Twy WA, that the right wing gear was getting too close to the taxiway edge (which was marked with double yellow lines) and he called out to the driver. He expected the driver to stop but the driver continued to push the aircraft. (According to the driver, he did not hear the headset man's call to stop.)

1.1.6.2 The headset man was not certain after the air tug had stopped whether the aircraft had left the paved taxiway. He could not recall whether the air tug driver told him that he intended to pull the aircraft forward, but he heard the air tug engine revving up (i.e. engine speed increasing) before the tow bar became detached from the NLG.

1.1.6.3 The headset man said that the area of the taxiway they were operating in was not illuminated and the visibility of the taxiway centreline was poor. He opined that Bay A4 was a difficult bay for pushback operation, if the aircraft was to face south, in view of the bay's orientation and tightness of apron space. He said it would be easier to push back the aircraft to face north.

1.1.7 Wing walkers' account of the incident

1.1.7.1 After the aircraft had cleared the obstacles on its left, the tail walker and the right wing walker went back to the parking bay to retrieve the chocks and return them to the aerobridge area. These two persons then drove the headset man's car to position at the end of the pushback path to be ready to assist in the disconnection of the tow bar from the aircraft.

1.1.7.2 The left wing walker went on the air tug and stood behind the headset man after the left wing was clear of obstacles. He said he was looking at the left wing during the pushback. He said he did not notice any anomalies during the pushback.

1.2 Damage to air tug

1.2.1 When the driver tried to pull the aircraft from the grass verge, the fuse pins sheared and the towing pin became detached from the NLG.

1.2.2 The detached towing pin was held in the clamp of the tow bar. The pin was found to have rotated 180° about its longitudinal axis from its original orientation (**Figure 6**). It could not be determined when and by whom the pin was disturbed.

[3] One supervisor said he had not spoken to the headset man. He was at the bay because there were some water servicing issues. The other supervisor said that there was no mention of the air tug driver when the headset man asked him 'how'. He had thought that the headset man was asking him how he was getting on. So he responded to the headset man with 'OK'.

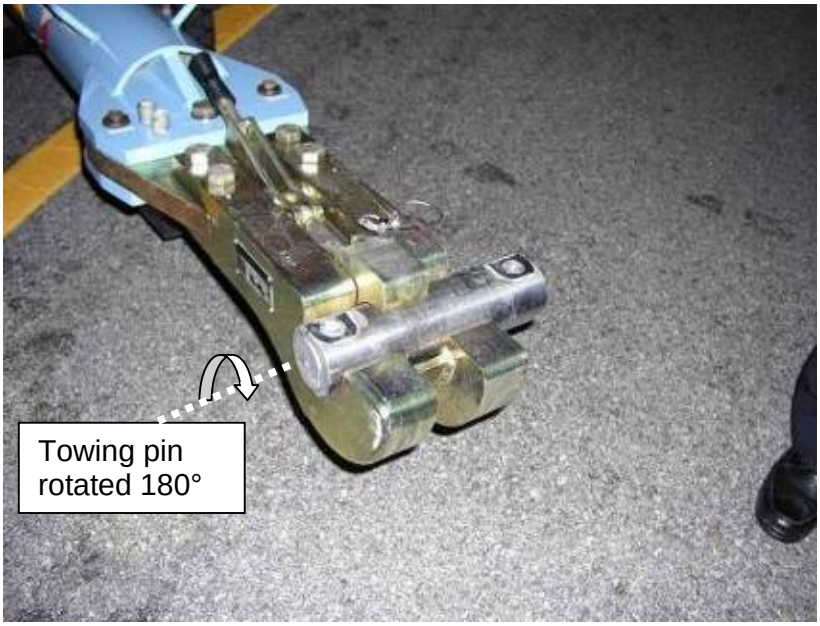


Figure 6. Tow bar clamp holding towing pin detached from towing fitting and rotated 180°

1.2.3 The hydraulic system of the air tug provided power for the steering system, the front and rear wheel brakes, and for lifting the driver's cabin. The air tug driver confirmed that he had checked and ascertained that the hydraulic pressure of the vehicle to be at least 100 bars before driving the vehicle. He also confirmed that there were no warning lights or defect messages in the display panel of the vehicle that would suggest a problem with the vehicle.

1.2.4 There was no trail of hydraulic fluid on the apron area nor was there a pool of hydraulic fluid at the aircraft parking area. There was no evidence to suggest that there was a leak in the hydraulic system before the incident.

1.2.5 The hydraulic elbow connector (near the steering cross bar of the air tug's rear wheels) that was attached to a hydraulic relay valve was broken, resulting in hydraulic fluid leaking onto Twy WA.

1.2.6 The clearance between the steering cross bar of the rear wheels and the broken hydraulic elbow connector was about 6 mm. The broken elbow connector had a paint smear. The colour of smear was similar to that of the steering cross bar nearby (**Figure 7**). This suggests that the steering cross bar and the elbow connector had come into contact with each other, probably when the air tug juddered at the moment it became separated from the NLG, and that the elbow connector broke as a result of the contact.

