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Australian Transport Safety Bureau

Ground collision with airport infrastructure involving British Aerospace AVRO 146-RJ85, VH-NJW

Perth Airport, Western Australia | 30 July 2019

Investigation

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Addendum

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Safety summary

What happened

On 30 July 2019, a British Aerospace BAe146-RJ85 aircraft, registered VH-NJW and operated by National Jet Express (Cobham), was being prepared for a charter flight from Perth Airport to Granny Smith, Western Australia. During the pre-flight checks, the flight crew did not identify that there was no pressure in the braking system and did not pressurise this system prior to engine start.

Around the time of the start of the final engine in the starting sequence, the aircraft began to roll forward.

The dispatcher noticed the aircraft rolling and alerted the crew. The crew attempted to use their foot brakes and the park-brake, however, there was no brake pressure. Around 18 seconds after the aircraft started to roll, it collided with objects at the edge of the apron.

What the ATSB found

The ATSB found that the flight crew did not effectively check the brake pressure during pre-flight checks. Procedures required that the captain check brake pressure during two separate checklists, which provided two opportunities to pressurise the hydraulic system before engine start. There was also a shared responsibility for the first officer to monitor and cross-check. These checks were not done effectively and as a result, the crew did not identify that there was no available pressure prior to engine start.

The operator's dispatch practices did not involve placing chocks on the nose-wheel once the main wheel chocks were removed for engine start. At engine start, there was no brake pressure restraining the aircraft, nor was there any chock to prevent an inadvertent roll forward. The combined thrust of the four aircraft engines at idle and the slight apron slope caused the aircraft to inadvertently roll forward.

The absence of braking pressure also meant that the crew were not able to stop the aircraft with the aircraft brakes. The crew had a very limited opportunity to take corrective action before the aircraft collided with infrastructure. It is likely that the short distance to the terminal and the influence of surprise combined to reduce the pilots' ability to respond.

What's been done as a result

Cobham have sent a notice to check and training captains reminding them of the importance of vigilance during checklists.

Cobham have also reported that they plan to revise procedures to include the requirement to use nose-wheel chocks when dispatching from stand-off bays and to align all applicable procedures to capture this requirement.

Safety message

This investigation highlights the importance of ensuring all checklist items are addressed.

As highlighted in this accident, individuals can be vulnerable to omit checklist items and this can lead to accidents. Aviation safety relies on a resilient safety system involving multiple defences. In the context of multi-crew operations, one of the key defences against this type of accident is the other pilot. Monitoring and cross-checking can provide a last line of defence to trap individual errors.

Although safety systems should seek to reduce the development of errors, where possible engineering defences should also be used to reduce error consequences. Simple mechanical barriers, such as chocks, can be an effective defence.

The occurrence

What happened

Aircraft preparation

On 30 July 2019, a British Aerospace AVRO 146-RJ85, registration VH-NJW (NJW), operated by National Jet Express (Cobham) was being prepared on Cobham bay NJ1, Perth Airport, for a charter flight to Granny Smith, Western Australia. The flight crew comprised the captain and the first officer (FO). In addition, there were 62 passengers and two cabin crew on board.

The flight crew signed on for duty at around 1330[1] for a scheduled departure time of 1430. The captain and the FO arrived at the aircraft and commenced pre-flight duties at around 1345.

While the captain and the FO completed the *pre-flight checks*, they remarked that the apron and the hangar were busy. A new aircraft was arriving later that afternoon and there were many people positioned around the apron to observe its arrival.

At around 1415, the dispatching engineer took position at the right side of the aircraft to operate the aircraft headset. He contacted the flight crew and requested clearance to remove chocks, which were at that stage installed on the outboard wheels of the left and right main landing gear.

After the captain gave the engineer clearance to remove the chocks, the engineer proceeded to walk around the outside of the aircraft, removing the left and right main wheel chocks. At around 1416, the engineer dragged both chocks away from the aircraft, off to an equipment bin at the edge of the apron.

Around this time, as part of the pre-start preparations, the flight crew conducted the *originating checklist*.

Engine start

At 1419, the engineer returned to the headset position on the side of NJW. The captain called the engineer, who confirmed that the chocks had been removed and the doors and panels had been secured, and that the crew were clear to start all engines. The engineer remained plugged in to the headset while he observed the engine starts.

After receiving the clearance from the engineer, the crew conducted the *starting checklist*.

After completing the starting checklist, the captain commenced starting the aircraft's four engines, in the normal 4-3-2-1 sequence, from right outboard engine to left outboard engine. The captain and the FO monitored engine indications to confirm the stable start of each engine. The FO monitored the engine light for each engine to confirm when the starter motor had disengaged and called 'starter cut-out' for each of engines four, three and two, as each completed a stable start.

