ACCIDENT

Aircraft Type and Registration:	P84 Jet Provost Mk 5, G-VIVM
No & Type of Engines:	1 Rolls-Royce Viper 20201 turbojet engine
Year of Manufacture:	1967 (Serial no: PAC/W/23907)
Date & Time (UTC):	16 June 2021 at 1300 hrs
Location:	North Weald Airport, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to aircraft nose structure and main landing gear. Nose landing gear collapsed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	15,000 hours (of which 350 were on type) Last 90 days - 42 hours Last 28 days - 16 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further AAIB enquiries

Synopsis

The commander performed a rejected takeoff (RTO) due to a reported lack of indication on the air speed indicator (ASI). Despite braking, the aircraft did not come to a stop before the end of the runway. It departed the paved surface into a grassy area and came to rest after striking a shallow earth bank and the airport perimeter fence. There were no injuries.

Examination and testing did not identify any defects with the aircraft's airspeed indicator or pitot/static system. Examination of the wheels and brakes did not identify any defects but accident damage prevented testing of the braking system. Damage to the wheels and brakes was consistent with the application of heavy braking during a high energy RTO.

The investigation considered that the braking demand arising from the rejected takeoff exceeded the ability of the aircraft braking system to bring the aircraft to a stop, in the available distance remaining.

History of the flight

The flight was intended to be a post-maintenance check flight. The commander, occupying the right seat, was accompanied by a passenger in the left seat. The passenger was also a pilot with experience on the Jet Provost, but whose pilot's licence was not current at the time. Earlier that morning, maintenance staff had towed the aircraft out of the hangar in preparation for the flight. The commander then carried out a pre-flight inspection.

The commander reported that the start-up and taxi out to the runway was normal and he lined-up for a full length departure. He stated that during the takeoff roll, the ASI, which normally starts to indicate at 50 kt, showed no indication. He decided to abort the takeoff when the aircraft was approximately one third the way down the runway, brought the aircraft to a halt and taxied back to the maintenance area, where he reported a lack of airspeed indication to the engineers.

Maintenance staff carried out a leak check of the pitot/static system and a functional check of the ASI using a hand-held leak-and-sense checker. When a pressure equivalent to approximately 130 kt[1] was applied to the system, the ASI was observed to indicate approximately 130 kt. When the commander returned to the aircraft, one of the maintenance staff also stood some distance in front of the aircraft and gently blew towards the pitot probe to demonstrate to him that the ASI needle moved in the appropriate sense. The commander observed this and was content to accept the aircraft.

The commander checked the brakes and tyres for any indications of residual heat remaining after the RTO and was satisfied that there were none. He also checked the brake wear indicator pins. After what he estimated to be an elapsed time of 1.0 to 1.5 hours since the first RTO, he taxied the aircraft to Runway 20 for a second takeoff attempt. As the aircraft accelerated, he again observed that there was no speed indication on the ASI and initiated an RTO. He estimated that at this point the aircraft was travelling at approximately 70 – 80 kt, with approximately 4,000 ft of runway remaining. He reported that initial gentle to moderate braking application had little effect, so increased the braking effort, again with no effect. He then applied full pressure on each brake in turn but it did not result in any lateral movement of the nose.

The aircraft departed the end of the runway at a speed of approximately 10 – 15 kt, into a grass area and came to rest after striking a shallow earth bank and the airport perimeter fence (Figure 1). Both occupants were unhurt and exited the aircraft without assistance. A small grass fire initiated next to each wheel as a result of the hot brakes. These were extinguished by the ARFFS.

The maintenance organisation indicated that the aircraft had initially departed the maintenance area at 1203 hrs, returning to the hangar after the first RTO at 1214 hrs. Following the completion of maintenance, the aircraft departed again at 1317 hrs and the accident occurred at approximately 1324 hrs.

Footnote

1 The leak-and-sense checker was not calibrated, but the 130 kt setting on the test kit was selected.

Figure 1
G-VIVM final position

Airfield information

North Weald Airfield is an unlicensed aerodrome, with grass and paved runways and an airfield elevation of 321 ft amsl. The main runway, Runway 02/20 has a paved surface and is 1,881 m (6,171 ft) long.

There is a 55 ft difference in elevation between each end of the runway, Runway 20 having an upslope and Runway 02 a downslope.

Additional information from the flight crew

The commander commented that as part of the pre-flight preparation he checked the hydraulic fluid level on the four brake foot motors, one on each brake pedal. He also recalled the hydraulic system pressure being within the normal range. He reported that the brakes appeared to operate normally during taxiing and engine run-up on both occasions and during the first RTO.

The commander commented that on the second takeoff attempt he wanted to give the ASI ample time to register an indication, and therefore allowed the aircraft to accelerate to what he estimated to be 70 – 80 kt. He estimated that he initiated the RTO and commenced braking when the aircraft was approximately abeam the intersection with Taxiway A2, from which point there would have been 1,433 m (4,700 ft) of runway remaining. He described "hardly any retardation" from the brakes during the RTO and considered that the aircraft should have stopped comfortably in the remaining distance.