1.2.7 The hydraulic pipe fitted to the broken elbow connector was found removed. According to the personnel involved, the pipe was removed for quarantine for investigation. Although the personnel had good intention when they removed the pipe, it should not have been done before AAIB investigators have inspected the vehicle and given their permission to do so.

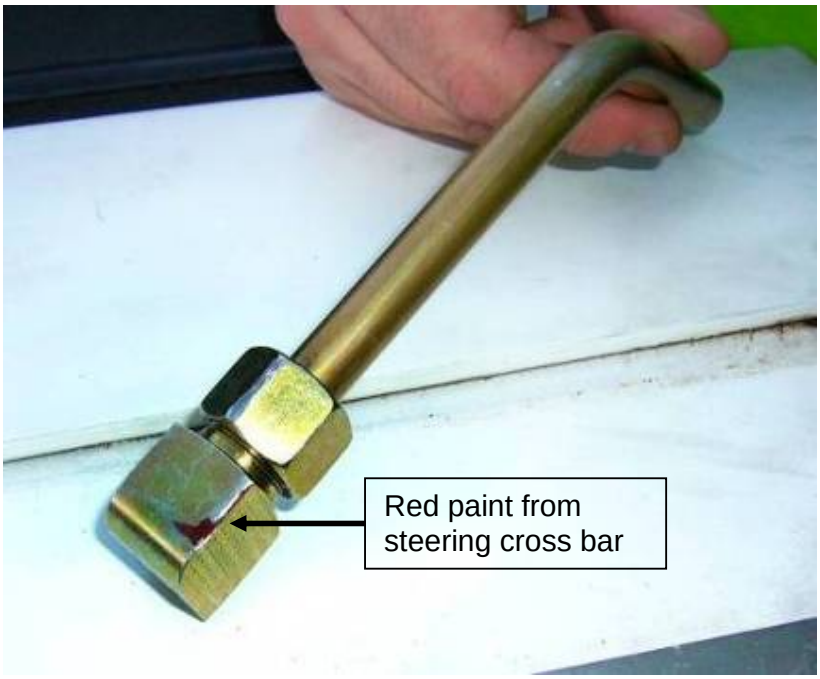


Figure 7. Red paint smear on the broken elbow connector

1.2.8 The air tug's hydraulic system was checked after the broken elbow connector was replaced. No hydraulic leaks were found.

1.2.9 The air tug was also found to be serviceable and roadworthy in post-incident tests. There were no problems with the steering system, the front and rear brakes systems, the parking brakes, the accelerator and the tyres. There was no evidence of any pre-existing problems with the air tug that could have affected the handling and control of the vehicle.

1.3 Personnel information

1.3.1 The pilot-in-command, co-pilot and ground controller held appropriate licence.

1.3.2 The air tug driver had about nine months' experience pushing/towing aircraft (including large aircraft such as the B777) at Changi Airport, after completing a six-week air tug training conducted by his company in March and April 2007. According to the driver, the practical training conducted at Bay 205 (a remote bay) at Changi Airport included one module using an old air tug (number 42) and a specially outfitted trailer simulating an aircraft. According to the air tug driver's company, the theoretical training included the air tug model involved in the incident and the aircraft types the air tug was capable of handling.

1.4 Aircraft information

1.4.1 The aircraft involved in the incident was serviceable and airworthy. The maintenance of the aircraft was not a factor in the incident.

1.5 Meteorological information

1.5.1 The incident occurred at night. At the time of the incident, the weather condition was clear. There was no precipitation.

1.6 Communications

1.6.1 The communications between the ground controller, the pilots and the headset man were normal.

1.7 Aerodrome information

1.7.1 Before Terminal 3 commenced operations, Bays A4, A5, B2 and B5 were used for A380 bay fitment check, aerobridge operation check, equipment placement check and pushback clearance check using the prototype A380 aircraft.

1.7.2 To push back an aircraft onto Twy WA from Bay A4 and have the aircraft face south, the aircraft needed to be turned through more than 90°. To have the aircraft face north would need a turn of less than 90°.

1.7.3 The apron area of Bay A4 had an up slope gradient of about one percent up to the centreline of Twy WA and a down slope gradient of about one percent from the centreline to the edge of the taxiway for drainage of rain water.

1.7.4 Bay A4 had a floodlight mast with a cluster of high intensity floodlights. On the night of the incident, all the floodlights were operating normally. The floodlights of the adjacent Bay A3 and Bay A5 were also switched on and operating normally. The aerodrome operator confirmed that the lighting of the apron area met ICAO Annex 14 requirements.

1.7.5 The bay had painted yellow (lead-in) lines which lead to and from the centreline of Twy WA. The lines were in good condition. Under the apron floodlight, the lines could be seen from the air tug driver's position all the way from where the aircraft was parked up to the intersection of the two curved yellow lead-in lines (near the edge of the taxiway). (See **Appendix 1.**)

1.7.6 The yellow lead-in lines are for guiding pilots taxiing in to dock at the passenger gate. Such lines are generally used by the air tug drivers as a guide for pushing back aircraft.

1.7.7 There was no specific pushback line at Bay A4 to guide the air tug driver to the taxiway centreline. Provisioning of pushback lines is not an ICAO Annex

14 requirement. The aerodrome operator had provided pushback lines at several other bays as a result of users' feedback.

