Australian Government
Australian Transport Safety Bureau

Landing gear malfunction involving Airbus A320, VH-VFN

Sydney Airport New South Wales on 1 August 2019

ATSB Transport Safety Report
Aviation Occurrence Investigation (Defined)
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Postal address: PO Box 967, Civic Square ACT 2608
Office: 12 Moore Street, Canberra ACT 2601
Telephone: 1800 020 616, from overseas +61 2 6257 2463
Accident and incident notification: 1800 011 034 (24 hours)
Email: atsbinfo@atsb.gov.au
Website: www.atsb.gov.au

Addendum

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Safety summary

What happened

On the morning of 1 August 2019, an Airbus A320, registered VH-VFN, was being operated as a regular public transport flight by Jetstar Airways from Sydney, New South Wales to Gold Coast, Queensland. On departure the flight crew received multiple warnings of the undercarriage not retracting completely. Despite extending and retracting the undercarriage again, the issue remained.

Meanwhile, another aircraft identified an object on the ground while taxiing at Sydney Airport and reported the sighting to the Air Traffic Control (ATC) Ground controller. The controller arranged for the debris to be collected by an airport ground car. Upon retrieval, the object was determined to be an aircraft part that was subsequently identified as an A320 main landing gear component.

ATC notified the flight crew that an aircraft part had been found. In addition, Jetstar communicated to the flight crew that the part had not yet been positively identified and advised the crew to follow their procedures. When all appropriate checks were completed, the flight crew elected to return to land at Sydney.

When it was determined the part was an apex pin of a main landing gear torque link, Jetstar Line Maintenance was concerned about the aircraft landing with the defect and attempted to contact the aircraft via radio. However, by this time the aircraft was on final approach to land and therefore not monitoring the company radio frequency. While the landing was uneventful, further damage to the left main landing gear occurred including the loss of brakes and severing of electrical sensors.

What the ATSB found

The ATSB identified that the head of the apex pin on the left main landing gear torque link failed due to cyclic fatigue. This then allowed the shank portion of the apex pin to slide out of the torque link, permitting the main landing gear axle to rotate out of alignment. The misalignment stopped the undercarriage from retracting completely and caused further damage to main landing gear components and systems during the taxi, take-off, and landing. Despite this, the aircraft landed safely.

The fatigue failure of the apex pin was the result of a crack that initiated during the quench step of the heat treatment process at manufacture. The crack was not detected during the manufacturing inspections for reasons that could not be determined. It also remained undetected during subsequent maintenance, although cracking was not specifically inspected for.

The ATSB also identified that, despite the failed part and aircraft being positively identified by elements within Jetstar, a message was unable to be conveyed to the flight crew before they returned for landing. As such, they were unaware of the true nature of the undercarriage defect and the associated risks. The additional information would have improved crew decision making.

The investigation also found that the breakdown in communication was the result of localised factors specific to this occurrence and that Jetstar has procedures in place to ensure that accurate and timely information is passed to airborne flight crew.

Finally, to enable the aircraft to be moved on the ground after the occurrence, the failed apex pin was reinstalled and temporarily held in place. This had the potential to damage the material evidence and prevent identification of the failure mode.

What has been done as a result

Airbus issued an Alert Operator Transmission (AOT) requiring recall or inspection of 1,988 apex pins. As a result of these inspections, 19 pins were removed from service due to cracking. Additionally, EASA issued Airworthiness Directive 2020-0130 mandating AOT A32N018-20 Rev 1.

Safran Landing Systems revised the manufacturing process for the apex pin prior to this failure as a result of subsequent parts being found cracked. Furthermore, they generated a design guidance document related to undercuts in heat treated parts.

Jetstar clarified non-normal operational communication guidance for ground crews in the Airport Operations Manual. This included dedicated phraseology for gaining priority on airband frequencies to relay high priority messages.

Safety messages

In this incident, the flight crew made the decision to return and land after seeking and assessing information from ground personnel relating to the landing gear malfunction. However, additional information was still being gathered. This highlights the importance of ensuring that operational processes permit coordinated, accurate and timely flow of information between ground personnel and flight crew to assist airborne decision making.

For safety investigations, preservation of evidence is vital in determining the circumstances of the occurrence and identifying safety issues that may present a hazard to continued operations. Any person involved in aircraft operations are encouraged not to put evidence at risk of further damage.

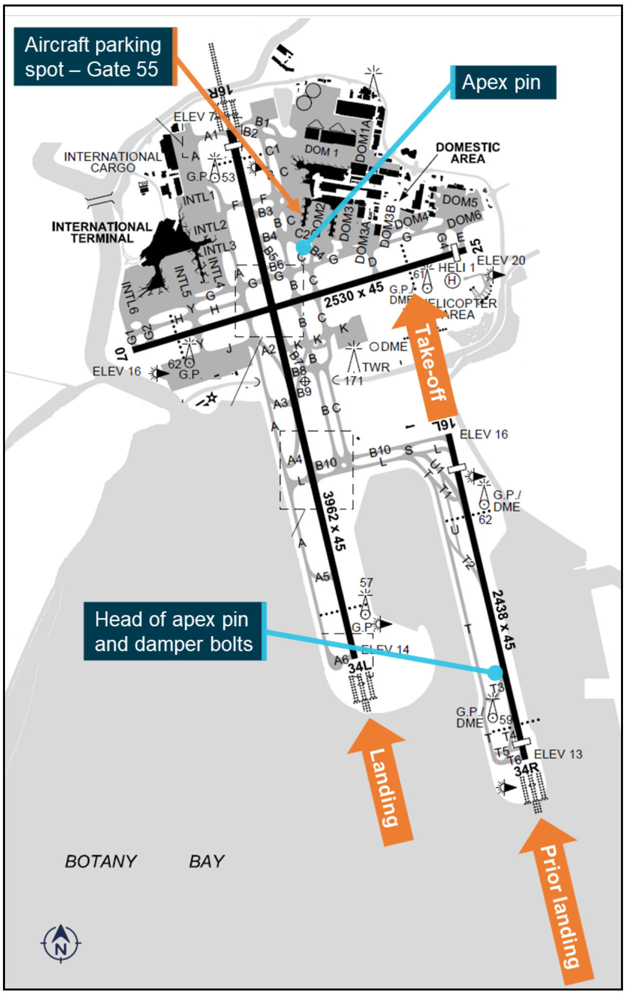
Contents

The occurrence

On the morning of 1 August 2019, an Airbus A320, registered VH-VFN, was being operated as a regular public transport flight by Jetstar Airways (Jetstar) from Sydney, New South Wales to Gold Coast, Queensland. It was the first flight of the day for the flight crew and the third for the aircraft and cabin crew. The aircraft had previously been flown on a return flight between Sydney and the Gold Coast, landing in Sydney on runway 34R.[1]

At 1020 Eastern Standard Time,[2] the aircraft was pushed back and commenced taxiing to runway 34R (Figure 1). While the aircraft was taxied to the runway, the crew of a following aircraft reported to the Sydney East Ground Controller (Ground) that they had sighted an item on the ground at the intersection of taxiways B4 and C.[3] Ground then sent an airport ground car to investigate the item, who reported 3 minutes later that the foreign object debris (FOD)[4] had been retrieved. The FOD was a metallic component, later identified to be an apex pin of a main landing gear torque link (see the section titled *Main landing gear strut* and Figure 2).