After the accident, he reviewed information from Skydemon software operated on an iPad device which had been mounted in the cockpit and was surprised to learn that the aircraft had actually reached a groundspeed of approximately 105 kt during the takeoff roll. While normal takeoff speed for the aircraft configuration and conditions on the day is in the range of 80 – 90 kt, he commented that the aircraft did not feel light on its landing gear as if it was at flying speed and this might be why he underestimated the speed which the aircraft had achieved. In retrospect the commander commented that he could have referred to the ground speed display on the iPad as a secondary source of speed information. With hindsight he also considered that it may have been appropriate to continue the takeoff and fly a circuit to land, but at the time he had been reluctant to do so without a valid speed indication. He also stated that, based on the first RTO, he had no reason to expect that the aircraft would not stop in the available distance.

The passenger stated that they had also been monitoring the ASI during both takeoff runs and confirmed that the needle did not move. On the second RTO, they described the brakes as "partly working but they ran out of ability."

Aircraft information

The Jet Provost Mk 5 is two seat ex-military jet trainer, with a side-by-side seating arrangement. On G-VIVM, the ASI occupied the top left position in a cluster of six instruments centrally grouped on the instrument panel (Figure 2). The ASI speed scale indicates from 50 to 500 kt.

Figure 2

G-VIVM central instrument cluster showing position of ASI

Each main landing gear has a single wheel, equipped with a hydraulic brake unit, consisting of a brake calliper mounted on the brake disc. The calliper incorporates three pistons, each of which drive a 'floating' friction pad against the outboard face of the disc when hydraulic pressure is applied. This drives the brake disc against three fixed friction pads mounted on the inboard side of the brake calliper.

The floating friction pads are not mechanically attached to the pistons but sit within a recess in the piston housing forming a contact fit. In normal operation, piston travel increases to compensate for increasing wear of the friction pads and a brake wear indicator pin at the centre of each piston, indicates when the brake pads need to be replaced.

G-VIVM was not equipped with an anti-skid system. The Aircrew Manual did not specify a minimum brake cooling period following an RTO.

Aircraft maintenance history

Prior to the accident, the aircraft had last flown on 4 November 2020. The aircraft's annual maintenance / 'Primary Star' inspection commenced in December 2020, but completion of the maintenance was delayed awaiting parts. Following completion of the maintenance, the aircraft was assessed as needing a post-maintenance check flight and the permit maintenance release was signed on 10 June 2021.

The aircraft remained hangared throughout this period with covers installed on the pitot/static ports. No pitot/static system inspections were called up in the maintenance schedule for the Primary Star inspection. The brakes were inspected and declared serviceable at the beginning of the maintenance input in December 2020. This included inspection of the brake wear indicator pins.

Aircraft damage

The nose light was damaged when the aircraft struck the airport perimeter fence. The nose landing gear had collapsed and the stabilising/retraction arm was broken. The pitot probe was bent upwards and cracked and the surrounding support structure deformed. The left main landing gear support strut had failed. Damage to both main landing gear wheels is described in the 'Aircraft Examination' section of this report.

Aircraft examination

Following the accident, the maintenance organisation tested the pitot/static system, in the presence of a CAA Airworthiness Surveyor. It was not possible to perform a full functional test due to the damage sustained by the pitot probe but the outer casing was blanked-off to prevent/reduce leakage. A leak-and-sense checker was attached to the pitot probe and when pressure was applied, the ASI needle responded in the correct sense. The pitot/static system was subsequently reverse-flushed using compressed air and a plastic bag over the end of the pitot tube to collect any debris. No evidence of a blockage or debris in the system was detected.

The water drain traps in the pitot/static system were examined and were found to be dry, with no water or condensation present.

The ASI was removed and sent to a specialist organisation for inspection and test, which reported that the unit was received in good condition with no fault found. It passed the functional test and was within calibration limits.

The wheels and brakes were examined in-situ by the maintenance organisation in the presence of an AAIB inspector and were then removed for further examination at the AAIB facilities. The left and right main landing gear wheels rotated freely and the tyres had remained inflated. There was no evidence of scuffing or flat spots on the tyres, indicating that they had been turning throughout.

Both wheels showed signs of heat exposure, including blistering of the surface coating on the wheels and brake callipers. The outboard sidewalls of each tyre exhibited areas of charred and cracked rubber. Both brake discs displayed heat damage and heavy scoring and gouging with the surface plating removed. On each calliper the inboard fixed friction pads had remained in place and were heavily worn, while all the floating friction pads had become dislodged from the pistons. The pistons had travelled all the way through the piston housing and one piston on each calliper had over-travelled, such that there was metal-to-metal contact between the piston crown and disc (Figures 3 and 4).