1.7.8 The 16 cm wide yellow centreline of Twy WA was non-reflective. The centreline was equipped with green lights which could be turned on selectively by the ground controller to guide aircraft to and from the runways. The green lights are used for operations at night or when visibility of the taxiways is degraded.

1.7.9 The taxiway centreline lights were not switched on at the time of the pushback. According to the air traffic services provider at the aerodrome, it was not a requirement for the green centreline lights to be illuminated for pushback purposes. The air traffic services provider was concerned that lighting up the green lights for pushback guidance would cause confusion to other taxiway users.

1.8 Flight recorders

1.8.1 The aircraft's cockpit voice recorder and flight data recorder were removed and read out in the AAIB recorder laboratory. The recorder data showed that no brakes were applied at the time the fuse pins were sheared.

1.8.2 The pushback path shown in **Appendix 2** was reconstructed with data from the flight data recorder. The reconstructed path was consistent with the observation that the aircraft had deviated from the yellow lead-in line during the pushback.

1.9 Medical and pathological information

1.9.1 The headset man and the air tug driver were sent for medical/toxicological examinations. The examination results were normal.

1.10 Fire

1.10.1 There was no fire. The Airport Emergency Service (AES) was activated. The AES provided good lighting during the investigation and aircraft recovery.

1.11 Tests and research

1.11.1 The investigation team observed a series of A380 pushback from Bay A4 to Twy WA in the early hours of the morning of 11 March 2008. An air tug of the same model as the one used on the night of the incident was used for the trial pushback. The air tug had additional lights fitted to augment the illumination. The aircraft was to face south on Twy WA. The

pushback was performed by an air tug driver[4] who had been pushing/towing aircraft since 1980 and who had experience handling an A380 aircraft.

1.11.2 To simulate the lighting condition of the night of the incident, the floodlights of Bay A3, Bay A4 and Bay A5 were switched on. The flood lighting of the apron area at Bay A4 was bright enough to light up the apron area and enabled the yellow lead-in lines to be seen from the air tug driver's position all the way from where the aircraft was parked up to where the two curved yellow lead-in lines intersect, near the edge of Twy WA (**Appendix 1**). Beyond this region Twy WA was not illuminated. The combination of the floodlights of Bay A3, Bay A4 and Bay A5 was such that there was no shadow cast by the aircraft over the lead-in lines for most of the pushback path. Even for a short section of the pushback path where shadow was cast, it was still bright enough to see the curved lead-in lines up to where they intersect.

1.11.3 During the first pushback the green centreline lights of Twy WA were switched on. The taxiway centreline lights (which were directional in design) could not be seen when viewed perpendicularly to the centerline. However, as one got closer to the centreline, the centreline lights could be seen when viewed obliquely. The centreline lights provided reference for the air tug driver to aim when pushing the aircraft into the taxiway.

1.11.4 To accomplish the pushback from Bay A4 to the taxiway, the driver had to clear the aerobridges at Bay A4 and the B777 parked at Bay A3. Following that, he had to use his judgment when turning the nose wheels of the aircraft to position the body landing gears on the yellow lead-in line. This required the aircraft to be pushed in an 'S' shaped path. This is shown on the sketch at **Appendix 3**.

1.11.5 It was noted that having the aircraft face north would involve a shallow 'L' turn which would be easier to manoeuvre.

1.11.6 In the second pushback, the green centreline lights were switched off. The yellow centreline of Twy WA was non-reflective and the taxiway was not illuminated. It was noted that it was very difficult to see the centreline from the air tug driver's position during the pushback even with the additional lights fitted to the air tug. The AAIB investigators also found it very difficult to see the taxiway centerline even when viewing it at an oblique angle to the centreline. Without the centreline for reference, the driver had to make a sharp turn to adjust the position of the aircraft to attempt to line up with the middle of the taxiway, but he did not manage to position the aircraft such that the taxiway centreline was in the middle between the aircraft's body gears. Instead, the left body gear was resting on the centreline and the right wing landing gear was about 11 m from the edge of the taxiway.

1.11.7 These trials showed that to push an A380 from Bay A4 to face south on Twy WA required skill and good judgment and that it was critical to adhere strictly to the lead-in line during the pushback. If the body landing gear is too far off

[4] This air tug driver was involved in pushing back the prototype A380 from various bays designated for A380 under the supervision of an Airbus representative when the prototype A380 aircraft were in Singapore earlier for testing out the aerodrome facilities.

the lead-in line there is little space left to allow the air tug driver to steer the aircraft back to the taxiway centreline. A centreline that could be seen (e.g. one painted with reflective paint or with centreline lights illuminated) would provide an aiming reference for the air tug drivers.

1.12 Organisational and management information

1.12.1 The composition of the pushback team was in accordance with the air tug operator's procedures, i.e. one headset man (team leader), one driver, two wing walkers and a tail walker.

1.12.2 The air tug driver's company provided the air tug driver with theoretical and practical training in March – April 2007. The theoretical training on the A380 consisted of classroom training pertaining to ground power units, water servicing, waste servicing, ground air-conditioning and pushback. There were two warnings in the "Pushback" section of the training material. These warnings were:

(1) To observe the maximum aircraft towing angle, and
(2) To observe the main gear and aircraft pushback line.