Figure 1: Airport map – Sydney Kingsford Smith



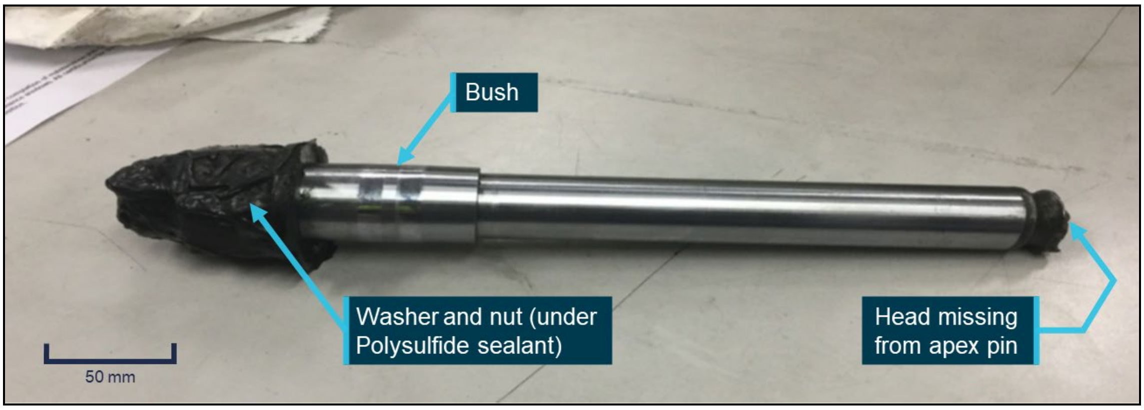
1 Runway number: the number represents the approximate magnetic heading of the runway in tens of degrees. The runway identification may include L, R or C as required for left, right or centre.
2 Eastern Standard Time (EST): Coordinated Universal Time (UTC) +10 hours.
3 Taxiway intersection B4 and C is approximately 250 metres south of Gate 55.
4 Foreign object damage or foreign object debris (FOD) is any article or substance, alien to an aircraft or system, which could potentially cause damage. The term FOD is used to describe both the foreign objects themselves and any damage attributed to them.

Source: Airservices Australia, modified and annotated by the ATSB

At 1038, VH-VFN took off, and after retraction of the undercarriage, the flight crew received numerous messages on the electronic centralised aircraft monitoring (ECAM) system,[5] two of which were 'L/G DOORS NOT CLOSED' and 'L/G GEAR NOT UPLOCKED'. The captain elected to continue the climb out over the sea. The flight crew informed air traffic control and requested vectors to an area where they could troubleshoot the problem. They then cycled the undercarriage to the extended and then retracted positions however, the issue remained.

At 1042, Ground simultaneously contacted two Jetstar aircraft taxiing for take-off. They were instructed to contact their engineering department as 'one of the safety officers has found a large piece of metal at the juncture of Bravo 4 and Charlie and it is believed to be from a Jetstar 320…'.

Figure 2: Apex pin as recovered from taxiway



Source: Jetstar Safety Department, annotated by the ATSB

At the same time, the Sydney Departures controller (Departures) informed the flight crew of VH-VFN of a 'large piece of metal' found on a taxiway. The flight crew then told Departures they required a return to the airfield. In a follow up discussion a minute later, Departures informed the flight crew 'they believe it might be a part of the landing gear' to which the captain responded, 'that would make sense'. Shortly after the aircraft entered a holding pattern off the coast.

At around 1048, a 'hard stop'[6] order was placed on departing Jetstar aircraft by the company as a result of the discovery of the apex pin on the taxiway.

At 1054, Departures advised VH-VFN to expect an approach to runway 25 when they were ready, but the first officer (FO) requested runway 34L because they were unsure about the serviceability of the brakes.[7] At this point, the FO confirmed that they had approximately 80 minutes of endurance.

In addition to the communication with Departures, the flight crew also contacted Jetstar's Sydney line maintenance (Line Maintenance) via radio several times to discuss the landing gear issue. Around 1055, an engineer communicated to the flight crew that a part had been found but it had not been positively identified. They advised the crew to follow their standard operating procedures.

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5 Electronic Centralised Aircraft Monitoring (ECAM) is a system that monitors aircraft functions and relays their status to flight crew. It also produces messages detailing failures.

6 A *hard stop* call is a term for stopping an aircraft departing due to operational or engineering issues associated with the flight, e.g. incomplete maintenance or paperwork.

7 Runway 16R/34L is the longest runway available at Sydney airport.

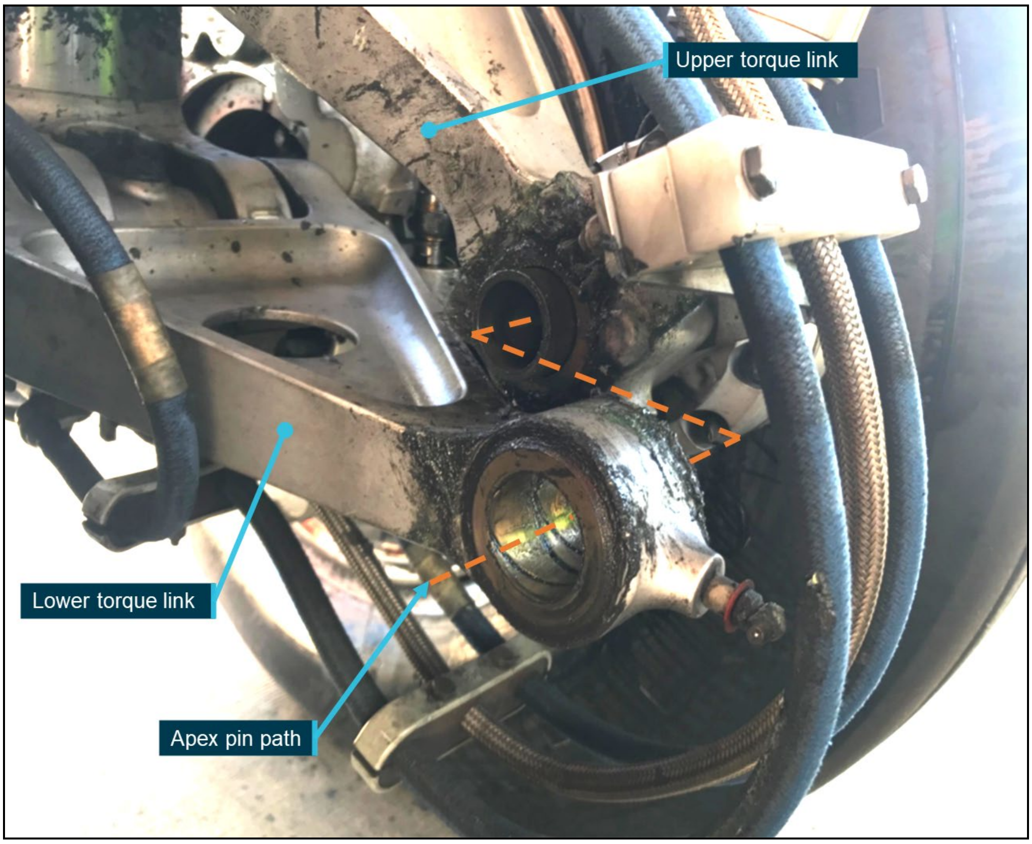
At 1059, believing there would be no further details from Line Maintenance, the aircraft left the holding pattern and was given vectors for an approach to land. The flight crew requested the airport's emergency services be put on a local standby.[8]

Around this time, Line Maintenance concluded the part was an A320 main landing gear (MLG) torque link apex pin and the Line Maintenance Supervisor (LMS) raised their concern with the Maintenance Operations Centre (MOC) [9] about the aircraft landing with such a fault. The MOC sought more information from the LMS. However, by the time MOC agreed with the LMS's concerns, the aircraft had safely landed.

At 1110, the aircraft landed and stopped on taxiway B9 (Figure 1) where it was inspected by the airport's Aircraft Rescue and Fire Fighting service fire commander. During the radio conversation between the fire commander and the FO, the FO discussed having a landing gear issue and that the aircraft was pulling to the left. The fire commander indicated that from their position in the vehicle, there were no visible issues with the aircraft.

The aircraft was then taxied on taxiway B to just short of taxiway B4 where Line Maintenance personnel inspected the MLG. The inspection found the left MLG[10] torque link apex pin was missing along with two bolts from the associated damper unit (Figure 3). A brake hydraulic hose was also frayed to the point of allowing fluid to escape. The aircraft was then slowly towed to the gate.

