Australian Government
Australian Transport Safety Bureau

Aircraft preparation event involving A320, VH-FNP

Perth Airport, Western Australia on 14 August 2018

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2018-063
Final – 11 September 2019

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Publishing information

Published by: Australian Transport Safety Bureau
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Addendum

Page	Change	Date

Safety summary

What happened

On 14 August 2018, a Virgin Australia Regional Airlines (VARA) A320, registered VH-FNP, was prepared for a scheduled passenger flight from Perth Airport, Western Australia, to Christmas Island. Landing gear ground locks (LGGL) were fitted to the landing gear of FNP during the preparation, and were not removed prior to pushback. A ground handler removed the locking pins from the LGGL, but did not remove the associated sleeves.

As the aircraft was pushed back, taxied and took off from Perth Airport, the LGGL sleeves fell from the landing gear, onto a taxiway and Runway 21. The remainder of the flight was uneventful and FNP landed safely at Christmas Island.

What the ATSB found

The ATSB found that a lack of documentation relating to installing and removing LGGL from VARA A320s, and an ineffective handover of responsibilities between two engineers, contributed to the engineers not detecting that the LGGL remained installed during the preparation for flight.

Although the flight crew aircraft exterior walk-around check identified the LGGL, this was at a time when the flight crew did not have access to the flight deck due to maintenance work on the flight deck. The disrupted pre-flight sequence for the flight crew contributed to the flight crew later not identifying that the LGGL were missing from the stowage compartment on-board.

There was no procedure for making maintenance log entries when LGGL were installed and removed. A maintenance log entry relating to LGGL would have provided another opportunity for both the flight crew and the on-board engineer to become aware that the LGGL had not been removed and stored on-board before flight.

Rather than inform an engineer or pilot as per procedures, the pushback driver removed the LGGL pins from the landing gear sleeves before pushback. This decision was affected by time pressure and prior experience removing pins from another aircraft type. However, as the lanyards attaching the pins to the sleeves was missing and the pushback driver did not understand the LGGL locking mechanism, he removed the pins and not the sleeves.

What's been done as a result

VARA introduced procedures requiring an authorised person to sign an Aircraft Readiness Log to certify that LGGL had been removed prior to flight. If the aircraft has been towed after the initial check, the check must be performed again. Towing procedures also now require the approved brake rider to ensure that LGGL have been removed after a positional tow.

VARA have also issued a notice to flight crews instructing them to use a standardised method for stowing LGGL pins and sleeves. A separate notice reminds ground handlers they should not remove pins themselves.

Safety message

This investigation highlights how a number of relatively small errors and/or omissions, associated with separate functional areas, can combine to potentially affect flight safety. In this case, the identification and rectification of any one factor would probably have significantly reduced the likelihood of the occurrence developing.

While all persons working in and around aircraft have specific roles, they also have a responsibility to notify the operating crew about any concerns they may have with the aircraft. It is imperative that any concerns are assessed and rectified by appropriately qualified personnel before flight.

Contents

The occurrence

What happened

On 14 August 2018, Virgin Australia Regional Airlines (VARA) was operating an Airbus A320-231 (A320), registered VH-FNP (FNP), on a scheduled passenger flight from Perth, Western Australia to Christmas Island. The scheduled departure time was 1305 local time.

Aircraft tow to departure bay

To prepare for departure, ground handling personnel towed FNP from the domestic apron to its departure bay at the international terminal. In preparation for this tow, a VARA Aircraft Maintenance Organisation (AMO) engineer (the apron engineer) fitted landing gear ground locks (LGGL)[1] to the landing gear of FNP. The apron engineer then performed the aircraft brake operator (ABO)[2] duty, as FNP was towed onto its departure bay at 1117.

At 1121, the apron engineer left FNP, as he had been instructed to supervise the refuelling of another aircraft. The apron engineer anticipated that he would return after the other aircraft had been refuelled, at which time he planned to supervise the refuel of FNP and remove the LGGL.

During this time, VARA engineers were working in the cockpit of FNP to rectify a defect with a navigational display. Another engineer who was travelling with FNP to Christmas Island (on-board engineer), was assisting with the rectification work. When the apron engineer left FNP, he anticipated that it might sit for some time due to the rectification work, possibly resulting in the aircraft being unserviceable for the planned flight.

Pre-flight walk-around

The flight crew for FNP comprised the captain, first officer (FO), and an augmenting crewmember.[3] For the first sector (to Christmas Island), the captain would be pilot flying (PF) and the FO would be pilot monitoring (PM).

The flight crew arrived at the aircraft about one hour before the scheduled departure time. The crew were unable to access the cockpit to conduct their pre-flight procedures because of the rectification work. An engineer advised the captain it would take about 30 minutes to complete the works, so the crew waited in the passenger cabin.

The captain tasked the augmenting crewmember with conducting the exterior walk-around, which he commenced at about 1202. During the walk-around, the augmenting crewmember observed that the LGGL were still fitted. He considered removing the LGGL but determined he could not do so safely.

After completing the walk-around, the augmenting crewmember returned to the cabin, and reported to the captain that the LGGL remained installed. The captain acknowledged this, and anticipated that the normal departure procedures would lead to the removal of the LGGL prior to flight.

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1 The design and function of the LGGL are explained in the context section of this report, and are shown in Figure 1.

2 The ABO rides with an aircraft during a tow. The ABO operates aircraft systems as required, including the aircraft brakes. This role is also referred to as the brake rider.

3 An augmented crew is a flight crew comprising more than the required minimum to operate the aircraft. Operators utilise augmented crews in order to ensure crewmembers do not exceed duty and flight time limits set out by relevant regulations (*Civil Aviation Order 48.1 2013*).

Refuelling

As the departure time approached, the apron engineer identified that he would be unable to return to FNP in time to supervise the refuel. Consequently, he phoned the on-board engineer and asked that he take over the remaining engineering duties for FNP, including supervising the refuelling.

At 1217, 48 minutes before the scheduled departure time, the on-board engineer left the flight deck of FNP. When the on-board engineer arrived at the refuelling console (on the fuselage under the wing), the refueller was already at FNP and had been waiting for some time. The on-board engineer recalled that the task of supervising the refuelling had been given relatively late in the pre-departure schedule for FNP.

From 1217 to 1245, the on-board engineer supervised the refuel, then returned to the flight deck.