As mentioned in paragraph 1.3.2, the practical training conducted at Bay 205 (a remote bay) included one module using an old air tug and a specially outfitted trailer simulating an aircraft.

1.12.3 Prior to this incident, the air tug driver had not towed or pushed an A380 aircraft.

1.12.4 The duties of the wing walkers as stated in their employer's procedures manual included giving safety clearance to the air tug driver and the headset man, and watching for the effects of wing tip growth when an aircraft turns.

1.13 Additional Information

1.13.1 Fuse pin design

1.13.1.1 According to Airbus, the shear strength of the fuse pins that connected the towing pin to the NLG was designed to be about 20 percent higher than that of the shear bolts on the tow bar. In this incident, the shear bolts on the tow bar did not shear. Instead, it was the fuse pins that had sheared.

1.13.1.2 Airbus found that the sheared fuse pins met its specification and that the pins sheared at about the predicted shear force of 715 MPa.

1.13.2 Shear bolts

1.13.2.1 During the investigation, it was found that one of the two shear bolts on the tow bar could be loosened at almost zero torque. The other bolt could be loosened at 5 Nm (about 44 lb-in). A check on a second tow bar of the same design yielded similar low torque values for the shear bolts.

1.13.2.2 According to the tow bar manufacturer, the two shear bolts on the tow bar were required to be tightened to a torque value of 122.6 Nm (about 90 lb-ft) and this torque value was indicated on the tow bar. (See **Figure 8**.) When the shear boIts are tightened (preloaded) to this torque value, the shear bolts will shear at a certain shear force. If the shear bolts are over-tightened, they will break earlier at a lower shear force. If the shear bolts are under-tightened, they become "too loose" in the bushes, then there is a risk that they will shear at a higher shear force.

1.13.2.3 Interviews with the equipment maintenance personnel revealed that the bolts were merely tightened using a ratchet wrench or a spanner. The bolts were not tightened with a torque wrench. One of the equipment maintenance personnel was not aware that the shear bolts needed a torque value of 122.6 Nm. He produced a torque wrench for a torque value of 20 Nm (175 lb-in) rather than one for the 122.6 Nm needed.

1.13.2.4 The torque wrenches that were used in the equipment maintenance had scales in imperial units (lb-ft, lb-in) and the maintenance personnel were not provided with conversion tables to convert imperial units to metric values.

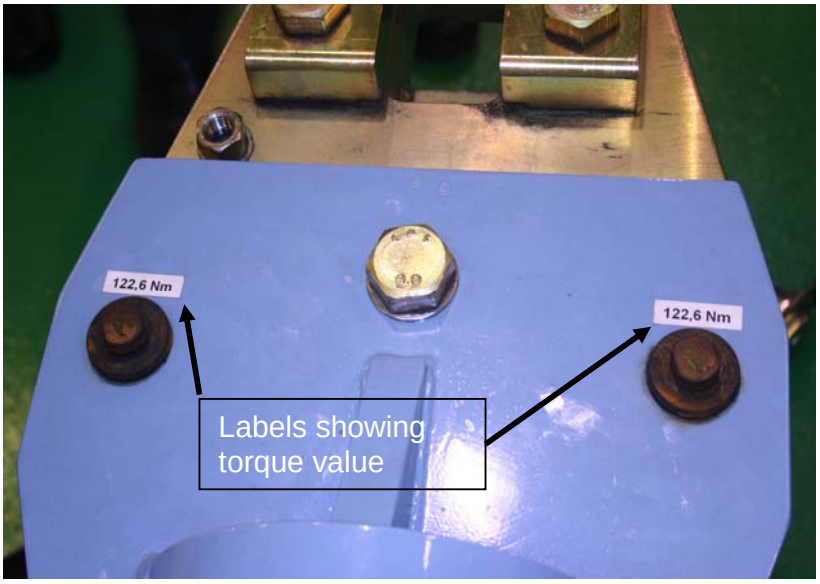


Figure 8. Labels on the tow bar showing the required torque value

1.13.2.5 Airbus specification for the distance between the shear bolts on the tow bar was 154.8 mm. The actual spacing between the two shear bolts on the tow bar was found to be 263 mm (**Figure 9**). The greater spacing could have affected the shearing characteristics of the shear bolts.