On the right wheel, two of the floating friction pads had fused to the disc and one was absent. Two pads found in the grass close to the left landing gear exhibited heavy wear; the third was absent. The recovered floating friction pads were not evenly worn across the entire surface area, but measured thickness ranged from 3.71 mm – 5.80 mm. This compared to a thickness of 16.05 mm for a new floating friction pad.

Figure 3

Right main landing gear wheel and brake disc.
Inset shows brake calliper and pistons

Figure 4
Left main landing gear brake disc.
Inset shows brake calliper and pistons

The maintenance organisation was unable to perform a functional test of the braking system following the accident due to the extensive damage to the wheels and brakes and the loss of hydraulic fluid from the system.

Landing and stopping performance

G-VIVM's takeoff weight prior to the first takeoff attempt was 7,500 lbs. The commander recalled the ambient temperature on the day being around 24 - 25 °C. The landing performance section of the Aircrew Manual gives a minimum ground run distance of 1,790 ft on a dry runway for an aircraft weight of 7,000 lb, with a threshold speed of 95 kt and a temperature of 25 ºC, with no wind[2]. Some adjustment of this figure would be required to take account of G-VIVM's weight, the speed achieved during the takeoff roll and the effect of wind/runway slope. However, it provides an approximate indication of the stopping distance from the point at which the RTO was initiated, which the commander expected G-VIVM to achieve.

Discussion

ASI

Examination and testing of the pitot/static system by the maintenance organisation and independent testing of the ASI, did not identify any defects which could explain the lack of airspeed indication reported by the commander. The reason for the absence of airspeed indication was not determined.

Footnote

[2] This figure was derived by linearly interpolating between the published landing performance figures for an ambient temperature of 20 and 30 °C.

Brakes

No problems were noted with the brakes during ground manoeuvring or the first RTO. The commander reported no evidence of residual heat in the brakes prior to the second takeoff attempt and the Aircrew Manual did not specify a minimum period for brake cooling.

Examination did not reveal any defects which might have led to a sudden loss of braking, although accident damage prevented post-accident testing of the braking system. The absence of flat spots on the tyres indicates that the brakes were not locked and the wheels continued to turn, rather than skidding during the RTO. The commander considered that it was normally possible to apply sufficiently heavy braking on the Jet Provost to cause flat spots on the tyres, given that it did not have an anti-skid system. He considered the absence of flat spots as evidence that the brakes were not functioning as expected.

Displacement of the brake pistons was consistent with hydraulic pressure being applied at the callipers and the extent of piston travel suggests heavy braking. Mechanical and heat damage to the wheels and brakes was consistent with the application of heavy braking, such as might occur during a high energy (high speed) RTO.

All six floating friction pads were displaced from the pistons, and four of them were found on or close to their respective wheels. Two were not retrieved and it is not known at what point these were liberated. The loss of one or more floating friction pads would substantially reduce braking efficiency and increase the temperature and wear rate experienced by the remaining friction pads. Disruption to the friction surface of the disc from direct contact with a piston would also have exacerbated this. It is therefore likely that this would have had an adverse effect on braking efficiency, which would have reduced throughout the ground run of the RTO.

The maintenance organisation commented that the design of the Jet Provost braking system was not considered particularly robust and some Jet Provost owners had replaced the original brakes with those from the Strikemaster[3], which were considered superior.

Decision-making

Having already experienced an earlier RTO due to a lack of airspeed indication, the commander was focused on the ASI during the second takeoff attempt and wanted to give it ample opportunity to indicate. In doing so the aircraft accelerated to a higher speed than the commander estimated, and likely a higher speed than during the first takeoff roll.

Although he didn't consider using it at the time, the commander later considered that it may have been prudent to refer to the ground speed display on the iPad as a secondary speed source during the second takeoff attempt. This may have facilitated the RTO being initiated at an earlier point.

Footnote

3 The BAC 167 Strikemaster was a ground-attack derivative of the Jet Provost T Mk.5.

In planning for the second takeoff attempt, it may have been prudent to review the aircraft stopping performance and identify a fixed reference point on the runway by which the takeoff would be rejected if the same fault recurred. The commander considered that the second RTO was initiated at approximately the same point on the runway as the first RTO and assessed that there was sufficient runway remaining in which to bring the aircraft to a stop. However, given that the aircraft had reached a groundspeed of approximately 105 kt, it is quite possible that the aircraft had travelled further along the runway than the commander recalled.

It was not possible to reconcile all the various sources of evidence available to the investigation to provide a complete understanding of why the aircraft did not stop before the end of the runway, but the investigation considered that the braking demand during the RTO exceeded the ability of the aircraft's braking system to bring the aircraft to a stop within the remaining runway distance available. Displacement of the floating friction pads during the ground run would also have had an adverse effect on braking efficiency.

Conclusion

The reason for the absence of airspeed indication was not determined. At the point at which the rejected takeoff was initiated, the braking demand exceeded the ability of the aircraft's braking system to bring the aircraft to a stop within the remaining runway distance available. Displacement of the floating friction pads during the ground run would also have had an adverse effect on braking efficiency.