Pre-flight cockpit preparation

The flight crew gained access to the cockpit about 30 minutes prior to the scheduled departure time. This was about 30 minutes after the augmenting crewmember had advised the captain that the LGGL were still installed.

The captain and the FO commenced their pre-flight procedures and checklists, performing allocated tasks as PF and PM respectively. These procedures started about 30 minutes later than normal, relative to the scheduled departure time.

Pushback and dispatch

At about 1247, the pushback driver and the dispatcher, employed by the ground handling agent Swissport, were in a pushback tug vehicle in front of FNP. The ground handlers had finished loading baggage onto the aircraft and were waiting for passengers to board before commencing pushback (using the tug vehicle) and dispatch duties.

While waiting in the pushback vehicle, the pushback driver saw pins and associated flags attached to the landing gear of FNP, which he considered unusual. The pushback driver made multiple attempts to radio the aircraft movements co-ordinator (AMCO) over a period of about 10 minutes, in order to request an engineer to inspect the pins. The pushback driver was unable to contact the AMCO.

At about 1258, seven minutes prior to the scheduled departure time, the pushback driver removed the LGGL pins from the landing gears, but unknowingly left the associated locking sleeves in place. The pushback driver placed the pins in the pushback vehicle.

Shortly after, the pushback driver went into the cockpit to have the load sheet signed by the flight crew. The dispatcher communicated with the crew via a headset plugged into the aircraft, to confirm all doors and panels were secured and that the aircraft was clear to push back. Neither ground handler mentioned the LGGL to the crew.

As FNP was pushed back, at about 1328, one of the LGGL sleeves fell unnoticed from the aircraft onto the taxiway. As FNP took off at 1339, a second sleeve fell from the aircraft onto Runway 21.

Identification of foreign object debris

In the two hours following the departure of FNP, there were a number of reported observations of foreign object debris (FOD) on Perth Airport runways and taxiways.

- At 1414, the crew of an arriving aircraft contacted air traffic control to report sighting FOD on Runway 21. A Perth Airport operations officer inspected the runway, but was unable to detect the FOD.
- At 1420, another arriving aircraft reported observing FOD at the northern end of Runway 21. A second operations officer located one of the LGGL sleeves adjacent to the Runway 21 precision approach path indicator.
- At 1510, the second LGGL sleeve was located in the taxi line behind bay 153/154.

Approach to Christmas Island

On descent into Christmas Island, the flight crew of FNP received a satellite phone call from VARA flight management, who advised of the discovery of LGGL parts at Perth Airport and asked that the flight crew check the flight deck stowage compartment for LGGL pins and sleeves. The flight crew identified that the LGGL parts were missing from the stowage compartment.

Considering the LGGL were unaccounted for, the flight crew identified there was a risk the landing gear was potentially damaged. The flight crew modified their approach plan so that the landing gear was lowered earlier, which gave the flight crew additional time to respond to any abnormal indications.

The approach and landing into Christmas Island was uneventful. The landing gear operated normally and there were no other indications of abnormalities.

Upon landing at Christmas Island, the flight crew notified the on-board engineer that the LGGL had not been stowed on-board FNP. The on-board engineer conducted a visual inspection of the landing gear and underside, and observing no damage, certified that FNP was serviceable.

Context

Indian Ocean Territory operations

The planned flight to Christmas Island was part of an Indian Ocean Territory (IOT) service, which VARA operated twice a week. On the day of the occurrence, the service departed from Perth to Christmas Island, before continuing to Cocos Islands then returning to Perth.

Augmented crew

Due to the duty time length for the IOT service, VARA operated the occurrence flight with an augmented crew. The augmenting crewmember on-board FNP was a training Captain who was qualified to perform the roles of both the first officer (FO) and captain.

The augmenting crewmember did not have any specified duties in the pre-flight sequence. However, it was common practice for augmenting crewmembers to conduct the exterior walk-around. The IOT service contained several additional requirements in terms of the pre-departure workload for the flight crew, so delegating the walk-around to the augmenting crew reduced the load on the pilot monitoring.

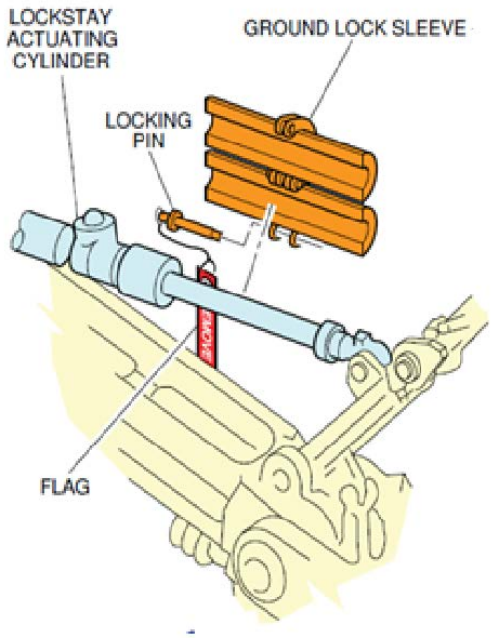
A320 Landing Gear Ground Locks (LGGL)

Landing gear ground locks are used to ensure physical down-locking of landing gear during towing operations when hydraulic power supply is not available. The LGGL for Airbus A320 aircraft comprise locking sleeves that fit around the landing gear, preventing the collapse or retraction of that gear, and pins that hold the sleeves in place. There are two types of LGGL used on A320s, those which secure the landing gear strut and those which secure the landing gear door actuating cylinder. The LGGLs installed on FNP were landing gear strut lock sleeves.

Figure 1 illustrates the design of the LGGL, whereas Figure 2 shows the LGGL used on FNP.