Figure 3: Main landing gear torque link assembly upon landing



[8] Local standby and emergency standby are the two levels of readiness by Aircraft Rescue and Fire Fighting service for an aircraft that has indicated a problem prior to landing at an airport. Local standby is the lower of the two levels and indicates the landing should be uneventful but the aircraft has some form of defect. Rescue services attend with a lower level of equipment based on the airport emergency plan.

[9] The Maintenance Operations Centre (MOC) is Jetstar's Continuing Airworthiness Management Organisation (CAMO) and covers Maintenance Watch and other engineering resources such as airport maintenance facilities.

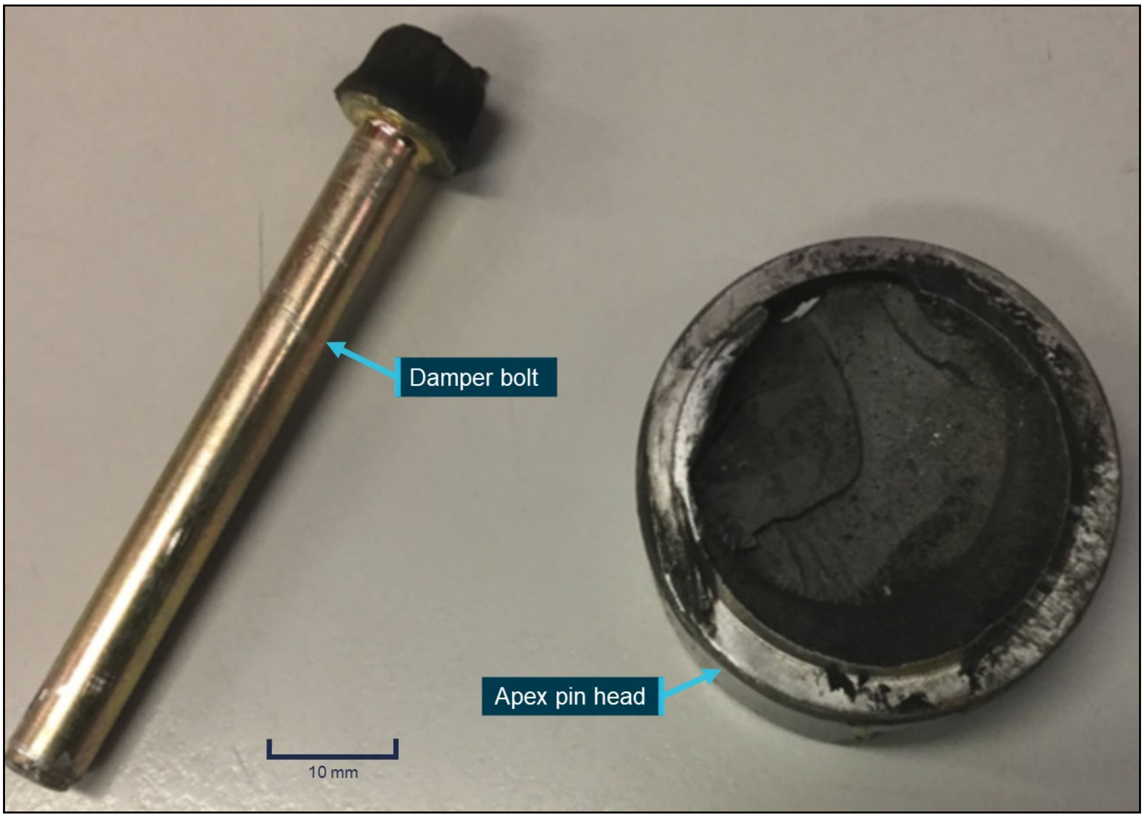
[10] All further references in this report to 'MLG' are associated with the left main landing gear unless otherwise noted.

Source: Jetstar Safety Department, annotated by the ATSB

After passenger disembarkation, the aircraft was to be towed to a hangar for inspection and repair. To reduce the potential for further damage, and as no spare apex pin was available, the failed pin was reinstalled and temporarily secured in place to ensure the landing gear stayed correctly aligned.

The following afternoon, the missing head of the apex pin and one damper bolt (Figure 4) were found by airport staff adjacent to the T3 intersection of runway 34R. Fifteen days later the second missing damper bolt was found during a routine FOD inspection of runway 34R.

Figure 4: A damper bolt and head of apex pin retrieved from runway 34R



Source: Jetstar Safety Department, annotated by the ATSB

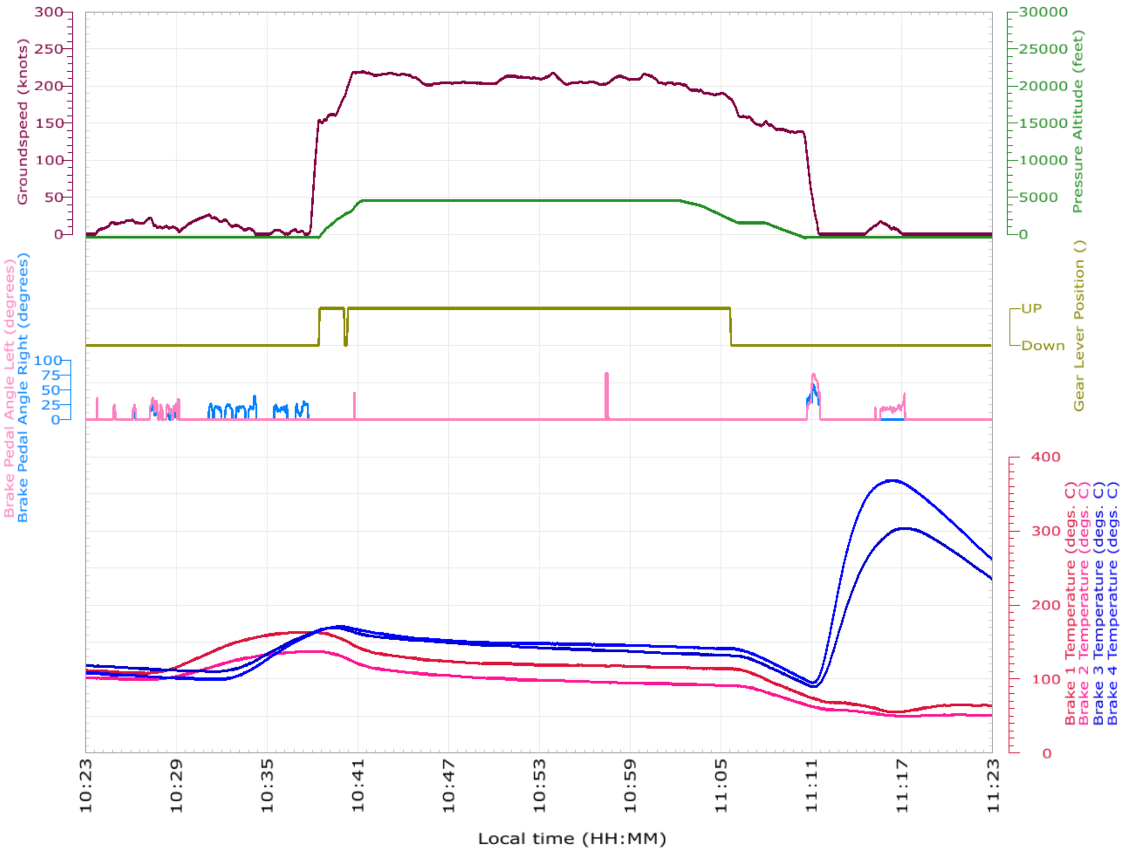
Context

Recorded data

Quick Access Recorder data

Quick Access Recorder (QAR) data (Figure 5) was retrieved from VH-VFN for the incident and prior flights. A review of the data from the previous two flights did not identify any anomalies.