NJW rolls forward

At about 1424, NJW started moving forward. The engineer, who was still connected to the aircraft via the headset, noticed that NJW was moving and alerted the crew. The engineer alerted the crew at about the time the FO called 'starter cut-out' for the stable start of engine one.

The crew said that they were confused and alarmed when they heard the engineer and took a moment to confirm that they were in fact moving forward. The crew recalled that their actions following this were:

- The captain's first action was to apply his foot brakes, only to observe that they had no brake-line pressure. The FO tried his foot brakes at around this time, which was also ineffective.

[1] Western Standard Time (WST).

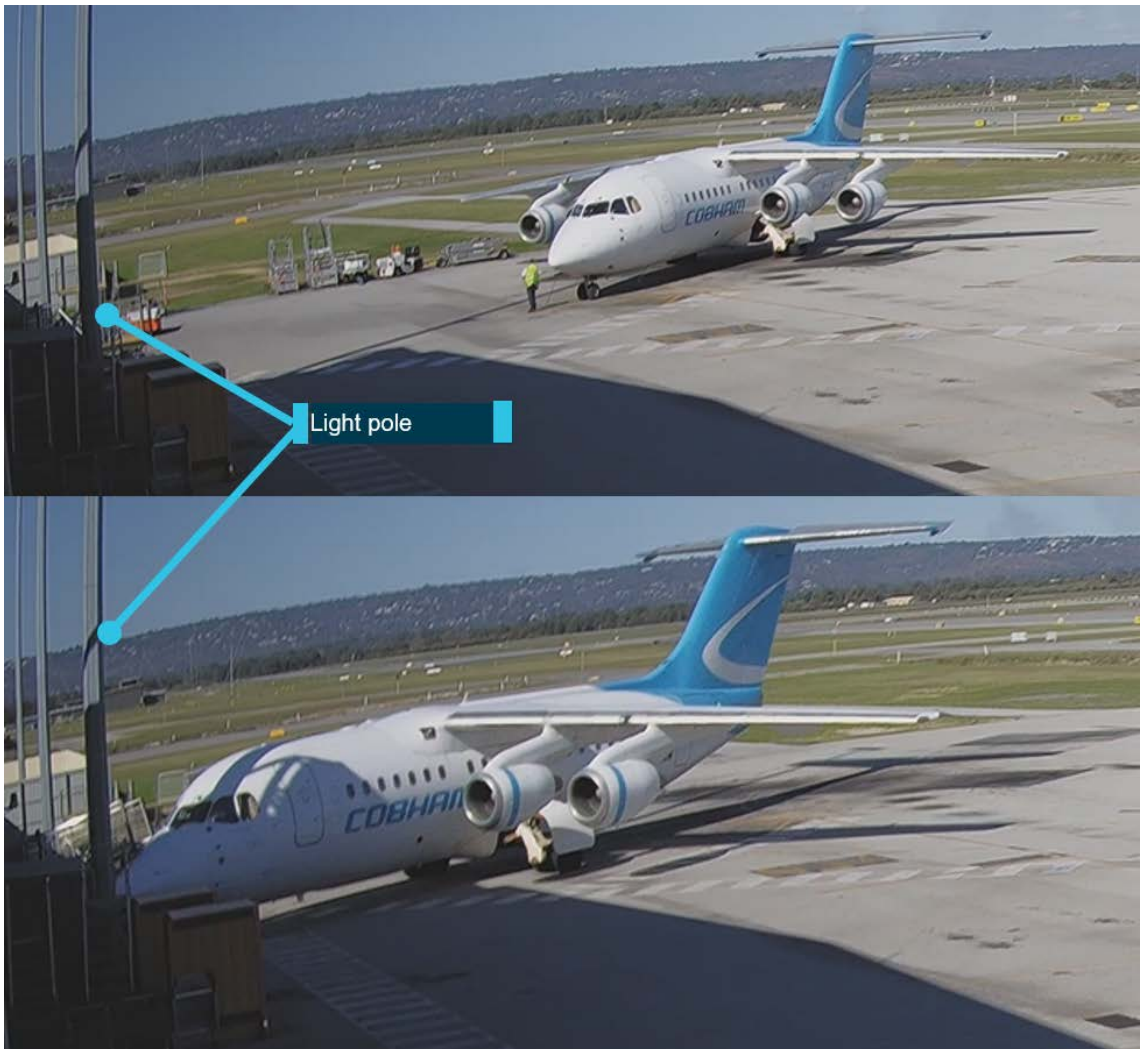
- The captain also recalled that he tried using the park-brake, which was ineffective.