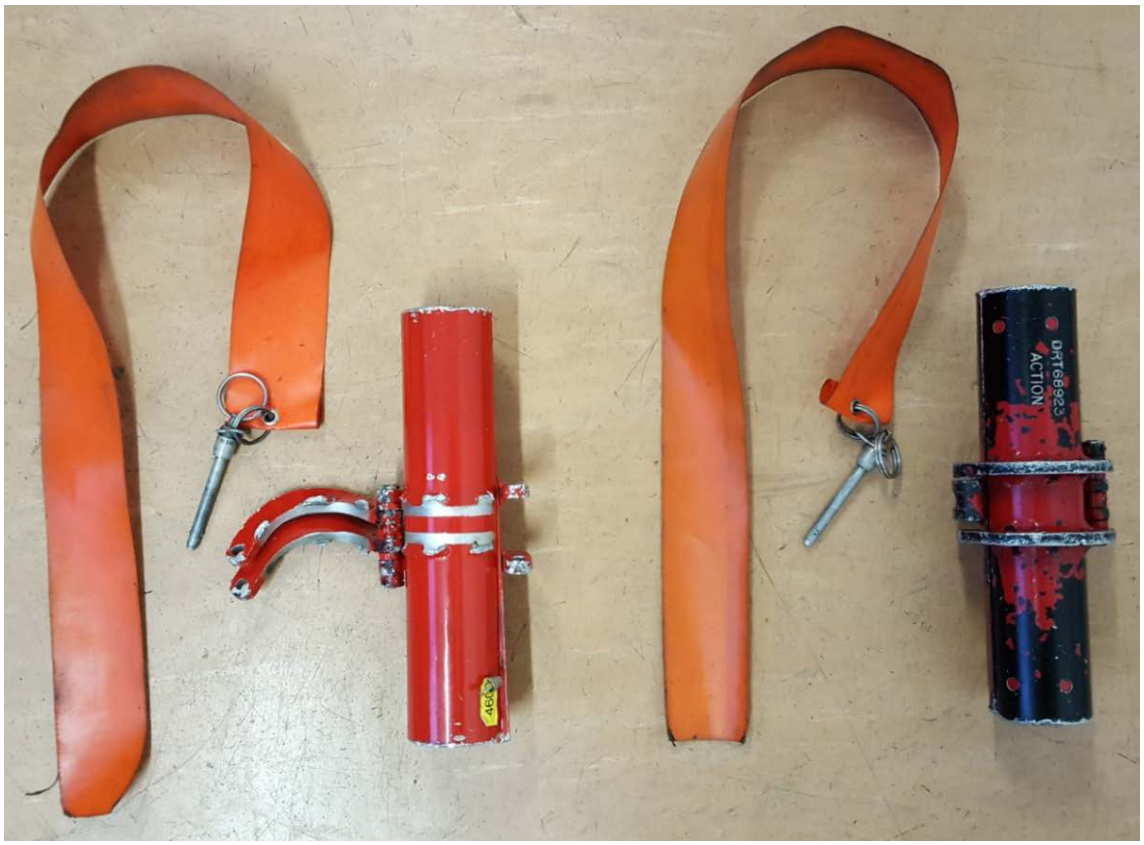
In normal operations, the LGGL would be removed from the aircraft prior to flight and stored in the flight deck stowage compartment.

Figure 1: Schematics showing design of LGGL strut locks



Source: Airbus, amended by ATSB

Figure 2: LGGL pins, flags and sleeves installed on VH-FNP



Source: VARA

As shown in Figure 1 and Figure 2, the LGGL have several design features to make them conspicuous. The LGGL sleeves are painted red and the pins have high-visibility flags attached.

Under normal conditions, a wire lanyard secures the LGGL sleeves to the pins, preventing separation of the two components. The lanyards were missing for both sets of LGGL on VH-FNP (FNP), a condition that had not been reported prior to the occurrence. The operator conducted a check across their fleet and missing lanyards were also found on two other aircraft.

VARA AMO procedures for using LGGL

The ATSB reviewed the systems and procedures in place to manage the installation and removal of LGGL from VARA A320 aircraft during and after a positional tow.[4]

VARA Approved Maintenance Program A320 (AMP)

This manual provided a detailed description of maintenance procedures for VARA A320 aircraft, and was applicable to VARA Aircraft Maintenance Organisation (AMO) personnel. The AMP did not provide procedures for towing. There were no procedures relating to installing or removing LGGL following a procedural tow.

A320 Aircraft Maintenance Manual (AMM)

This manual described the maintenance procedures for the A320 as specified by Airbus. The AMM stated that safety devices (LGGL) were to be installed on landing gear prior to towing. The AMM did not describe steps for removing LGGL after completing a tow.

[4] A positional tow is a specific activity meaning towing an aircraft from one bay to another to reposition the aircraft.

Virgin Group Operations Manual: Airport Airside Operations Manual (AAOM)

The AAOM provided instructions for towing Airbus A330 and Boeing 737 type aircraft. The instructions specified the requirement to install and remove LGGL, and that the Aircraft Brake Operator (ABO) riding on the aircraft during the tow was responsible for doing this task for these aircraft types.

The AAOM did not describe towing procedures for A320s, nor the responsibilities of the ABO for this aircraft type. The only mention of landing gear pins on A320s in the AAOM was in the section on aircraft dispatch procedures for A320s and Fokker 100 aircraft. These procedures stated that removal of landing gear pins was the responsibility of the flight crew and engineering.

VARA line maintenance procedures (LMP)

The LMP in effect at the time of the occurrence (dated 11 September 2017), noted that towing should be conducted in accordance with the AMM. Limited other guidance was provided in these procedures and there was no documentation for installing or removing pins as part of towing procedures. The section titled 'Removal of locking and safety devices' was empty, denoted as 'Reserved'.

The previous version of the LMP (dated 9 September 2016) provided a summary description of the tasks involved in towing aircraft, but did not document a step for removing LGGL after a tow was completed. The section titled 'Removal of Locking Devices' stated:

- The captain was responsible for ensuring all locks prior to flight, and must confirm with the first officer that lock pins had been removed and stowed on board the aircraft.
- Authorised aircraft maintenance engineers must remove locks and stow them on the aircraft.
- The dispatcher would provide an additional check during the pre-dispatch walk-around to ensure all locks had been removed.

Procedures as understood by engineers

The ATSB found that there were no specific procedures for removing LGGL from A320s after a positional tow. Consequently, the ATSB examined the engineers' understanding of the process for installing and removing LGGL.

At interview, the on-board engineer said that the normal sequence after towing an aircraft onto the departure bay was for the engineer to remove the LGGL and stow them on board the aircraft. The on-board engineer indicated it was not normal practice to leave the LGGL on aircraft.

The apron engineer said it was approved practice for engineers to leave pins in place after towing an aircraft, particularly if the aircraft was likely to sit for a while or may be unserviceable and towed off the bay. In such circumstances, engineers would leave the LGGL installed after performing the tow and only remove the LGGL when they returned to supervise the refuel.