Figure 5: Recorded data for the complete flight



During the initial climb on the incident flight, the aircraft did not successfully complete a full undercarriage retraction sequence, with the aircraft failing to sense the MLG up locks engaging and the gear doors closing. Approximately 90 seconds later the undercarriage extension/retraction was cycled with the landing gear being selected down successfully and then reselected up. Again, the aircraft failed to record a complete retraction of the MLG.

QAR data also showed that, on the taxi to the departure runway, left and right wheel brake applications were matched by temperature rises in the corresponding brakes. This was indicative of the brakes working correctly. On landing, despite application of both brakes, only the right wheel brake temperatures rose while the left brake temperatures continued to cool, implying the left wheel brakes were not functioning.

The aircraft manufacturer advised that an aircraft would remain directionally controllable at high speed due to the effectiveness of the fin and rudder, and at low speed with the nose wheel steering. With medium autobrake and the brakes of one wheelset failed, the calculated aircraft braking distance required increased from 1,360 m to 1,540 m. Sydney Kingsford Smith Airport runway 25 is 2,530 m and runway 34L is 3,962 m.

Electronic Centralised Aircraft Monitoring System data

The Electronic Centralised Aircraft Monitoring (ECAM) system displays messages to the crew via a dedicated interface and also sends the messages via the Aircraft Communications Addressing and Reporting System (ACARS)[11] to the operator's Maintenance Watch.[12] The following ECAM messages related to the undercarriage were presented on the incident flight.

Table 1: ECAM Messages

Phase	Date & Time (Local)	Title
05 – Lift Off	01 Aug 19 – 1039	L/G DOORS NOT CLOSED
05 – Lift Off	01 Aug 19 – 1039	L/G GEAR NOT UPLOCKED
06 – Cruise	01 Aug 19 – 1039	BRAKES RELEASED
06 – Cruise	01 Aug 19 – 1106	BRAKES ALTN BRK FAULT
06 – Cruise	01 Aug 19 – 1106	BRAKES RELEASED
08 – Touch Down	01 Aug 19 – 1110	L/G SYS DISAGREE
09 – 80kts	01 Aug 19 – 1110	BRAKES – N/WS MINOR FAULT

Source: Jetstar Safety Department. Only messages relevant to the undercarriage and wheel brake systems are listed here. Other messages that are not of a consequence to this incident were removed for clarity.

'L/G DOORS NOT CLOSED' is a high priority message whereas 'L/G GEAR NOT UPLOCKED' is a low priority message. Higher priority messages are listed and actioned first. The order of messages may have reinforced to the flight crew that the landing gear door was at fault. Instead, the landing gear door fault was most likely a consequence of the MLG failing to uplock due to the wheels not being in proper alignment.

While not providing specific information about the nature of the fault to the flight crew, the 'BRAKES ALTN BRK FAULT' message reflected the system sensing the damage to the left wheel brakes.

Aircraft information

The Airbus A320 is a twin-engine, narrow body transport category aircraft that seats up to 186 passengers (depending on configuration). VH-VFN was manufactured in 2013 and had completed 21,256 flight hours and 11,687 flight cycles.

Main landing gear strut

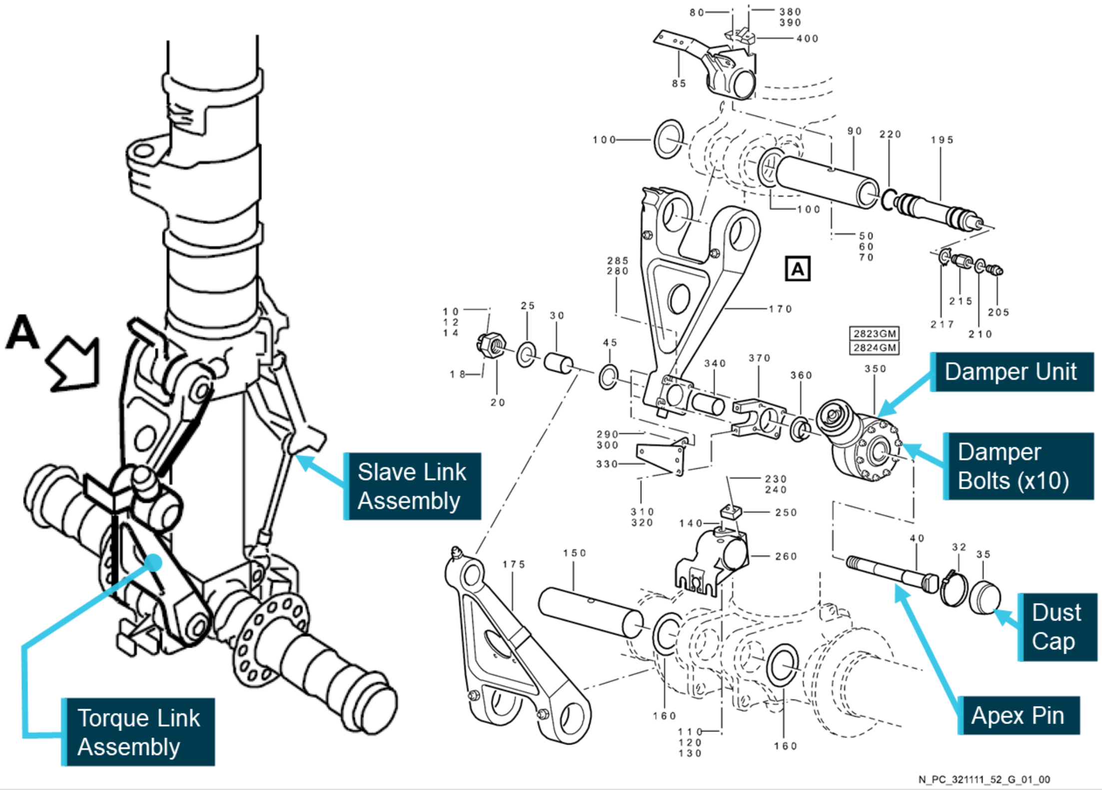
The aircraft has a conventional tricycle undercarriage arrangement. Each retractable main landing gear (MLG) consists of two wheels and brake assemblies, on a common axle centreline, one each side of the landing gear strut (Figure 6). Rotation of the oleo-pneumatic strut is constrained by a torque link on the forward side between the two wheels.

The apex pin of the torque link connects the upper and lower torque link. This allows rotational torque loads to be transmitted between the landing gear strut and axle, while allowing free vertical movement of the shock absorber contained within the strut.

[11] Aircraft Communications Addressing and Reporting System is a digital datalink system for transmission of short messages between aircraft and ground stations via airband radio or satellite.

[12] Maintenance Watch – Most airlines have a group called Maintenance Watch. This is an engineering part of the organisation that actively monitors the airworthiness status of the company's fleet, particularly aircraft flying. They monitor real-time aircraft data, including system warning messages, received by ACARS and arrange for aircraft swaps when aircraft become unserviceable. They also provide engineering expertise to the organisation and flight crew regarding the aircraft and its systems.

Figure 6: MLG assembly and exploded torque link assembly



Source: Airbus S.A.S. A320 series IPC Figure 32-11-11-52G (Sheet 1), modified by the ATSB

The apex pin also passes through a damper unit that attaches to the upper torque link. The head of the pin is protected from the environment by a rubber dust cap. The tail of the pin, nut, washer and locking pin assembly are protected by a coating of polysulfide sealant.

The upper and lower torque links also act as carriers for hydraulic brake hoses and an electrical harness connecting to equipment on the axles. Another link, known as the slave link, is fitted to the aft side of the strut and supports more hydraulic hoses and electrical wiring but is not designed to perform any anti-rotation function.

Aircraft damage

Detailed inspection of the aircraft MLG after the flight determined that, in addition to the failed apex pin, other items on the MLG were missing or damaged. These included:

- three hydraulic hoses damaged or frayed by contact with the wheel rim, with one hose leaking
- scoring damage to the apex damper unit following contact with the wheel rim and tyre, and two missing through bolts
- scoring damage to wheels, tyres and brakes from contact with the upper torque link and damper unit
- a cut wiring harness
- bending of the slave link.