The FO heard a loud bang, which he said was consistent with the sound of the park-brake releasing upon application of the foot brakes. The FO recalled this was shortly after he tried using the foot brakes.

With the aircraft rolling towards objects at the edge of the apron, the captain reached up to the overhead panel where the hydraulic pump switches are located. The captain said he could not recall what his intention was for this action, but said that he did not complete whatever that action was supposed to be.

About 18 seconds after the start of the roll-forward, NJW collided with movable aircraft stairs, which were in front of the Cobham terminal. The stairs struck the front of the aircraft, beneath the right pilot seat. Shortly after, NJW collided with a bollard in front of a light pole, then with the light pole itself. The roll-forward and collision with airport infrastructure was captured on Cobham CCTV (images shown in Figure 1).

Figure 1: CCTV showing start of roll-forward (top) and collision with infrastructure (bottom)



Source: Cobham, Original image cropped and annotated by ATSB

The aircraft was substantially damaged by the accident (see Figure 2). One cabin crew member was thrown from a standing position into a door handle during the collision with the light pole, but was not injured. There were no injuries to the other crew or the passengers.

Figure 2: VH-NJW following collision with airport infrastructure

Source: Cobham

Context

Accident location

The accident occurred on the Cobham apron at Perth Airport. VH-NJW was parked at bay NJ1, which is directly in front of the Cobham terminal buildings in the north-west corner of that apron.

Bay NJ1 is close to the edge of the apron with a slight slope from the parking position towards the terminal. Documentation supplied by Perth Airport indicated that the apron and aircraft parking positions were designed and approved in accordance with the Civil Aviation Safety Authority (CASA) Manual of Standards (MOS) part 139, Aerodromes.

Aircraft information

The BAe 146 is a four-engine turbofan aircraft, manufactured by British Aerospace (BAe). NJW was an Avro RJ85, a variant of the BAe 146. Because NJW routinely operated on gravel runways, metal deflectors (gravel kits) had been fitted to the aft of the nose landing gear.

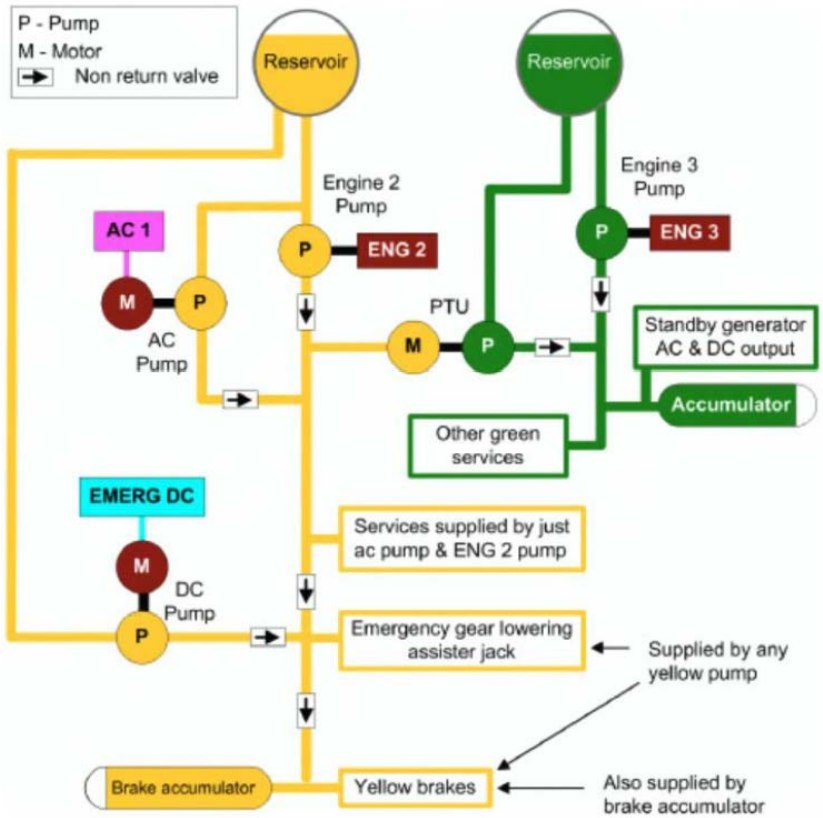
A detailed mechanical inspection was conducted of the aircraft's braking systems after the accident. There was no indication that any defects or anomalies were contributory to the collision.