Recent changes to pre-flight engineering duties

In the months preceding the occurrence, changes to the responsibility for performing pre-flight dispatch duties for VARA aircraft affected the procedures used by engineers.

Prior to the change, VARA AMO engineers were responsible for dispatch. The process included a walk-around safety check, including a check of the landing gear prior to the departure of each aircraft. Engineers involved in this occurrence said that any LGGL left installed through the preparation of the aircraft would be removed at this point.

On 21 May 2018, Swissport (then Aerocare) took responsibility for dispatch duties. AMO engineers advised that they continued to conduct informal walk-arounds after dispatch duties transferred to Swissport, although there was no requirement to do so. The on-board engineer

advised that he did not perform a walk-around after supervising the refuel of FNP because he perceived that he was running late and there was no requirement to perform a walk-around.

Handover of VARA AMO Engineering Duties

For this incident, the handover of engineering duties for FNP was conducted orally (via mobile phone). The two VARA AMO engineers recalled that they could clearly hear the other. However, their recollections of the handover content differed:

- The apron engineer recalled that he advised the on-board engineer that FNP was on the bay and needed to be refuelled. The apron engineer also recalled that he advised that the pins (meaning LGGL) were still installed on FNP.
- The on-board engineer recalled that the request was to perform the refuel only and that he was not told that the pins remained on FNP.

The apron engineer recalled he perceived the handover had been effective at the time. Neither engineer recalled confirming their understanding of the remaining tasks following the handover.

The VARA AMO did not have documented procedures or training relating to the handover process between engineers.

Flight crew pre-flight procedures and checklists

Formal procedures and checklists are essential for overcoming the limits of pilot memory, and ensuring that actions are completed in sequence and without omission. According to Degani and Wiener (1990):

> The major function of the flight deck checklist is to ensure that the crew will properly configure the airplane for any given segment of flight. It forms the basis of procedural standardisation in the cockpit

The pre-flight procedures and responsibilities for VARA A320 flight crews were described in the Flight Crew Operating Manual A320 (FCOM) and the A320 Quick Reference Handbook (QRH)

Preliminary cockpit preparation

The flight crew perform the preliminary cockpit preparation procedure prior to all flights. The procedure included checking that the three landing gear pins and pitot tube covers were on board and stowed. The QRH assigns this duty to the pilot monitoring (PM).

The FO and the captain indicated that the normal sequence was to check the stowage compartment during the process of exiting the cockpit to conduct the exterior walk-around checks. The stowage compartment on-board FNP was located in such a way that it was difficult to check the LGGL while seated in the flight seat.

The ATSB noted that the check of the stowage compartment was not necessarily dependent on the walk-around, although the crew perceived the tasks were normally performed together.

Exterior walk-around

The exterior walk-around was part of the normal duties for the PM and occurred immediately after the preliminary cockpit preparation procedures. The exterior walk-around comprises a sequential check of the exterior of the aircraft, including checking that the nose, left main, and right main landing gear safety pins have been removed.

The VARA Flight Operations Policies and Procedures Manual (FOPPM) was applicable to all aircraft operated by VARA. The FOPPM described additional procedures applicable where LGGL

remain fitted during the exterior walk-around. In these circumstances, the FOPPM stated that the captain must:

- Direct that the LGGL are removed prior to taxiing.
- Confirm the LGGL have been removed by the display of the locks/pins by an authorised person from an appropriate position on the ground.
- Acknowledge (in the form of a 'thumb up' sign) indicating he/she is satisfied that all locking devices have been removed. (The first officer can also perform this acknowledgement).

The augmenting crewmember performed the exterior walk-around for FNP according to procedure, before returning to the aircraft and telling the captain that he had observed the LGGL were still installed. The augmenting crewmember conducted this walkaround while the remaining flight crew were waiting in the passenger cabin. However, there is no evidence that the captain subsequently directed or confirmed the removal of the LGGL as documented in the FOPPM.

Before start checklist

The Before start checklist is part of the Normal checklist and is called after cockpit preparation is completed. The VARA A320 Normal checklist was designed such that all actions should be completed from memory prior to the flight crew calling for and performing the Normal checklist, reading from a laminated card. The VARA FOPPM stated:

> The normal checklist is the most effective method of identifying procedural omissions and is the last line of defence in preventing an undesired aircraft state.

The Normal checklist is a challenge-response type checklist. The pilot flying (PF) was responsible for calling for the checklist, while the PM was responsible for reading checklist items. The PF was then responsible for checking the relevant system, before responding to the PM. For the 'Cockpit Prep is completed' checklist item, both the PM and PF are responsible for confirming the status of the aircraft.

The Before start checklist was designed to be performed in two parts, with the parts separated by a line. The crew had to perform checks of seven aircraft systems before pushback, then four further system checks after pushback. The first two items on the checklist were:

- Cockpit Prep is completed
- Gear Pins and Covers are removed

The captain reported that although he was aware the flight crew did perform the Before start checklist, he did not have a specific memory of this checklist from the occurrence flight. The FO did not report any details about the Before start checklist either. Consequently, the ATSB could not verify the specific actions of the flight crew in conducting this checklist. It is not unusual for individuals to have difficulties recalling a particular iteration of a highly-practiced task, and no inference is made regarding the captain's difficulty remembering the Before start checklist for this flight.

Procedural tasks and errors

Procedures and checklists are important defences against equipment failures and other adverse events, and the failure to perform them properly can have severe consequences for flight safety.[5] Nonetheless, research has found that checklist deviations occur relatively frequently, relative to other forms of deviation from operating procedures. Such deviations include missed checklist items, procedures performed at inappropriate stages of flight, verbal response to checklist items without actually sighting the item, and performing flow-check procedures as read-do (Dismukes and Berman, 2010).

[5] For example Helios Airlines Boeing 737 accident, 14 August 2005. For a description of checklist errors associated with this accident, see Dismukes and Berman, 2010.

A substantial body of research has investigated conditions associated with checklist and procedural deviations in the context of aviation. In particular, research on prospective memory errors in aviation has identified a number of task situations that increase prospective memory demands and may increase the likelihood of error.

Episodic tasks

In situations where pilots are required to remember to perform an action at a later time, prospective memory is negatively affected when that action is not usually performed. In the context of flight operations, the time between forming an intention and the window of opportunity to act, is often filled with other tasks and demands that will divert a pilot's attention away from what they need to remember to do. In such circumstances, pilots often forget to perform the delayed task.