The tyre treads had evidence of diagonal scoring which indicated that the MLG had not remained aligned with the aircraft during the landing.

Apex pin

Manufacturing process

The apex pin was manufactured from high strength steel in 2012. During its manufacture, the pin was initially roughly machined to oversize, heat treated to improve mechanical properties, and then machined to final size. The final machining included providing an undercut relief radius between the shank and the head, and formation of the head shape. Subsequently, parts of the pin underwent plating and corrosion protection processes. The part was subject to various manufacturing inspections, including a magnetic particle inspection (MPI),[13] which it passed (Manufacturer's investigation).

Maintenance inspections

The MLG on the aircraft was last inspected in November 2017 as part of the aircraft's maintenance program (AMP) 2C heavy maintenance inspection. During that assessment, the torque link was dissembled. The relevant inspection task required a check for excessive play in the hinge joints of the assembly, which it passed. The task did not require a visual or other non-destructive inspection (NDI) of the apex pin. With Jetstar utilisation of VH-VFN, the 2C heavy maintenance inspections occurred approximately every 2.5 years and the pin had undergone this maintenance task twice.

The maintenance program also required the undercarriage to be overhauled every 10 years or 20,000 flight cycles (FC), whichever occurred first. The overhaul included disassembly of the undercarriage, with the apex pin inspected in detail and subject to an MPI if repaired. VH-VFN had yet to reach this overhaul requirement.

The apex pin had a life limit of 60,000 FC.

Pre-flight inspection

The first officer (FO) conducted the required pre-flight walkaround inspection for the incident flight which included the MLG wheels, tyres and strut. The FO did not report any anomalies with the inspection.

Licenced Aircraft Maintenance Engineers (LAME) were responsible for inspections of the aircraft on the first flight of every third day. The occurrence flight was the third flight of the day, so no formal inspection of the aircraft was carried out by a LAME.

Rectification action

Approximately two months prior to this occurrence, a European-operated A320 had an apex pin failure. Upon notification of both events, the landing gear manufacturer was advised, and an investigation launched. The pin was identified as being from the same manufacturing batch as the one installed on VH-VFN. This pin had accumulated 12,340 flight cycles. Due to the two pin failures, Airbus recalled the remaining 10 pins from this batch via individual contact with operators. Cracking was subsequently identified in five of those pins.

As a result, Airbus issued Alert Operators Transmission (AOT)[14] A32N018-20 to operators worldwide on 23 January 2020, which recalled two batches either side of the initial batch (48 pins).

[13] Magnetic Particle Inspection: is a non-destructive inspection (NDI) process for detecting surface and shallow subsurface discontinuities in ferromagnetic materials. The process puts a magnetic field into the part which is distorted by the discontinuity. The change in magnetic field is highlighted by ferrous particles applied to the surface either dry or in a wet suspension.

[14] An Alert Operators Transmission is Airbus service documentation that requires immediate, urgent or timely action to be taken by an operator to ensure the ongoing safe operation of affected aircraft. It is broadly equivalent to a Service Bulletin and is usually issued in response to a newly discovered service fault that may affect other operators.

The affected pins were requested to be removed at the earliest opportunity. As a result of this action, 15 pins were found cracked.

On 27 April 2020, AOT A32N018-20 Rev 01 was issued to add inspections for a further 1,940 pins. Apex pins serial numbers added in this revision were requested to undergo an MPI at the operator's maintenance facilities. This action was reviewed by the European Union Aviation Safety Agency (EASA), and on 8 June 2020 EASA issued Airworthiness Directive (AD) 2020-0130, which mandated compliance with Airbus AOT A32N018-20 Rev 01.

In August 2020, as part of inspections required by EASA AD 2020-0130, Jetstar identified a total of 12 aircraft with apex pins, and one spare part, listed in the Airworthiness Directive that required inspection. Jetstar found one additional cracked apex pin during the conduct of these inspections. That pin had acquired 13,402 flight cycles and was listed in Appendix 4 of AOT A32N018-20 Rev 01. The serial number indicated it was manufactured prior to the other identified fractured pins.

The ATSB identified three other occurrences overseas where pins in service listed in Appendix 4 of AOT A32N018-20 Rev 01 had been found cracked and reported.

Manufacturer's investigation

The failed apex pin shank and head from VH-VFN, which had accumulated 11,687 flight cycles, were sent to the MLG manufacturer, Safran Landing Systems (Safran) for inspection and analysis.

Safran conducted an investigation that included a detailed examination of the fractured parts. It concluded the cracks were initiated during manufacture of the parts and the parts failed due to cyclic fatigue. The investigation reviewed both the manufacturing processes and inspections.

Manufacturing process

Safran determined that the small radius under the head of the initial machining introduced a stress concentration during a subsequent heat treatment quench hardening process,[15] that in some pins, resulted in the formation of a crack. The crack plane was found to align with the initial machined undercut (Figure 7). Despite a final machining process removing more material and providing a large relief radius under the head, some cracks were large enough so as not to be eliminated. Temper discolouration on the crack surface of some returned pins was indicative of the crack being initiated either during the quench process, or between the quench and temper steps of the heat treatment activities.[16]

In summary, Safran concluded the cracks were initiated during the manufacturing process and were not caused by environmental effects in service.

The vast majority of apex pins in service were inspected as part of the AD and found not cracked (Rectification action). Safran determined that this disparity was likely associated with manufacturing variations including tool sharpness, surface finish and quench bath temperature, even though those variations were within allowable limits.

In 2014, some apex pins were found cracked during a manufacturing inspection. With no evidence of prior inspection failures nor cracks being found in-service, no action was taken against parts already produced. However, in response to the defective batch, the initial radius under the head of the machined pin was increased.

Additionally, in 2018 the company generated a design guidance document for radii in high strength steel parts prior to heat treatment in response to inspection failures in different parts.

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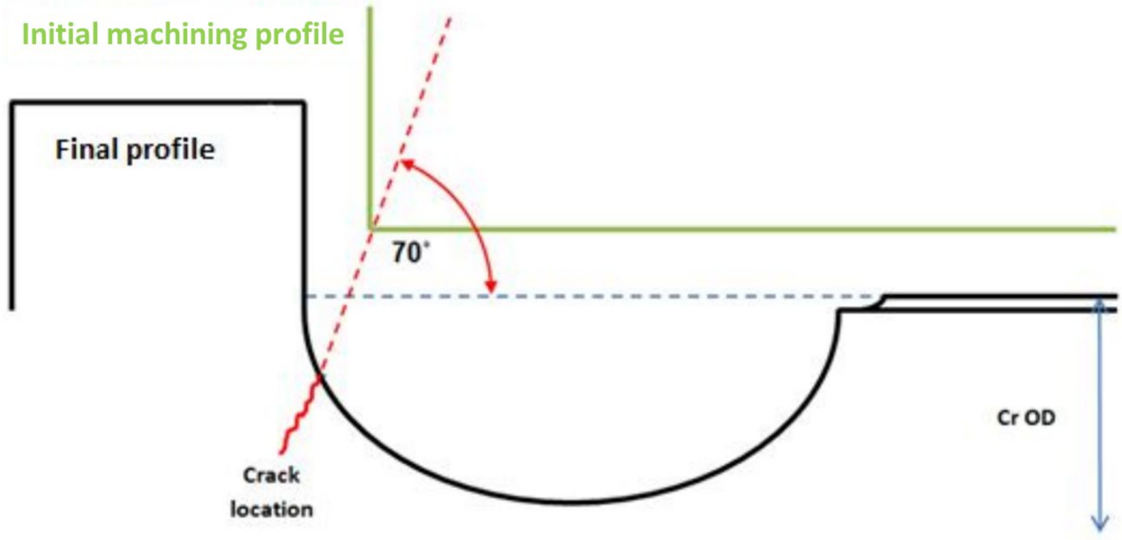
[15] Quench hardening is a mechanical process in which steel and cast-iron alloys are strengthened and hardened. The part is heat soaked at an elevated temperature (800-900ºC), then rapidly cooled in water, oil or air to set certain crystalline structures, locking in favourable mechanical properties.