BAe 146/ RJ85 braking system

The braking system consists of the foot brakes and a park-brake. The brakes are powered by the aircraft hydraulic system which has two subsystems: yellow and green. Only the yellow system powers the parking brake while both systems power the foot brakes. A selector switch on the centre console controls which system (yellow or green) supplies power to the wheel brakes.

Two reservoirs store fluid, one for each system. Pumps draw fluid from the reservoirs, pressurise that fluid and in doing so provide power to operate the brakes. Accumulators store fluid under pressure and provide reserves of hydraulic power. A schematic diagram of the hydraulic system is provided in Figure 3 below.

Figure 3: BAe 146/RJ85 hydraulic system schematic



Source: BAe

Systems for supplying brake pressure

The main pumps for providing hydraulic power are the engine driven pumps (EDPs). These pumps require engine power to operate. Without engine power, the yellow system can be pressurised by an AC electrical pump. When the AC pump is activated, it supplies pressure to the brake system almost instantaneously.

During a normal pre-flight sequence, the yellow system would only be pressurised using the AC pump. This would be done on an as-needs basis following the check of the park-brake during the originating checklist and of the brake pressure during the before start checklist. The EDPs will only supply pressure after they are selected on during the *After start* checks.

Power for the green system is primarily supplied by the number 3 engine EDP. Without engine power, the green system is pressurised by Power Transfer Unit, which is mechanically powered by the yellow system. Therefore, prior to engine start, without accumulated pressure or yellow system power, the green system will not be pressurised.

Yellow system brake accumulator

The brake accumulator is a secondary reservoir in the yellow system that supplies emergency and park-brake pressure. No pump is needed to supply pressure to the yellow system if the brake accumulator has been charged. The brake accumulator can be charged through the AC pump or using the emergency DC pump.

The accumulator, once charged, stores pressure. The pressure stored in the accumulator decays, however, the decay rate is normally low enough to ensure adequate park-brake pressure for around 150 minutes. The rate of decay increases if the park-brake valves are in poor condition.

A specific inspection was conducted on the pressure decay rate of the brake accumulator from NJW, which complied within the manufacturer's specification of 150 minutes. Prior to the

scheduled flight to Granny Smith, the aircraft had returned at 0847. Therefore, it had been well over 150 minutes since the aircraft was powered.

Controls and Instruments

Gauges on the captain's instrument panel indicate the pressure available in the yellow and green hydraulic systems (hydraulic pressure). Gauges in front of the left-side (captain's) control column indicate the level of pressure being supplied by the yellow and green systems (brake pressure).

The foot brakes are located in front of each pilot, as they sit in their flight seats.

The park-brake handle is located on the centre console. The park-brake can be released by depressing the right-hand seat brake pedal or by moving the handle. Disengagement of the park-brake on the RJ85 tends to produce a 'bang' sound, unless the park-brake handle is guided down to the un-activated position.

Low accumulator pressure warnings

When the brake accumulator pressure is less than 2500 psi, a BRK ACC LO PRESS annunciator light illuminates on the hydraulics panel, overhead the left-hand seat. The activation of the warning on the hydraulics panel triggers the illumination of the HYD↑ caption on the Master Warning Panel (MWP), which will cause amber attention-getting lamps on the glare-shield to flash and a single chime sound.

By pressing the attention-getting lamps on the glare-shield, pilots can acknowledge the warning light on the hydraulics panel, which will have the effect of dimming the light. Acknowledging warnings means that existing warnings are no longer displayed at full brightness, however, if triggered, new warnings will be displayed at full brightness.

The MWP also has a Test and Ground Operation switch. The *BAe 146 Aircraft Maintenance Manual* describes the function of this switch, when pulled into the ground operation (mute) position:

> the light intensity on the MWP is set to a level sufficient to have seen under average daylight conditions, the bright-up function, the triple and single-chime inputs to the audible warning system and the red warning and amber caution lamp flasher circuits are inhibited. The switch has an integral red warning light to indicate that the mute system is in operation.

The pilots reported that they did not recall seeing or hearing any alerts or warnings during the accident sequence. The FO stated that the Test and Ground Operation switch had been pulled (to ground operation) prior to power on. This switch had been pushed in (to the normal position) prior to engine start, as per the operator's *Power-on Checklist* procedures. The FO also stated that it was normal practice to see the hydraulic caption on the MWP activated prior to engine start.

Pre-flight procedures

The ATSB examined the pre-flight procedures used by Cobham crews, particularly as they relate to setting and pressurising the aircraft brake system. The primary document for these procedures was the Cobham manual OM-B2-146, BAe146 *Aircraft Operating Manual* (The operating manual). The other source was the British Aerospace *Flight Crew Operating Manual* (FCOM) for the BAe146/RJ series aircraft. The operating manual states that it takes precedence over the FCOM.