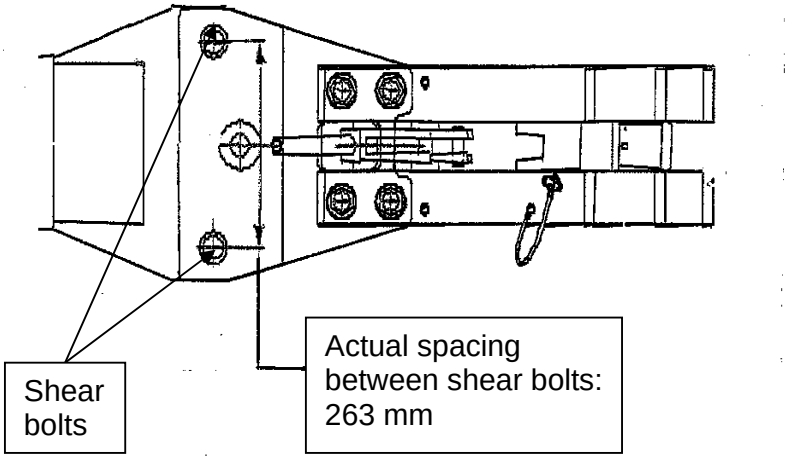


Figure 9. Spacing between the two shear bolts on tow bar

2 ANALYSIS

2.1 The actions of the pilot-in-command, co-pilot and ground controller were not a factor in the incident. The analysis covered the following areas:

(a) Pushback crew
(b) Pushback line
(c) Tow bar maintenance, fuse pins and shear bolts

2.2 Pushback crew

2.2.1 Pushing back an A380 from Bay A4 onto Twy WA and having it face south would need skill and good judgment on the part of the air tug driver. The air tug driver involved in the incident had no experience towing or pushing an A380 aircraft before this incident and had not exercised proper judgement in adhering to the lead-in line which led to the taxiway centreline. The air tug driver's company did not provide practical training on handling of an A380 for the air tug driver even though this was a new and large aircraft type. It was also the air tug driver's first time pushing an aircraft out of Bay A4.

2.2.2 The air tug driver's company's pushback procedures had warned drivers to observe the aircraft's nose wheel turning angle and the main gear's adherence to the lead-in line during the pushback. In the incident, the driver was able to maintain the aircraft's nose gear turning angle within its limits. However, he did not keep the body landing gear close to the lead-in line. Instead, he allowed the aircraft to deviate from the lead-in line. With the aircraft close to the edge of the taxiway and deviated substantially from the lead-in lines, he had little space to continue the push onto the centreline of the taxiway.

2.2.3 During the trial pushback when the green taxiway centreline lights were switched on, it was observed that the lights could be seen when one got closer to the centreline and looked at them at an oblique angle to the centreline. The lights provided a reference for the air tug driver.

2.2.4 It was noted during the trial pushback that with the taxiway centreline lights switched off, the centreline was difficult to see even though the air tug had additional lights fitted. On the night of the incident, the driver would have difficulty trying to see the taxiway centreline on the unlit taxiway with the normal head lamps. Without this visual cue, the air tug driver would have no reference for which he could aim when pushing back the aircraft.

2.2.5 It would have been prudent for the driver to stop the pushback and assess the situation if he could not see the taxiway centreline instead of continuing with the pushback.

2.2.6 As the leader of the pushback team, the headset man was not assertive enough in stopping the air tug driver when he noticed the aircraft had deviated significantly from the lead-in line or when he saw the right wing gear was getting close to the taxiway edge.

2.3 Pushback line

2.3.1 The flood lighting of the apron area at Bay A4 was bright enough for the pushback crew to see the yellow lead-in line from where the aircraft was parked up to the intersection of the two curved lead-in lines.

2.3.2 The curved lead-in line could be seen clearly and could be used by the air tug drivers as a guide for pushing aircraft onto the taxiway. However, it would need skill and good judgment to adhere to the lead-in lines when pushing back an A380 aircraft from Bay A4.

2.3.3 The taxiway centreline lights were directional for guiding pilots taxiing aircraft to and from the runway. To use them for guiding aircraft pushback might cause confusion to other taxiing aircraft if the green lights cover long stretches of taxiway. However, it was noted from the trial pushback that the green centreline lights could help the air tug driver spot the centreline.

2.3.4 For a parking bay such as Bay A4, availability of a pushback line would alleviate the difficulty of having to manoeuvre the aircraft in an 'S' shaped path and would help air tug drivers of different skill levels. (See **Appendix 4**.) A pushback line is not an ICAO Annex 14 requirement.

2.4 Tow bar maintenance, fuse pins and shear bolts

2.4.1 The equipment maintenance personnel apparently lacked knowledge of proper maintenance of tow bars. An inappropriate torque wrench was produced for loosening the shear bolts of the A380 tow bar.

2.4.2 The torque wrenches presented for torque loading the tow bar shear bolts were calibrated in imperial units (lb-ft and lb-in). The maintenance personnel were not provided with conversion tables to convert imperial units to metric values that were used for the tow bar shear bolts. Lack of conversion tables could induce unnecessary conversion errors on the part of the maintenance personnel who were not familiar with the imperial units and result in improper tightening of fasteners.

2.4.3 The material specification strength of the fuse pins fitted on the nose landing gear was found to meet the specification and had sheared at approximately the predicted shear strength.

2.4.4 The spacing between the two shear bolts (263 mm) on the tow bar was wider than that specified (154.8 mm) by the aircraft manufacturer.

2.4.5 The shear bolts on the tow bar involved in the incident could be loosened at torque values that were much lower than the required preload. The lowered torque values could have been a result of the bolts working loose due to tow bar usage or improper tightening or both. The reduced tightness resulted in lower preload on the shear bolts, causing the shear bolts to require higher than normal force to shear, and this high force might have resulted in the fuse pins' strength being exceeded before the shear bolts' strength was exceeded.