[16] Quenched parts are often tempered to reduce brittleness and increase low fracture toughness that may result from the quench hardening process. It involves reheating the part to a temperature lower than the quench step (200-700ºC) and slowly cooling to relieve internal stresses and permit some crystalline restructuring.

Figure 7: Crack location



Source: Airbus S.A.S. modified by the ATSB

Manufacturing inspection

In accordance with Safran manufacturing procedures, apex pins underwent inspections during, and after, manufacture but before being released to service to ensure the part conformed to design specifications. Because the component was heat-treated to improve mechanical properties, the pin underwent an MPI. All pins in the occurrence batch passed the MPI inspection. That batch contained both pins that failed in service and five others subsequently found cracked.

The manufacturer's investigation found that the inspector who conducted the MPI inspection on the batch of parts met qualifications, performance reviews, audits, eyesight requirements and had demonstrated their ability via MPI rejection of other parts. No personal circumstances were identified that may have influenced the ability of the inspector to detect cracked components and the organisation's on time performance, capacity and production changes were also assessed with no unfavourable results. Part-specific NDT technique and MPI process controls were also checked and found to conform to specification requirements.

Communications during the flight

Jetstar Operations Control Centre (JOCC) was responsible for the coordination and day-to-day running of the aircraft fleet. The JOCC used company HF frequencies and satellite communications to pass updated weather and operational changes to aircraft in flight. These means of communication were also used by flight crew to seek engineering support from the Maintenance Operations Centre (MOC) who had a Duty Technical Manager (DTM) at the JOCC.

Jetstar also utilised company VHF airband frequencies at major airports to pass operational information to crews of aircraft on the ground as well as those airborne in the local vicinity. Flight crew could also use this local VHF frequency to advise engineers at the airport of maintenance issues with their aircraft. Jetstar policy was that for any abnormal operations or delays, the JOCC would coordinate communications and be responsible for the company response. Thus, the JOCC was the primary point of contact in the event of any abnormal operations.

Flight crew could use company frequencies at certain times of the flight, however, during take-off and approach to land, sterile flight deck procedures[17] were in place and flight crew did not monitor company radio frequencies, nor use ACARS.

Communication timeline

The following timeline of the occurrence and the communications during the incident was developed from multiple sources, mainly telephone calls and ATC VHF radio call records. As the Jetstar company VHF radio calls were not recorded, the times are approximate.

[17] A sterile flight deck environment incorporates procedures throughout safety critical phases of flight, such as take-off and approaches to landing, during which non-essential activities and communications by flight crew are not permitted.

Table 2: Timeline

Event	Time (local) (hh:mm:ss)	Elapsed Time (mm:ss)	Time until Landing (mm:ss)
Apex pin detached from VH-VFN	10:24:40 *	-	45:54
FOD reported on taxiway C by the crew of a following aircraft	10:25:59	1:19	44:35
FOD picked up by airport ground personnel (Car 4)	10:29:30	4:50	41:04
A Jetstar aircraft crew informed Jetstar Engineering of FOD report	10:30:00 *	5:20	40:34
VH-VFN take off	10:38:26	13:20	32:08
Car 4 informed ATC of the nature of part found on taxiway. First indication the FOD was an aircraft part	10:39:44	15:04	30:50
ATC asked taxiing aircraft JQ764 and JQ912 to contact their Engineering department	10:42:05	17:25	28:29
ATC informed the crew of VH-VFN of an aircraft part found on the taxiway	10:43:18	18:38	27:16
ATC informed the crew of VH-VFN that Qantas Engineering believed it was from the landing gear	10:44:50	20:10	25:44
Part arrived at Jetstar Line Maintenance	10:47:00 *	22:20	23:34
JQ912 indicated to ATC that they had been requested to return to the gate for an inspection	10:49:15	24:35	21:19
JOCC representative, Duty Captain, Safety and Maintenance Watch group call started	10:52:49	28:09	17:45
Jetstar Line Maintenance contacted Maintenance Operations Centre (separate to group call) to advise of part found and that the crew of VH-VFN should be contacted	10:59:00 *	34:20	11:34
VH-VFN commenced approach	10:59:24	34:44	11:10
JOCC representative, Duty Captain, Safety and Maintenance Watch group call ended	11:00:14	35:34	10:20
At the direction of the JOCC, Line Maintenance attempted to contact VH-VFN via company frequency.	11:05:00*	40:20	05:34
JOCC representative telephoned Sydney tower #1	11:08:01	43:21	02:33
JOCC representative telephoned Sydney tower #2	11:08:52	44:12	01:42
VH-VFN landed	11:10:34	45:54	-

* estimated

Sydney Airports Corporation Limited (SACL) Car 4 retrieved the FOD and took the part to Qantas Engineering, as the majority of aircraft using taxiway C were Qantas operated. Qantas Engineering identified the part as from an A320. As Qantas did not operate that aircraft type, they redirected SACL to Jetstar Engineering. The part subsequently arrived at Engineering about 23 minutes before VH-VFN landed.

Linking the two events

The ATC centre in Sydney linked the FOD to VH-VFN as they received information directly on both events, albeit through different controllers. This meant the crew of VH-VFN was informed an unidentified aircraft part had been found on the taxiway less than 5 minutes after the aircraft took off and only 3.5 minutes after the FOD was reported to ATC.

Information related to the discovery of the apex pin on the taxiway and VH-VFN's MLG retraction issues were received by separate parts of Jetstar. The organisation only had a limited time to link the two events given VH-VFN would turn off direct communication channels with the company during the approach which commenced 11 minutes before the landing.

Four Jetstar personnel (Jetstar Operations, Safety, Maintenance Watch and the Duty Captain) had a group call to brief and troubleshoot the reasons for VH-VFN returning to the airport. From the ECAM messages automatically relayed from the aircraft to Maintenance Watch, they correctly identified that the failure of the MLG leg to uplock was the primary issue and that the gear door not closing was a consequence.

Given it was the third flight of the day, they ruled out gear pins[18] still being installed as a cause. They concluded, at 1100, no action was required until the aircraft landed. At that stage, this key group was unaware that the apex pin remnant had been found and been with Jetstar Line Maintenance for 13 minutes.

Shortly after the group call ended, Jetstar representatives made multiple attempts to contact VH-VFN via company frequency which was indicative of the organisation successfully linking the two separate events.

Communication with aircraft

While airborne, the flight crew contacted Line Maintenance on the company VHF frequency at least twice. Line Maintenance informed the flight crew that a part had been found but it had not been positively identified. They further advised the flight crew to follow their procedures to manage the situation, which was in line with multiple Jetstar procedures manuals. The captain reported to the ATSB that they were frustrated that the part could not be identified.

The flight crew, having completed all checks, thinking that no further information from Line Maintenance would be forthcoming and believing it was only a gear door issue, initiated an approach for a return landing at Sydney Airport.

It was reported that contact with VH-VFN on the company VHF frequency was delayed in part due to reluctance to broadcast details over an open radio frequency. This was due the media and external persons often monitoring exchanges. It was mentioned in the company's administration manual for personnel to be mindful of this fact.

Direct radio contact with VH-VFN was additionally complicated when the company frequency became congested due to the 'hard stop' call by Line Maintenance going out to taxiing aircraft. Multiple taxiing aircraft were using the frequency to determine the reason for the call back and requesting gates to return to.

By the time the JOCC, MOC and Duty Captain contacted the flight crew via Line Maintenance on the company VHF frequency regarding the criticality of the now identified part, the aircraft was on approach to land. Due to sterile flight deck procedures, the flight crew was no longer monitoring the company radio frequencies or ACARS messages. As a result, the only effective means of contacting the aircraft at that time was via ATC. ATC procedures permitted the passing of messages from the operator to the aircraft during times of an emergency however, an emergency

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[18] Gear pins – are pin inserted into key locations in the MLG retraction mechanism to ensure the undercarriage cannot be inadvertently retracted on the ground. Pins will be installed while the aircraft is on the ground overnight or in maintenance but not during a turnaround.

had not been declared by the flight crew. JOCC personnel twice phoned the Sydney ATC but no requests were made by JOCC to pass on safety critical information to the aircraft.