In terms of the use of checklists, the operating manual states:

> The Checklists allow the development of 'scans' which can be accomplished before the checklist is read… The checklist then becomes the means to verify that items have not been forgotten…
>
> The 'Challenge and Response' method shall be used, which requires the pilot reading the checklist to call the 'Challenge', after which both pilots shall, if physically possible, visually verify that the required action has been completed, and then the pilot nominated on the checklist as the respondent (usually the pilot who completed the action) shall reply with the required response.

Regarding the guidance for both pilots to visually verify each response item, the FO said that he found this difficult. The FO reported that he found it challenging to provide an additional

verification of the captain's checks since he was focussed on performing the duties allocated to him as the first officer. The FO said he thought verifying all of the captain's actions would result in delays to getting the aircraft away on time.

Originating checklist

The flight crew conduct the *Originating checklist* (or the equivalent *Transiting checklist*) prior to engine start for all flights. The originating checklist contained the following checks:

> Park-brake. Captain's responsibility. Select the park brake on and check that the pressure is not less than 1,500 psi.

This checklist item provided an opportunity to check that there was sufficient brake pressure being applied, and to charge the brake accumulators, if required. The captain reported that it was normal to charge the hydraulics using the AC pump during the originating checklist.

The flight crew performed the originating checklist during the pre-flight sequence. The first officer called the item 'park-brake' and the captain responded 'on, pressure checked'.

The captain reported to the ATSB that he recalled performing the originating checklist, but did not have a recollection of performing the check of the park-brake or the pressure gauge. The FO said he could not recall if he looked at the pressure gauge during the originating checklist, to cross-check the captain's responses.

Starting checklist

The flight crew conduct the *Starting checklist* after receiving clearance to start the engines from the dispatcher. The first checklist item is 'Brake Pressure'. The operating manual described this check as 'ensure the brake pressure is at least 2500 psi immediately before push back or start.'

The crew conducted the starting checklist. For the brake pressure item, the first officer called 'brake pressure' and the captain responded 'check'.

The captain stated he could not recall checking the brake pressure gauge during the starting checklist. The FO reported he could not recall whether he looked at the pressure gauge during the starting checklist.

After start scan

During the start of each engine, the FO monitors the starter operating light and calls 'starter cut-out' when the light extinguishes, to indicate stable start. The after-start scans are performed after stable start is confirmed for the final engine in the starting sequence (engine 1). Item 2 of the after-start scan is completed by the captain and included the following:

> Select ENG 2 PUMP and ENG 3 PUMP ON and observe YELLOW and GREEN system pressures increase to normal (3100 +/- 50psi). Select PTU on only after GREEN system pressure has been checked.

The crew did not perform the after-start scans because of the development of the accident. This is described in the analysis section following.

Cobham procedures for chocking aircraft

Chocks are routinely fitted fore and aft of aircraft wheels to reduce the risk of the aircraft inadvertently rolling forwards or backwards. The following summarises Cobham procedures for chocking 146/RJ85 aircraft.

Cobham Ground Operations manual, OM-A6

Manual OM-A6 contained higher-level procedures for Cobham ground operations personnel, not specific to aircraft type. These procedures stated that prior to dispatch, ground handling personnel were to remove all chocks from the main landing gear and ensure that a chock was repositioned

150 mm ahead of the nose-wheel. The procedure did not specify any specific requirement, related to nose-wheel chocks, for gravel-kitted aircraft.

Cobham BAe 146 Ground Operations manual, OM-B6

Manual OM-B6 provided type-specific instructions for ground operations on BAe 146/RJ85 aircraft. The manual stated that chocks should be placed fore and aft all wheels, including nose-wheels. The procedures further stated that nose-wheel chocks should be used in windy conditions, or when the parking area was on a slope.

The manual provided limited instructions for the removal and repositioning of chocks in the section describing dispatch duties for aircraft on standoff bays using the intercom. The manual described the sequence of communications that should be made between the captain and the ground, being:

> Captain: 'Brakes parked, clear to remove chocks'
>
> Ground: 'Chocks removed'

This procedure indicated ground personnel removed all chocks at this stage. It did not specify the requirement to reposition chocks ahead of the nose-wheel, as stated in manual OM-A6.

Cobham BAe 146/RJ85 dispatch training

Cobham dispatch training materials described the steps involved in preparing a 146/RJ85 aircraft for dispatch as including the following:

> Remove chocks from the main outboard wheels.

There was no step relating to repositioning chocks to the nose-wheel.