2.4.6 The wider spacing between the shear bolts could have affected the shearing characteristics of the shear bolts and compounded the under-tightening of the shear bolts in causing the pre-mature failure of the fuse pins.

3 FINDINGS

From the evidence available, the following findings are made. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

3.1 Owing to the orientation of Bay A4 with respect to Twy WA and the space restriction, pushing an A380 from the bay to face south on Twy WA required skill and good judgment in manoeuvring the aircraft along the yellow lead-in line.

3.2 The lighting of Bay A4 area was adequate to enable the yellow lead-in lines to be seen from the bay up to where the two curved yellow lead-in lines intersect.

3.3 The taxiway centreline at Bay A4 area was not reflective and was difficult to see.

3.4 The air tug driver failed to exercise proper judgment in adhering to the lead-in line when pushing back an A380 aircraft from Bay A4.

3.5 The air tug driver did not stop the pushback to assess the situation when he had deviated from the lead-in line and could not see the taxiway centreline.

3.6 The air tug driver's company had assigned a driver who was pushing out an A380 aircraft for the first time.

3.7 The head set man was not assertive enough to stop the air tug driver when he noticed the aircraft had deviated from the lead-in line.

4 OTHER ISSUES

4.1 The shear bolts on the tow bars were at much lower torque values than that stipulated. This could be a result of the bolts working loose through usage or improper tightening or both.

4.2 The under tightening of the shear bolts would have caused the shear bolts to become too loose, requiring a higher force to shear the bolts.

4.3 The shear bolt distance on the tow bar was wider than that specified by the aircraft manufacturer. This could have affected the shearing characteristics of the shear bolts.

4.4 The torque wrenches were calibrated in imperial units and there were no conversion tables for their conversion to metric units for use by the equipment maintenance personnel.

4.5 The equipment maintenance personnel apparently lacked knowledge of proper maintenance of tow bars.

4.6 The elbow connector on the air tug was removed without prior permission of the AAIB investigators.

4.7 The towing pin in the tow bar clamp had been disturbed.

5 SAFETY ACTIONS

5.1 The air tug driver's company has since inspected all its tow bars to ensure that the shear bolts were tightened to the stipulated torque values.

5.2 The air tug driver's company has since made available to its maintenance personnel torque meters in metric units for maintenance of the A380 tow bars.

5.3 The tow bar manufacturer has redesigned the shear bolt distance to that specified by Airbus and improved on the locking hardware to better ensure effective locking of the shear bolts. The air tug driver's company is now using A380 tow bars with shear bolt spacing of 154.8 mm.

5.4 The aerodrome operator has provided pushback lines to guide air tug drivers to push aircraft from Bay A4 onto Taxiway WA to face North or South.

6 SAFETY RECOMMENDATIONS

6.1 It is recommended that:

6.1.1 The air tug driver's company review the training of its air tug drivers to handle new aircraft types.
[AAIB Recommendation R-2009-001]

6.1.2 The air tug driver's company review the training of its maintenance personnel on proper maintenance of tow bars.
[AAIB Recommendation R-2009-002]

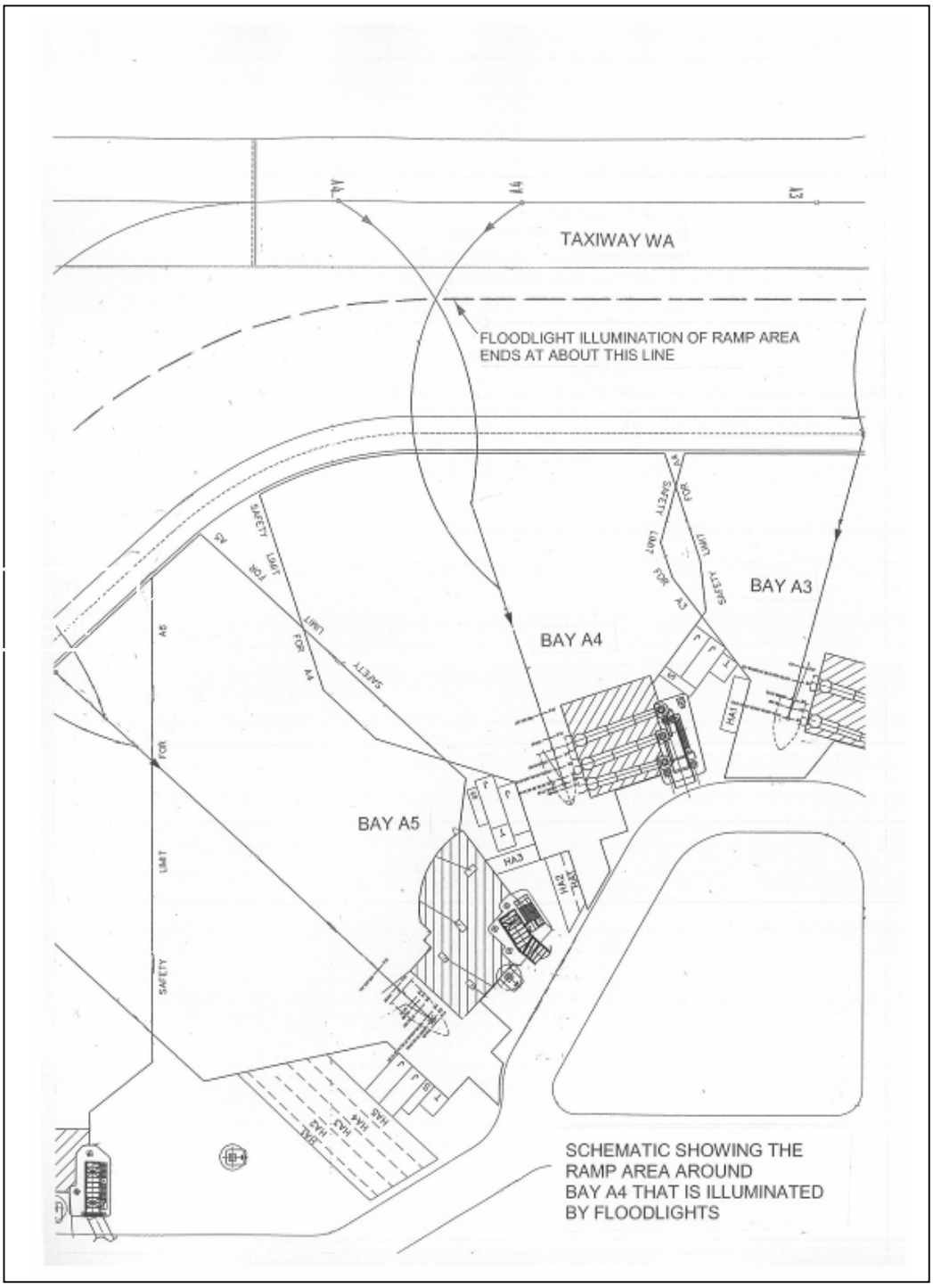
6.1.3 The aerodrome operator consider painting the taxiway centrelines with reflective material in order to enhance their conspicuousness and to avoid such incident recurring on other taxiways.
[AAIB Recommendation R-2009-003]