In response to this event, the operator advised it had clarified non-normal operational communication guidance for ground crews in the Airport Operations Manual. This included dedicated phraseology for gaining priority on airband frequencies to relay high priority messages.

Safety analysis

Introduction

On departure from Sydney the Airbus A320 landing gear failed to completely retract. Faced with limited specific information on the nature of the malfunction, the flight crew made the decision to return to Sydney, landing safely. The ATSB found that the failure of the left main landing gear (MLG) torque link apex pin, which was found on a taxiway, allowed the wheels to rotate out of proper alignment. This stopped that landing gear from retracting and caused damage to other systems on the MLG.

This analysis will examine the reason for the apex pin failure along with the associated inspections and maintenance programs for identifying defects. In addition, it reviews the actions taken by the flight crew and ground-based support infrastructure during the incident.

The ATSB found the flight crew response to the incomplete undercarriage retraction and subsequent landing was conducted in a proficient manner.

Apex pin manufacturing

The apex pins were manufactured by initially machining an oversize profile, which was then heat treated and finally machined to size including a large relief radius under the pin head. The identification of temper scale on the crack face from the heat treatment was conclusive evidence that the crack found on the occurrence pin (and several others) was induced as part of the quenching process. The initiated cracks were large enough they were not completely removed by the subsequent machining process.

While it was established that the radius of the initial machining under the head was too small to prevent heat-related cracking, most pins did not crack. It was concluded that another factor, or factors, were required, in combination with the size of the radius, to initiate a flaw. These factors included variations in cutting tool sharpness, undercut surface roughness and/or the quenching bath temperature, even though these features may have been within prescribed tolerances.

Manufacturing inspection

The manufacturer's investigation of the post-manufacturing inspections focused only on the initial batch of 12 pins, two of which had failed in service and five pins were subsequently found cracked. The review of the human factors and organisational elements of the company at the time could not determine why these cracks were not found in this batch during the routine non-destructive testing (NDT) magnetic particle inspection (MPI).

Before the manufacturer's investigation was completed, and as a result of the airworthiness directive, 15 pins were found cracked from adjacent batches and four pins found cracked from other batches. These additional pins indicate it was unlikely cracking in pins at manufacture was a one-off event. The identification of cracks in 2014 that resulted in a manufacturing change also indicates that it was possible for cracks to be identified at manufacture.

Torque link disconnect

Following initiation of a crack during manufacture, the head of the apex pin fractured from the shank due to cyclic fatigue. The exact time of this event could not be determined. This left the apex pin shank free to migrate from the MLG upper and lower torque links thereby allowing them to disconnect just after pushback from the gate. The apex pin shank was shed onto the taxiway approximately 250 m from the pushback position.

The consequence of the torque link disconnection during the taxi and take-off was the misalignment of the MLG. During the flight the MLG was retracted twice. In both cases, either the MLG failed to lock in the retracted position or the MLG did retract successfully but the aircraft failed to sense this, i.e. sensor failure. Given the potential for misalignment without the apex pin, incomplete retraction of the MLG was considered the most likely reason. That conclusion is reinforced by the Captain's comment regarding the unusual airflow noise. Damage to other systems including the brake lines on the MLG was further evidence the wheel set rotated out of alignment, contacting the upper torque link and adjacent equipment.

Risk analysis conducted after the incident regarding the loss of brakes on one wheel set concluded that an aircraft would remain directionally controllable at high speed due to the effectiveness of the fin and rudder, and at low speed with the nose wheel steering. The braking distances were determined to have increased by approximately 10-15 per cent.

While the disconnected torque link reduced the directional stability and braking performance due to the misaligned axle and failed left brake set, the degradation was manageable and the aircraft landed safely. The use of runway 25 would have been acceptable, however the crew's choice to request and use the longer runway 34L was prudent.

Flight crew decision making

The failed apex pin was collected from the taxiway approximately 40 minutes prior to VH-VFN landing. Within 15 minutes of the part being collected from the taxiway, the crew were advised by ATC that the object was likely associated with an aircraft's landing gear. At about this time, the pin was delivered to Jetstar Line Maintenance. While Line Maintenance were identifying the part, Jetstar Operations Control Centre (JOCC) was troubleshooting the reported landing gear 'failure to uplock' issue with VH-VFN. Being unaware of the failed pin and based on information available to them, the JOCC determined the aircraft could be examined after landing.

After completing troubleshooting procedures, with no additional issues identified, the flight crew elected to return to Sydney Airport. During this time, the captain requested additional information on the part found on the taxiway from ATC and Jetstar however, at the time of those requests it had yet to be positively identified. While the flight crew perceived the issue to be associated with the landing gear door, they mitigated their limited information by requesting the longer runway and for emergency services to be on standby. In this instance, these measures were not required however, they were effective in enhancing safety for a landing with an unknown problem.

Communication

For airborne Jetstar aircraft, communication with the company was primarily received and coordinated by the JOCC through HF, ACARS or Satellite communication methods. For operational reasons, the company had a local company VHF frequency at many airports that flight crew could use to communicate with local ground and engineering staff for efficient running of the business.

While this was a valid and efficient secondary line of communication, the JOCC had no visibility of these communications. For this reason, Jetstar procedures required all entities of the company to inform the JOCC of diversions, delays, or defects. Any communications with airborne aircraft beyond normal routine operational messages were required to go through the JOCC/Duty Captain to ensure consistent and appropriate messages were passed to flying aircraft.

Messages to the flight crew before the formal identification of the part followed the operator's procedures/policy of only passing factual information to the aircraft crew. Having considered the provided information, the crew elected to return to Sydney Airport. While that decision was reasonable in the context of what the crew knew, the aircraft had 80 minutes of fuel remaining and there was no immediate urgency to return to the airport. It also meant that JOCC and Line Maintenance had a significantly reduced timeframe to identify and determine the severity of the fault. As such, an opportunity was lost for the organisation to gain a more complete picture of the situation while the aircraft was still airborne.

The company procedures prevented troubleshooting advice and non-factual information being passed to the aircraft. The policy was based on prior experiences of non-standard technical advice and workarounds being passed to aircraft, sometimes with detrimental effect.[19] However, advice to the flight crew that people on the ground were working to identify the part and a suggestion that the aircraft continue to hold until that time, if able, would have been valuable to the crew on this occasion. The captain stated in an interview that had they known the identity of the part, they would have changed their approach to the landing preparations, including preparing the cabin for an emergency landing and enacting airport emergency procedures.

Jetstar policy and procedures required Line Maintenance to notify the JOCC when it was realised the part may be from an airborne aircraft despite Line Maintenance being in contact with the flight crew. As the aircraft was airborne, it was the JOCC's responsibility to coordinate communication with VH-VFN. While that process was essential for ensuring accurate and coordinated information was passed to aircraft's flight crew, on this occasion, a potential message to the aircraft was delayed while the part's identity was clarified and confirmed by the JOCC.

Following positive identification that the detached pin created a potentially hazardous situation, ground personnel endeavoured to get a message to the flight crew. However, they were unable to contact them because the flight crew had started the approach to landing and, as per procedures, stopped monitoring the company frequency. Expeditious messaging to aircraft needs to be balanced with coordinated and accurate communication.

Failed apex pin temporarily reinstalled

Due to unavailability of spares, Jetstar temporarily reinstalled the failed apex pin shank into the torque link. This action was to enable safe towing of the aircraft to the maintenance hangar however, it had the potential to damage evidence on the fracture surface. At that time, the apex pin shank was the only piece of evidence available. Ultimately, the apex pin head was located, and analysis of both fracture surfaces determined the failure mechanism.