Procedures 'as done'

The ATSB sought to determine the 'as-done' and 'as-taught' procedures for using chocks by Cobham dispatchers, to see if there was any variance from the 'as-written' procedures. A senior ground handler at Cobham, who was responsible for training dispatchers, advised that normal practice was for dispatchers to remove chocks during dispatch and not reposition chocks to the nose-wheel of any aircraft. Dispatchers were taught to remove chocks in a manner consistent with the dispatch training materials.

The dispatching engineer for NJW indicated he understood the procedures to be that chocks were not fitted to the nose-wheels of gravel-kitted aircraft.

Recorded data

Personnel from Cobham secured a copy of the quick access recorder (QAR) data for analysis and provision to the ATSB. The flight data recorder (FDR) and cockpit voice recorder (CVR) were also removed and dispatched to the ATSB laboratory in Canberra for analysis.

The QAR file provided a record of the entire pre-flight sequence. It shows the engines powering up in sequence (4-3-2-1). Soon after engine 1 began to power-up, the QAR shows an increase in longitudinal acceleration, consistent with the aircraft beginning to move forward. About 18 seconds later, a spike in longitudinal acceleration likely indicates the collision with objects at the end of the apron. All four engines are then shut-down. The QAR shows that there was insufficient hydraulic pressure available in the brake system to provide effective braking throughout the entire pre-flight sequence.

The FDR started recording about 7 seconds before the collision, after which it then stops recording. An examination of FDR data from a previous NJW flight indicated the FDR began recording after all engines had been started and the park-brake was released for taxiing. This would suggest that for this accident, the start of FDR data coincided with the release of the park-

brake handle. This is consistent with the FO's recollection of hearing the park-brake handle release (loud bang) during the rolling sequence.

The ATSB concluded that the park-brake was likely set to ON prior to engine start. However, without sufficient hydraulic pressure, the brakes were not effective.

Ground-cockpit communications

The ATSB considered what each crew member and the dispatcher recalled about what they heard and what they said during the time the aircraft was rolling towards the terminal. The following summarises these recollections:

- The dispatcher recalled that when he saw the aircraft was moving, he said words to the effect of 'brakes parked' into his headset. He repeated this several times, with an increasingly urgent tone. The dispatcher said the flight crew did not acknowledge any of these messages.
- The captain recalled hearing the dispatcher say the aircraft was moving via intercom. The captain reported hearing one such alert from the dispatcher and that the dispatcher's tone was urgent.
- The FO recalled he heard the dispatcher say 'brakes, brakes' on his headset, at around the time he (the FO) called 'starter cut-out' for engine one. The FO recalled then saying 'brakes' himself.

The CVR captured audio relating to the communications between the cockpit and the dispatching engineer. The following table summarises relevant communication:

Time (WST)	Recorded audio
	(Sound of ATIS[2] playing)
14:23:50	Dispatcher: brakes parked
	(ATIS resumes)
14:23:53	Dispatcher: BRAKES PARKED
14:23:54	FO: Brakes Brakes Brakes
14:23:55	Dispatcher: BRAKES BRAKES BRAKES! GROUND TO COCKPIT! BRAKES PARKED!

The recorded audio is generally consistent with the dispatcher's recollection. The combined evidence suggests that the crew may not have heard the dispatcher's initial warning about the aircraft rolling. It also indicates that the flight crew were not aware that the aircraft was rolling until four seconds after the initial warning and around ten seconds prior to the eventual impact.

[2] Automated Terminal Information Service.

Safety analysis

Hydraulic systems not pressurised

The flight crew did not effectively check the brake system pressure during the originating checklist or the starting checklist. The captain did not identify that the pressure was less than required and consequently, did not pressurise the system prior to engine start. This was contrary to the checking requirements during these checklists.

Due to the low pressure, it is very likely that the BRK ACC LO PRES warning was current throughout the pre-flight sequence. However, the flight crew reported they had pulled the test and Ground Operation into the ground operation (mute) position, which would mean no attention-getting glare-shield lamps would flash and no aural chime would sound.

Furthermore, it is likely that this warning was generated at an early stage of the pre-flight. It would be common for flight crews to receive a low accumulator pressure warning at aircraft power-on since accumulator pressure would likely have decayed and pumps not yet activated. Consequently, flight crew would likely acknowledge the warning with the expectation that normal procedures would subsequently pressurise the accumulator. In such circumstances, the warning would not be effective at alerting the crew that the hydraulic system was not pressurised prior to engine start. The implication is that the safety system is reliant on effective checking by the operating crew.

Research has found that checklist deviations occur relatively frequently, compared to other forms of procedural deviation. Common forms of checklist deviation include responding without checking and performing flow-check procedures as read-do (Dismukes and Berman, 2010).