The flight crew of FNP were required to delay their usual checks, including checking the on-board stowage compartment and acting on the report from the augmenting crewmember, until they were able to access the flight deck. The captain reported that by the time he was able to access the cockpit, other information had 'got in front' of the augmenting crewmember's report.

Interruptions

Interruptions during the pre-flight sequence can significantly affect flows and checks. Line observation research showed that flight crews experience frequent and unpredictable interruptions during pre-flights, which takes their attention from allocated tasks (Loukopoulos, Dismukes and Barshi, 2001). This research also showed that because interruptions mean pilots were required to form and defer intentions, this increased the likelihood of error.

During the pre-flight preparations for this flight, the crew experienced several interruptions. The captain recalled there were inaccuracies in the maintenance log and loading documentation, and that he needed to attend to this and re-check the documentation prior to certifying the airworthiness of FNP. Moreover, the pre-flight sequence involves a high level of workload for the flight crew, with many competing requirements. In the context of the preparation of FNP, there were other tasks and demands the flight crew attended to after gaining access to the flight deck.

Loss of normal cues and routines

As normal procedures are highly structured, and flight crews conduct these procedures over many hundreds of flights, the procedures become highly habitual over time. Along these lines, Dismukes (2008) reports that pilots often develop significant cue-behaviour associations for routine tasks. Importantly, Dismukes notes that when the prompting cue for those tasks is removed, pilots are more likely to forget to perform the task.

In this occurrence, the normal sequence for the PM pre-flight tasks was in a sequence involving standing up for the intention to leave the cockpit for the walk-around. With practice, the actions associated with standing and doing the walk-around probably developed cue-behaviour associations with other tasks in particular checking the cockpit stowage compartment.

Methods for ensuring procedures and checklists are completed

Formal safety systems and individual strategies can be used to prevent checklist deviations, to help ensure procedures and checklists are performed appropriately.

In terms of formal systems, the operator provided training to support the ability of flight crews to manage distraction and disruption, and assessed flight crew competence on those skills. In particular, pilots received threat and error management classroom training, and were assessed on these skills as part of cyclical simulator training. The classroom training included education for pilots on the effects of distractions and interruptions, and advised crews to manage distraction using a range of techniques, including re-starting interrupted checklists, and using memory aids. The flight crew for FNP had all received passing assessments for threat and error management skills in their most recent simulator assessments, prior to the incident.

The flight crew of FNP recalled a number of strategies, which they normally used while conducting procedural tasks and checklists. The main strategy was to use materials available within the cockpit to create a visual reminder of an outstanding or otherwise required action. For example, the captain described using the pull-down cockpit compass to remind him that further action was required. The FO reported turning the Quick Reference Handbook manual from portrait to landscape orientation to provide a similar reminder. The flight crew also reported using the take-off data cards to create written reminders.

However, these strategies rely on access to the cockpit. In this case, the flight crew's normal process was disrupted due to delayed access to the cockpit, so their normal strategies were unavailable.

Maintenance log requirements for LGGL

The maintenance log records the details of maintenance activities performed on an aircraft, in order to meet regulatory requirements relating to issuing certificates of release to service. When a maintenance activity is performed, engineers make a maintenance log entry to record the details of that activity, as well as a second entry to certify that the activity is completed.

VARA Continuing Airworthiness Management Organisation (CAMO) procedures did not define installing and removing LGGL as a maintenance activity, so there was no requirement to record these activities in the maintenance log.

Use of maintenance log by flight crews

As part of the preliminary cockpit procedure, the captain reviews documentation, including the maintenance log, to determine the airworthiness of the aircraft. In this way, the maintenance log provides a means of ensuring safety-critical maintenance information is communicated effectively between the flight crew and the engineers.

The captain reported that during the preparation of FNP, he checked the documentation associated with the serviceability of the aircraft, including the maintenance log. However, the log did not contain an entry regarding the LGGL as an entry was not required by the procedures.

Use of maintenance log by engineers

The maintenance log also functions as a means for engineers to determine the maintenance status of an aircraft. The log is relatively unambiguous regarding maintenance activities that are yet to be certified as completed.

In the pre-flight sequence for the occurrence flight, the on-board engineer used the maintenance log to record the stowage of the engineer's flyaway kit on-board FNP. The maintenance log did not record any activities related to fitting and removing the LGGL, nor was there any requirement to record these activities.

Previous occurrence

On 12 April 2016, a VARA Fokker 100 aircraft departed from Perth Airport with landing gear pins (equivalent to LGGL) attached. The pins had been fitted so that the aircraft could be towed prior to the flight, but had not been removed. The aircraft was required to conduct an air turn-back, and safely landed at Perth Airport.

An internal investigation by the operator found that the captain had conducted an external inspection and identified the pins. However, the captain had regarded removing pins as an engineering function and assumed that they would be removed prior to departure. An engineer had conducted a pre-dispatch walk-around inspection, but had not detected or removed the pins.

The operator subsequently recommended that the VARA CAMO consider making the installation and removal of gear pins an action that requires a maintenance log entry. This would require engineers to sign when pins were installed, and sign-off when they were removed. After a review,

the operator introduced an Aircraft Readiness Log, which would perform the same function as described above. The log was introduced on 8 October 2018. The recommended actions had not yet been implemented at the time of the A320 incident on 14 August 2018.

Ground handling context

Ground handler background information

The pushback driver was trained for both the pushback and dispatcher roles for A320 aircraft. On the day of the occurrence, the pushback driver was performing the role of leading hand on an IOT flight for the first time without supervision. Being new to this role, he felt additional pressure to ensure he did everything correctly. The pushback driver also felt pressure to get the aircraft out on time, because he did not want delays to affect his subsequent flights that day.

Prior to this occurrence, the pushback driver had removed pins from Boeing 737 aircraft. The pushback driver described this as being done to assist the engineers, and as having occurred under the supervision of the engineers. The pushback driver recalled that the 737 has pins in a similar position to the LGGL on the A320. He also thought the A320 LGGL were equivalent to pins on a 737 and was not aware that the A320 LGGL had a sleeve. The on-board engineer also recalled instances of ground handlers assisting engineers by removing pins from aircraft.

The dispatcher was trained for the dispatcher duties on A320 aircraft, although was new to the role. When the ground handlers considered removing the LGGL from FNP, the dispatcher deferred to the judgement of the pushback driver.