Notwithstanding unavoidable situations, where possible, preservation of evidence is vital in determining the circumstances of an occurrence and identifying safety issues that may present a hazard to continued operations.

[19] ATSB AO-2018-056 Depressurisation and crew incapacitation, Boeing 737-376SF, VH-XMO

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition, 'other findings' may be included to provide important information about topics other than safety factors.

Safety issues are highlighted in bold to emphasise their importance. A safety issue is 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 operating environment at a specific point in time.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the landing gear malfunction involving Airbus A320, VH-VFN that occurred on departure from Sydney Airport on 1 August 2019.

Contributing factors

- **During the manufacture of the apex pin, the initial machined profile led to unintended stress concentrations at the quench stage of the material heat treatment process that resulted in the part cracking. The crack was not removed by the final machining process. (Safety issue)**
- Despite apex pins being subject to magnetic particle non-destructive inspections during manufacture, for reasons that could not be identified, this inspection did not detect the crack that was present in the occurrence pin.
- The head of the apex pin failed due to cyclic structural fatigue, which led to disconnection of the left main landing gear (MLG) torque link. This left the MLG strut free to rotate out of fore/aft alignment.

Other factors that increased risk

- The MLG brakes failed due to the strut rotating and a wheel contacting and fraying a hydraulic hose. This most likely occurred during take-off.
- Despite the failed part and aircraft being positively identified by elements within Jetstar, a message was unable to be conveyed to the flight crew who returned for landing unaware of the true nature of the undercarriage defect and the associated risks. The additional information would have improved crew decision making.

Other findings

- The undercarriage failed to fully retract by not engaging the gear uplocks and not permitting the gear doors to fully close. This was likely due to the wheels and axle being out of alignment.
- The torque link disconnect, the consequential landing gear misalignment and brake failure had the potential to reduce directional control and braking performance on touchdown. However, the degradation was manageable and the aircraft landed safely.
- The failed apex pin was temporarily reinstalled by engineers to enable the towing of the aircraft off the taxiway and back to a gate for disembarkation. This had the potential to damage evidence on the fracture surface. At that time, the pin shank was the only piece of evidence available to understand the failure mechanism as the pin head had not yet been located.

Safety issues and actions

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues. The ATSB expects relevant organisations will address all safety issues an investigation identifies.

Depending on the level of risk of a safety issue, the extent of corrective action taken by the relevant organisation(s), or the desirability of directing a broad safety message to the aviation industry, the ATSB may issue a formal safety recommendation or safety advisory notice as part of the final report.

All of the directly involved parties were provided with a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

The initial public version of these safety issues and actions are provided separately on the ATSB website, to facilitate monitoring by interested parties. Where relevant, the safety issues and actions will be updated on the ATSB website as further information about safety action comes to hand.

Crack initiated during manufacture

Safety issue description

During the manufacture of the apex pin, the initial machined profile led to unintended stress concentrations at the quench stage of the material heat treatment process that resulted in the part cracking. The crack was not removed by the final machining process.

Issue number:	AO-2019-039-SI-01
Issue owner:	Safran Landing Systems
Transport function:	Aviation: Other
Current issue status:	Closed-Adequately addressed
Issue status justification:	Manufacturing process corrected and existing parts checked for airworthiness.

Proactive safety action taken by Safran Landing Systems

Action number:	AO-2019-039-PSA-01
Action organisation:	Safran Landing Systems
Action status:	Closed

In response to the two pin failures and the subsequent investigation, Safran Landing Systems reviewed the manufacturing process and identified that subsequent to the pins' manufacture, the manufacturing process had been amended to include a larger initial machining radius under the pin head. This change significantly reduced any stress concentrations under the head that may be induced by the heat treatment process. Additionally, the company generated a design guidance document for radii in high strength steel parts prior to heat treatment.

Proactive safety action taken by Airbus

Action number:	AO-2019-039-PSA-04
Action organisation:	Airbus
Action status:	Closed

In response to the two pin failures, Airbus issued AOT A32N018-20 on 23 January 2020, which recalled some apex pins. As a result of analysis conducted, AOT A32N018-20 Rev 01 was issued on 27 April 2020 expanding the number of pins to be inspected. As result, aircraft operators were adequately informed of the issue and could take appropriate action.

Proactive safety action taken by European Union Aviation Safety Agency

Action number:	AO-2019-039-PSA-05
Action organisation:	European Union Aviation Safety Agency (EASA)
Action status:	Closed

In response to the two pin failures and the subsequent investigation conducted by Airbus, EASA issued airworthiness directive AD 2020-0130 on 8 June 2020, which mandated the inspections required by Airbus AOT A32N018-20 Rev 01. As result, aircraft operators were adequately informed of the issue and could take appropriate action.

ATSB comment

The ATSB reviewed the above proactive safety action taken by Safran Landing Systems, Airbus, and the European Union Aviation Safety Agency (EASA) and determined the action adequately addressed the issue. The manufacturing processes have been corrected, including the development of design guidance material for the development of any future components with similar features. The existing components that may have contained cracks have been recalled through direct communication and via inspection mandated by an EASA Airworthiness Directive.

Safety action not associated with an identified safety issue

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Additional safety action Jetstar Airways

In response to this event, the operator advised it clarified non-normal operational communication guidance for ground crews in the Airport Operations Manual. This included dedicated phraseology for gaining priority on airband frequencies to relay high priority messages.

General details

Occurrence details

Date and time:	1 August 2019 – 1110 EST	
Occurrence class:	Incident	
Occurrence categories:	Landing gear / Indication, Objects falling from aircraft, Hydraulic	
Location:	Sydney Airport, New South Wales	
	Latitude: 33º 56.77' S	Longitude: 151º 10.63' E

Aircraft details

Manufacturer and model:	Airbus A320-232	
Registration:	VH-VFN	
Operator:	Jetstar Airways Pty Ltd	
Serial number:	5566	
Type of operation:	Air Transport High Capacity	
Departure:	Sydney, New South Wales	
Destination:	Sydney, New South Wales	
Persons on board:	Crew – 6	Passengers – 160
Injuries:	Crew – Nil	Passengers – Nil
Aircraft damage:	Minor	

Glossary

ACARS	Aircraft communications addressing and reporting system
AD	Airworthiness directive
AMP	Aircraft maintenance program
AOT	Alert operator transmission
ARFF	Aircraft rescue and fire fighting
ATC	Air traffic control
DTM	Duty technical manager
EASA	European Union Aviation Safety Agency
ECAM	Electronic centralised aircraft monitoring
FC	Flight cycles
FO	First officer
FOD	Foreign object damage
	Foreign object debris
JOCC	Jetstar Operations Control Centre
LAME	Licenced aircraft maintenance engineer
LMS	Line maintenance supervisor
MJO	Manager Jetstar Operations
MLG	Main landing gear
MOC	Maintenance operations centre
MPI	Magnetic particle inspection
NDI	Non-destructive inspection
NDT	Non-destructive testing
SACL	Sydney Airports Corporation Limited
QAR	Quick access recorder
VHF	Very high frequency

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the captain of the incident flight
- Jetstar Airways Pty Ltd
- Airbus
- Safran Landing Systems
- Bureau d'Enquêtes et d'Analyses (France)
- Airservices Australia
- Sydney Airport Corporation Limited
- recorded data from the Quick Access Recorder on the aircraft.

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section 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 following directly involved parties:

- the flight crew
- Jetstar Airways Pty Ltd
- Airbus
- Safran Landing Systems
- Bureau d'Enquêtes et d'Analyses (France)
- Civil Aviation Safety Authority

Submissions were received from:

- a flight crew member
- Jetstar Airways Pty Ltd
- Airbus
- Safran Landing Systems
- Bureau d'Enquêtes et d'Analyses (France)

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- independent investigation of transport accidents and other safety occurrences
- safety data recording, analysis and research
- fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

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

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining liability. At the same time, 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. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.