Flight crews are particularly vulnerable to checklist errors during the pre-flight sequence. During pre-flight, flight crews are faced with many competing requirements and can experience perceived or explicit pressure to make on-time departure requirements. Line observation research has found that the pre-flight stage of flight presented many and varied events that distracted and interrupted flight crews (Loukopoulos, Dismukes and Barshi, 2001).

None of the factors identified in the research were particularly prevalent in the development of this accident. The flight crew were not experiencing significant time pressure and there were no identifiable disruptions during the pre-flight checklists. Although the busyness of the airport due to the impending arrival of a new aircraft was consistent with there being a distraction for the crew, there was no evidence that the crew were distracted in a way that affected their performance of the checklists. On board recorders showed that the crew did not have any non-pertinent conversations while completing the checklists.

Overall, the missed pre-flight checks in this accident are indicative of the general vulnerability to omissions during checklists, particularly in the pre-flight sequence. Checklist performance is imperfect, and as such, resilient systems utilise redundant defences in order to reduce the likelihood of error and to minimise error consequence. The ATSB notes that the development of this accident required two separate omissions from checklist procedures. The safety system therefore did have some redundant controls, but these relied on vigilant checklist performance.

In multi-crew flight operations, one defence against individual checklist failures is the role of the other pilot. Monitoring and cross-checking is a key recovery defence in the multi-crew safety system and deficiencies in cross-checking has been implicated in the development of major accidents (Sumwalt, Thomas and Dismukes, 2002). Dismukes and Berman (2010) suggest that captains should explicitly brief the FO that they (the captain) will make mistakes and it is the job of the FO to detect mistakes and point them out.

While it may be challenging to monitor the other pilot for the entirety of flight preparation and into the flight, it is critical that this monitoring does occur during checklists. The design of checklist

procedures reflects the criticality of the checklist items for ensuring safe flight. Checklists are limited to only those items that are critical and checklist procedures are designed so that flight crews have no other tasks to perform while doing the checklist.

In the development of this accident, the initial and primary missed checks related to the captain not performing the checklist items as required to identify no brake pressure. However, there was also a shared responsibility for the FO to monitor and cross-check. The FO did not monitor the checking actions of the captain and did not independently check the pressure systems. Because neither crew member effectively checked the pressure system, there was no braking pressure available during engine start.

Chocking procedures

The dispatcher's decision to not reposition chocks to the nose-wheel of NJW was consistent with the training provided to ground handling personnel and the normative practice at Cobham. The training provided to dispatchers did not mention a requirement to reposition chocks to the nose-wheel. Prior to the accident, Cobham personnel were not repositioning chocks to the nose-wheel of departing aircraft.

Cobham procedures and training materials did not provide clear instructions regarding the use of nose-wheel chocks during dispatch. One of the manuals did state that dispatchers should reposition a chock to the nose-wheel, while another manual did not specify this requirement.

The absence of a clear requirement to reposition a chock to the nose-wheel of departing aircraft prior to engine start reduced the available defences against uncontrolled roll-forward.

Roll-forward and response

The combined forces of idle thrust from the four engines, and the slight slope of the apron, acted to overcome the inertia of the parked VH-NJW. In the absence of chocks, NJW rolled forward from its parking position. While it is likely that the park-brake was set prior to the start-up sequence, the lack of brake pressure would have made braking ineffective. Similarly, the crew's attempt to use the foot brakes and the park-brake after the aircraft was rolling had no effect since there was no brake pressure.

After the confirmed stable start of the final engine (engine one), the next step in the normal pre-flight sequence included activating the engine driven pumps as part of the after-start scans. However, the ground handler alerting the crew, and the observation that the aircraft was rolling, meant that the pilots' attention was diverted away from the normal pre-flight sequence, and toward responding to the perceived emergency situation. As such, the development of the accident meant that the pilots did not conduct the after-start scans.

The parking position NJ1 was close to the edge of the apron. It took around 18 seconds from when the aircraft started to roll to when it struck objects at the edge of the apron. Consequently, there was limited time to identify the problem and take action to recover from the unintended roll-forward.

The dispatcher attempted to alert the crew that the aircraft was rolling shortly after the roll commenced. However, the crew did not hear the initial alert and did not identify that the aircraft was rolling until around four seconds after that alert. It is possible that this delayed alert was associated with the crew listening to the ATIS. The delay in the crew identifying that the aircraft was rolling may have reduced the likelihood of them taking effective recovery actions to pressurise the hydraulic system.