Ground handler procedures and training

A320 procedures for ground handlers require the dispatcher to perform a walk-around check prior to departure. The procedures also instructed ground handlers to ‘be aware’ of landing gear pins, and indicated that the dispatcher should check that landing gear pins have been removed during the walk-around. The procedures stated that any abnormalities (such as unexpected pins) must be reported to the pilot in command immediately after the walk-around.

The training material for the dispatcher role described a similar procedure to the above. The training materials stated the dispatcher should report anomalies to the captain and/or an engineer.

The ground handler training did not show or describe the LGGL specifically. There was no indication in any training material relating to what the LGGL were, or how they function.

Pushback driver understanding and usual practices

At interview, the pushback driver noted he had been taught that if he saw anything unusual or unexpected on an aircraft, he should ‘tell somebody, either a supervisor or the AMCO, try to get an engineer’. The pushback driver reported he had been taught this during initial training, and could not recall any further reinforcement of this procedure.

The pushback driver reported that, in the context of responding to unusual observations during aircraft preparation, he would normally try to contact the AMCO, to get an engineer. The pushback driver reported this occurred very infrequently, noting that the last time he had cause to contact an engineer about an unusual observation was six months prior to this occurrence.

Factors affecting non-communication with flight crew

The decision to remove the LGGL pins and not contact the flight crew was contrary to procedures and training. The pushback driver reported that he did not consider contacting the flight crew. There were several opportunities for both the pushback driver and the dispatcher to communicate with the crew throughout the pre-flight sequence, and there was no technical barrier to this communication.

The ATSB considered whether a high power gradient between the ground handlers and the flight crew contributed to the non-communication. Pilots have substantially more aviation knowledge

and more status in the context of the operation, and this is can lead to a high power gradient between them and the ground handlers. Research has shown that individuals are less likely to raise concerns with individuals they perceive to have significantly more power than they do.

Communication between the ground and the plots is a regular requirement of the ground handler roles, as part of dispatch and receipt duties. The pushback driver reported that he felt ‘fine’ talking to the crew, although he indicated his preference was to communicate with engineers. The pushback driver stated that when he entered the cockpit to deliver the loading information, the LGGL did not seem important and that his main concern was getting the aircraft out. This implies the pushback driver did not mention the LGGL due to a perception of importance, rather than reluctance due to power gradient.

In terms of safety systems which may reduce the problematic effects of power gradients, non-technical skills training completed by the flight crew included content which described the impacts of very high power gradients, specifically the importance of creating an atmosphere where others feel safe to communicate concerns. The flight crew had all received passing assessments for communication skills for the non-technical skills components of their most recent simulator assessments, prior to the incident.

Although a high power gradient may have existed, there was insufficient evidence to determine that this influenced the non-communication between the crew and the ground handlers.

Safety analysis

Ineffective handover of engineering duties

The handover of pre-flight engineering duties between the VARA Aircraft Maintenance Organisation (AMO) engineers did not effectively transfer the responsibility to remove landing gear ground locks (LGGL) from VH-FNP (FNP).

Handing over duties from one person to another has been found to be associated with increased risk of error and accidents (Parke and Kanki, 2008). The main risk associated with handover is that critical task information is lost. There are two primary mechanisms of possible information loss during a handover: critical information may be omitted, or it may not be correctly received.

The ATSB was not able to establish exactly what was said during the handover, or how it was said. The on-board engineer reported that following the handover, he did not know the LGGL remained on FNP. The two engineers reported different accounts of the handover, further supporting the absence of effective communication. It is likely that one or both form(s) of information loss occurred.

The risk of information loss during handover is influenced by the mode and methods used to conduct handover. Research has shown that oral-only handovers are associated with much higher levels of error, when compared to handovers that supplement oral methods, such as using note-taking or printed information (Bhabra, Mackeith, Monteiro, & Pothier, 2007).

Although oral-only handover is associated with greater information loss, effective communication and listening methods can moderate this. These include closed loop communication, where both the sender and receiver actively confirm that the message was transmitted as intended. Research suggests that this is effective at ensuring team members maintain shared awareness, even in complex environments (Bearman, Paletz, Orasanu and Thomas, 2010).

The ATSB did not identify any training or other materials which supported the use of effective communication skills in this context. It is possible that the use of oral-only handovers, and the absence of training or other supports for these handovers, increased the risk of information loss.

Because the handover was not effective, the on-board engineer had no expectation that the LGGL pins may have been in place on FNP when he supervised the refuel. It is likely that this contributed to the on-board engineer actions which resulted in him not detecting the LGGL pins.

Towing procedures not documented

There were no procedures specifying when or how LGGL were to be removed from VARA A320s after positional tows. Procedures which did specify these requirements did not apply to A320s.

Reason (1997) describes how the absence of appropriate formal procedures produces the conditions for the development of work-arounds and other informal practices. Where no formal procedures exist, individuals will tend to improvise and develop procedures based on their own understanding. Such improvisation is associated with high levels of error.

Procedures also facilitate a shared understanding of how and when tasks are done. Research has shown that successful team performance requires that team members develop shared mental models for the job and the task, which relate to how the task is performed, in terms of what procedures are involved (Mathieu, Goodwin, Heffner, Salas, & Cannon-Bowers, 2000). Appropriate, accessible written procedures facilitate the development of this shared understanding between team members.

Although the importance of procedures may seem abstract, these concepts were illustrated in the occurrence. The absence of appropriate procedures for removing LGGL meant that the engineers

did not have an appropriate reference for how that task should be performed, and instead used their own informal procedures.

The engineers had different understandings of the task of removing LGGL from A320s. The apron engineer stated that it was accepted practice for LGGL to be left installed on aircraft after positional towing. In contrast, the on-board engineer reported that normal practice was to remove LGGL from the aircraft after a tow.

The absence of a procedure for removing LGGL contributed to the absence of shared understanding between the engineers regarding the removal of LGGL from FNP. This contributed to the LGGL remaining in place throughout the preparation of FNP.

Expectancy affected detection of LGGL

The on-board engineer had opportunity to sight the LGGL after leaving the cockpit and walking to the refuelling panel. It is likely that if the on-board engineer observed the LGGL, he would have removed them appropriately and placed them in on-board stowage compartment. The ATSB determined that the LGGL were likely to have been highly conspicuous, and there were no indications that fatigue or visual obstruction were contributory. However, the on-board engineer reported that he did not expect to see the pins when he supervised the refuel.