7 APPENDICES

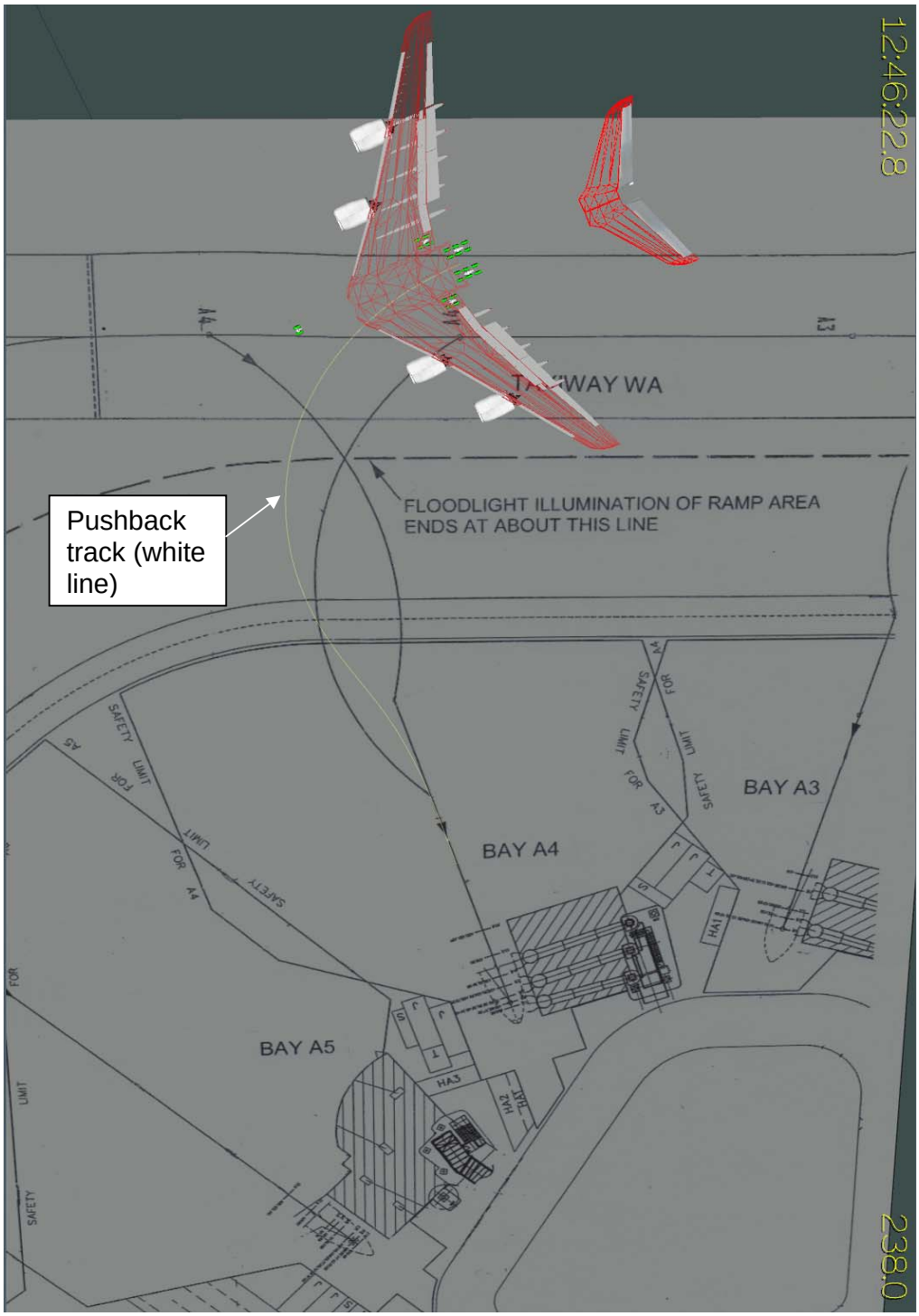
Appendix

1 Schematic showing illuminated areas of the apron around Bay A4
2 Pushback track of the aircraft
3 The ‘S shape’ trial pushback track
4 Pushback lines added to Bay A4 apron