In this case, the crew had around 10 seconds from the time they were alerted that the aircraft was rolling, to when the aircraft struck objects at the edge of apron. In that time, the crew had to confirm that the aircraft was rolling, attempt to use the braking system, identify that there was no pressure, pressurise and then apply the brakes. Time would also be required for the brakes to

arrest the movement of the aircraft. The ATSB concluded that there was a very limited opportunity for the crew to take action to avoid the collision.

The crew were surprised when they heard that the aircraft was rolling, which further reduced their ability to respond. Research has shown that responses to unexpected and surprising situations are slower and more variable. For example, simulator research with experienced pilots has shown that upset recovery performance is much worse when pilots are surprised by the onset of the upset (Landman, 2017).

The nature of the crew's response to the rolling aircraft is consistent with the effects of surprise. The crew reported that they were shocked and confused when they heard the aircraft was rolling and took steps to confirm that themselves. The psychological effects of surprise can include freezing, a loss of situational awareness and not remembering appropriate operating procedures (Rivera, Talone, Jentsch and Yeh, 2014; Burki-Cohen, 2010); the captain's action of reaching to the overhead panel, then not completing this action, is also consistent with him being surprised by the unfolding accident.

As the crew did not take the necessary steps to pressurise the hydraulic system, they were not able to stop the aircraft rolling forward. As a result of the roll-forward, the aircraft collided with the objects at the edge of the apron.

Findings

From the evidence available, the following findings are made with respect to the Ground collision with airport infrastructure involving British Aerospace AVRO 146-RJ85, VH-NJW at Perth Airport, Western Australia on 30 July 2019. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The crew did not effectively check the brake system pressure during either the originating checklist or the starting checklist. As a result, the crew did not identify that there was no brake pressure prior to engine start.
- After engine start, the aircraft inadvertently rolled forward and collided with objects at the edge of the apron. The absence of brake pressure, the slope of the apron and the absence of a nose-wheel chock were contributory to the aircraft rolling forward.
- The operator's dispatch practices did not involve placing chocks on the nose-wheel for engine start. Although some ground handling procedures indicated nose-wheel chocks should be used, the operator’s training did not involve a step to place chocks on aircraft nose-wheels. The absence of a nose-wheel chock fore of the aircraft reduced the defences against the aircraft rolling forward.
- The crew had a very limited opportunity to take corrective action before the aircraft collided with objects at the edge of the apron. It is likely that the short distance to the edge of the apron and the influence of surprise combined to reduce the crew’s ability to respond.

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 action in response to this occurrence.

Cobham reported that following this accident, the internal safety team reminded Check and Training captains that there is a responsibility to observe and verify responses to checklist items, that it is not acceptable to take a checklist response as given. The head of training and checking also sent a notice to check and training pilots which highlighted the requirement of vigilance during checklists. This notice also directed check and training pilots to threat and error management guidelines. As additional actions, Cobham reported that the occurrence will be incorporated into the Cobham Human Factors Training, and that there has been an enhanced focus placed on Line Operations and Safety Auditors to monitor checklist performance.

Cobham reported that they are undertaking several actions related to chocking procedures. This includes updating the procedures OM-A6 and OM-B6 to include the use of nose-wheel chocks for dispatches from stand-off bays. Cobham reported that they are reviewing other procedures relating to chocking and will align all procedures to include the use of nose-wheel chocks. Cobham also reported they have commenced spot checks of chocking during aircraft start, and that these spot checks are ongoing.

General details

Occurrence details

Date and time:	30 July 2019 – 1430 AWST	
Occurrence category:	Accident	
Primary occurrence type:	Taxiing collision	
Location:	Perth Airport, Western Australia	
	Latitude: 31° 55.536' S	Longitude: 115° 57.77' E

Aircraft details

Manufacturer and model:	British Aerospace PLC AVRO 146	
Registration:	VH-NJW	
Operator:	National Jet Express Pty Ltd (Cobham)	
Serial number:	E2329	
Type of operation:	Charter - Passenger	
Departure:	Perth, Western Australia	
Destination:	Granny Smith, Western Australia	
Persons on board:	Crew – 4	Passengers – 62
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Substantial	

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 the flight crew, the engineer, Cobham Aviation Services, BAe Systems via the accredited representative the UK Air Accidents Investigation Branch, the Civil Aviation Safety Authority,

Submissions were received from Cobham Aviation Services, BAe Systems, and the first officer. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

About the ATSB

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.

About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope, fact-gathering investigation was conducted in order to produce a short summary report, and allow for greater industry awareness of potential safety issues and possible safety actions.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

Ground collision with airport infrastructure involving British Aerospace AVRO 146-RJ85, VH-NJW, Perth Airport, Western Australia on 30 July 2019

AO-2019-038
Final – 30 January 2020