Research shows that expectation affects attention and perception, influencing what people detect and whether they attend to information (Wickens and McCarley, 2008). As identified in the phenomena of inattentional blindness, people can fail to detect even highly salient targets when they are not expecting to see them (Simons, 2000).

It is likely that the on-board engineer's low level of expectancy that the LGGL would be installed on FNP reduced the likelihood he would to detect the LGGL.

Flight crew disrupted in pre-flight procedures

The flight crew of FNP omitted several checks and actions that would normally have detected that the LGGL had not been stowed on-board the aircraft as required. These were:

- The captain did not perform the required actions after the augmenting crewmember advised the LGGL remained on FNP during the exterior walk-around.
- The first officer (FO) did not check the landing gear stowage compartment.
- Neither the captain nor the FO identified that the LGGL were not stowed on-board during the Before start checklist. It is likely that these items were not performed, or that the crew responded to the checklist items without visually inspecting the associated systems.

It is unlikely that role confusion associated with the delegation of the walk-around contributed to the omission of the cockpit stowage check by the FO.

The flight crew were delayed in accessing the flight deck. Consequently, the captain needed to remember that the LGGL had been observed during the walk-around, but could not act on this information for around 30 minutes. The captain did not implement any alternative reminder and relied on his memory to remember to perform a future action. After the crew gained access to the flight deck, they had other demands associated with the pre-flight. It is likely that the delay adversely affected the captain's ability to remember to act on the LGGL information.

The delay also meant that the crew did not have access to the usual reminders they would employ as a method to ensure checks were performed, as these methods relied on access to the cockpit.

Because the walk-around task was delegated to the augmenting crewmember, the FO varied his normal sequence of pre-flight checks. When the FO entered the cockpit, and sat in the flight seat to conduct his pre-flight checks, there was no requirement to leave his seat because the augmenting crewmember had already performed the walk-around. The sequence of events he normally relied upon to check the stowage compartment was not necessary, so there was no cue

for him to check the stowage compartment and this step was missed. In general, it is preferable to manage delays and interruptions by ensuring that procedures are performed in their usual sequence. Where there are known barriers to completing procedures, it may be preferable to delay commencing those procedures until the barriers are removed.

As summarised, the normal pre-flight sequence for the flight crew was disrupted due to maintenance work on the flight deck and delegation of the exterior walk-around check. This contributed to the flight crew not identifying that the LGGL were missing from the stowage compartment on-board FNP.

No maintenance log requirement for LGGL

Installing and removing LGGL was not defined as a maintenance activity. Consequently, there was no requirement for VARA AMO engineers to make maintenance log entries for these tasks. This meant that when the captain reviewed the log during the preliminary cockpit preparation procedure, there was no indication that the LGGL remained fitted to the aircraft and not stowed on-board the aircraft.

In the absence of maintenance log entries, the flight crew relied on visual checks during the pre-flight procedures to check. The context in which these checks occur, being the pre-flight sequence, can be characterised as typically involving a high level of workload, with frequent interruptions and distractions. As illustrated in this occurrence (and in the research literature), such conditions increase the likelihood of flight crews omitting pre-flight checks (Loukopoulos, Dismukes and Barshi, 2001).

This absence of LGGL maintenance log requirements also affected the ability of the on-board engineer to identify that the LGGL remained on FNP. This meant that engineers relied on oral-only methods to communicate the status of this task. As there was no requirement for VARA engineers to conduct a walk-around, there were limited other opportunities for the on-board engineer to notice that the LGGL had not been removed prior to flight.

It is likely that a maintenance log entry relating to LGGL would have provided another opportunity for the flight crew and the engineer to become aware that the LGGL had not been removed and stored on-board FNP before flight.

Pushback driver decision to remove LGGL pins

The pushback driver recognised that the LGGL pins and associated flags needed to be removed before flight. Although it was outside of his procedures, the pushback driver decided to remove the LGGL pins from the landing gear of FNP, but inadvertently did not remove the LGGL sleeves from the landing gear. Because the pins were removed prior to the dispatcher walk-around check, there was no opportunity for the dispatcher to identify the LGGL during that check. Neither the pushback driver nor the dispatcher advised the flight crew that the LGGL had been detected and/or removed. These decisions and the result was influenced by the following.

Time pressure

Research has shown that when individuals make decisions under pressure, they tend to sample less information overall (Wright, 1974), and perceptions of time pressure can reduce decision-making and judgement performance (DeDonno and Demaree, 2008). Time pressure is also associated with the use of less-analytical decision-making.

After attempting to contact the AMCO for around 10 minutes the pushback driver perceived pressure to ‘get the aircraft out’. This perceived pressure was partly due to the pushback driver wanting to perform well as a new leading hand on IOT flights. The ATSB established that there was no pressure explicitly placed on the pushback driver to expedite tasks during the preparation of FNP. It is likely that perceived time pressure influenced his decision to remove the pins from FNP.

Pushback driver's experience removing pins from Boeing 737s

When the pushback driver perceived the pins on FNP, he recognised this as being similar to prior experiences of removing pins from 737 aircraft. The pushback driver perceived that he would be able to remove the pins FNP, and that this action was required to prepare FNP for flight.

Pushback driver's lack of understanding of LGGL mechanism

Although the pushback driver correctly recognised the pins needed to be removed before flight (as indicated by the flags), he did not realise the sleeves also needed to be removed. The ATSB noted that the role of a ground handler is limited in scope and responsibility. There was no requirement for a global understanding for aircraft systems or equipment, including the LGGL. Conducting a procedure outside of his responsibility therefore greatly increased risk as his actions were then reliant on an understanding of a system he had not been trained in (Rasmussen, 1983).

Missing lanyards

As the wire lanyard was missing for both sets of LGGL, there was no physical defence to ensure the sleeves could not be left on the aircraft without the locking pins in place. While a last line of defence, such a simple mechanism would have been an effective protection against an occurrence such as this.