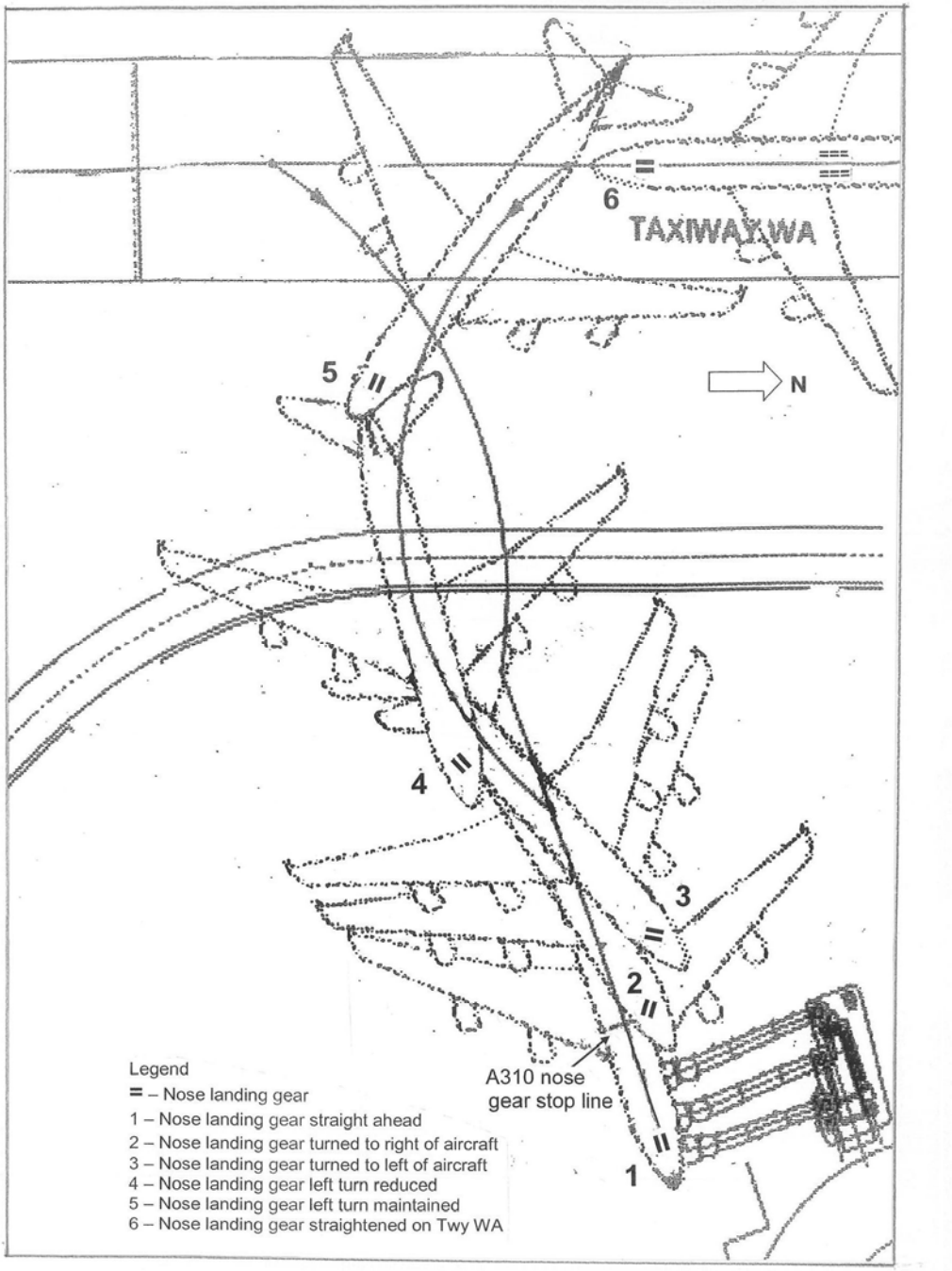
Appendix 1



Schematic showing illuminated areas of the apron around Bay A4



Pushback track of the aircraft



Sketch showing ‘S – shape’ trial pushback track

Appendix 4

Pushback lines added to Bay A4 apron