Findings

From the evidence available, the following findings are made with respect to the aircraft preparation event involving A320, VH-FNP (FNP) at Perth Airport, Western Australia on 14 August 2018. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- The handover of pre-flight engineering duties between engineers did not effectively communicate the requirement to remove landing gear ground locks (LGGL), contributing to the on-board engineer having no expectation of any further requirement to perform additional checks or tasks relating to the exterior of the aircraft.
- There was no formal documentation regarding when LGGL pins should be removed following a positional tow. The absence of a formal process contributed to the LGGL remaining in place throughout the preparation of FNP, and the on-board engineer having no expectation that the LGGL were still installed when he supervised the refuel.
- The normal pre-flight sequence for the flight crew was disrupted due to maintenance work on the flight deck and delegation of the exterior walk-around check. This contributed to the flight crew not identifying that the LGGL were missing from the stowage compartment on-board FNP.
- The operator did not have a procedure for making maintenance log entries when LGGL were installed and removed. The maintenance log entry relating to LGGL would have provided another opportunity for the flight crew and the engineer to become aware that the LGGL had not been removed and stored on-board FNP before flight.
- Rather than inform an engineer or pilot as per procedures, the pushback driver removed the LGGL pins from the landing gear sleeves before pushback. However, as the lanyards attaching the pins to the sleeves was missing and the pushback driver did not understand the LGGL locking mechanism, he removed the pins and not the sleeves.

Safety issues and actions

The safety issues identified during this investigation are listed in the Findings and Safety issues and actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

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

Additional safety action

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 actions in response to this occurrence

Responding to a previous occurrence involving gear pins (LGGL) not being removed prior to flight, VARA reviewed existing procedures and industry practice. VARA introduced an Aircraft Readiness Log and associated procedures, which meant that an authorised person must sign a log entry whenever LGGL pins were installed and removed, to certify that LGGL have been removed prior to flight. If the aircraft has been towed after the initial check, the check must be performed again. This procedure was communicated to involved parties within VARA, the VARA Approved Maintenance Organisation and VARA Continuous Airworthiness Maintenance Organisation, as well as other affected parties, on 5 December 2018.

The memo issued on 5 December 2018 also updated towing duties for procedural towing. The memo specified that it is the responsibility of the approved *brake rider* (Aircraft Brake Operator) to ensure that the LGGL are installed before towing, and removed after towing is completed. The memo also specified that the Aircraft Brake Operator document the actions in the Aircraft Readiness Log.

VARA issued a notice to flight crews in April 2019 which instructed them to use a standardised method of stowing LGGL pins and sleeves in the stowage compartment. Flight crews were instructed to stow the LGGL such that the flag ends were partially exposed, to assist with easier identification during the pre-flight inspection.

VARA also issued a ‘Safety Alert’ message to all ground handlers after the incident. This message emphasised that ground handlers should not remove LGGL pins, and instructed them to notify either the pilot-in-command or maintenance personnel if they were to observe gear pins installed during their walkaround or prior to an imminent pushback. The message also showed photographs of A320 and Fokker F100 landing gear with pins installed and removed.

General details

Occurrence details

Date and time:	14 August 2018, 13:28 WST	
Occurrence category:	Incident	
Primary occurrence type:	Aircraft preparation	
Location:	Perth Airport, Western Australia	
	Latitude: 31° 56.4180' S	Longitude: 115° 58.0200' E

Aircraft details

Manufacturer and model:	Airbus A320	
Registration:	VH-FNP	
Operator:	Virgin Australia Regional Airlines Pty Ltd	
Type of operation:	Air Transport High Capacity - Passenger	
Persons on board:	Crew – 3	Passengers – Unknown
Injuries:	Crew – 0	Passengers – 0
Damage:	Nil	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- flight crew
- engineers
- ground handling personnel
- aircraft operator.

References

Bearman, C., Paletz, S. B., Orasanu, J., & Thomas, M. J. (2010). The breakdown of coordinated decision making in distributed systems. *Human factors*, *52*(2), 173-188.

Bhabra, G., Mackeith, S., Monteiro, P., & Pothier, D. D. (2007). An experimental comparison of handover methods. *The Annals of The Royal Surgical College England*, 298-300.

DeDonno, M. A., & Demaree, H. A. (2008). Perceived time pressure and the Iowa Gambling Task. *Judgment and Decision making*, *3*(8), 636.

Degani, A., & Wiener, E. L. (1990). *The human factors of flight deck checklists: The normal checklist (NASA Contractor Report 177549)*. Moffett Field, CA: NASA Ames Research Centre.

Dismukes, R. K. (2008). Prospective memory in aviation and everyday settings. *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives*. NASA Ames Research Centre.

Dismukes, R. K., & Berman, B. (2010). *Checklists and Monitoring in the Cockpit: Why Crucial Defenses Sometimes Fail*. Moffett Field, CA: NASA Ames Research Centre.

Loukopoulos, L. D., Dismukes, R. K., & Barshi, I. (2001). Cockpit interruptions and distractions: A line observation study. In *Proceedings of the 11th international symposium on aviation psychology* (pp. 1-6). Ohio State University Press Columbus, OH.

Mathieu, J. E., Goodwin, G. F., Heffner, T. S., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology, 85*(2), 273-283.

Parke, B., & Kanki, B. G. (2008). Best practices in shift turnovers: Implications for reducing aviation maintenance turnover errors as revealed in ASRS reports. *The International Journal of Aviation Psychology*, *18*(1), 72-85.

Reason, J. (1997). *Managing the Risks of Organisational Accidents*. Routledge.

Simons, D. J. (2000). Attentional capture and inattentional blindness. *Trends in cognitive sciences*, *4*(4), 147-155.

Wickens, C. D., & McCarley, J. S. (2008). *Applied Attention Theory.* Boca Raton: Taylor & Francis Group.

Wright, P. (1974). The harassed decision maker: Time pressures, distractions, and the use of evidence. *Journal of applied psychology*, *59*(5), 555.

Submissions

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

A draft of this report was provided to Virgin Australia Regional Airlines, Swissport, CASA, the captain, first officer, augmenting crewmember and onboard engineer on board VH-FNP, the apron engineer and the pushback driver.

Submissions were received from Virgin Australia Regional Airlines and Swissport. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The ATSB is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: 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 that fall within the ATSB's jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

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

Purpose of safety investigations

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

It is not a function of the ATSB to apportion blame or determine 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.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

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

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

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Terminology used in this report

Occurrence: accident or incident.

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

Contributing factor: a factor that, had it not occurred or existed at the time of an occurrence, then either:

(a) the occurrence would probably not have occurred; or

(b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or

(c) another contributing factor would probably not have occurred or existed.

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

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