# Aviation Safety Investigation Report 199602602

## de Havilland Canada Dash 8

## 17 August 1996

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**Occurrence Number:** 199602602 **Occurrence Type:** Accident
**Location:** Broome, Aerodrome
**State:** WA **Inv Category:** 4
**Date:** Saturday 17 August 1996
**Time:** 1844 hours **Time Zone** WST
**Highest Injury Level:** None

**Aircraft Manufacturer:** de Havilland Canada
**Aircraft Model:** DHC-8-103
**Aircraft Registration:** VH-JSI **Serial Number:** 229
**Type of Operation:** Air Transport Test
**Damage to Aircraft:** Substantial
**Departure Point:** Broome WA
**Departure Time:** 1722 WST
**Destination:** Broome WA

**Crew Details:**

| Role | Class of Licence | Hours on Type | Hours Total |
|---|---|---|---|
| Pilot-In-Command | ATPL | 4200.0 | 14100 |
| Co-Pilot/1st Officer | ATPL | 50.0 | 9060 |

**Approved for Release:** Friday, September 20, 1996

FACTUAL INFORMATION

History of the flight

The aircraft was scheduled to complete a flight test following major repairs to the left wing and fuselage. These were carried out in Broome to repair damage resulting from a birdstrike which occurred in May 1996 (BASI report 9601590). The crew for the flight comprised two experienced pilots, one of whom was a qualified test pilot, and a flight test engineer. There were no passengers. When the landing gear was selected up, after takeoff, the nose landing gear door unsafe and landing gear handle lights remained on. The gear was selected down and safe indications were obtained. The gear was selected up a second time and it retracted normally. The test flight was continued, with sequences being completed up to the landing gear tests. Landing gear down selection resulted in a safe indication on the main gear (two green lights) and unsafe indications on the nose gear (a red gear light, no amber door light and a light in the gear handle). Actions were completed in accordance with the abnormal and emergency checklist however, the nose gear continued to indicate unsafe.

An inspection by ground engineers, during a fly-past, determined that the nose gear was still retracted but the gear doors were partially open. Positive-gravity manoeuvres and a touch-and-go landing failed to shake the nose gear free. The crew decided to land at Broome once all other traffic was clear and emergency services were in place. Advice from the manufacturer's representative in Broome indicated that the propellers would remain clear of the runway during the landing. A landing was completed with the aircraft sliding to a stop on its main wheels and nose, 460 m after touchdown.

Nose gear locking mechanism

To release the nose gear, using either the normal or alternate systems, the over-centre up-lock initially moves further away from the neutral position before moving back through neutral to the gear extension position. Movement of the up-lock causes a corresponding movement in the upper drag strut. Inspection determined that the nose landing gear had been jammed in the up position as a result of a lack of clearance between bolt heads securing a cover plate on the nose leg and the upper drag strut. The lack of clearance prevented the initial unlocking movement. Witness marks were found on the upper drag strut where the bolt heads had been making contact with it.

Nose leg history

The nose leg had been removed from another aircraft following a ground incident some months prior to this accident. As it was damaged, it was sent to an overseas workshop for repair. When the nose leg was returned to the operator a cover plate, which is designed to protect microswitches associated with the nosewheel steering system from dust and stone damage, was missing. The overhaul shop advised the operator to obtain a replacement. The operator believed it already had a suitable replacement in a box in its store in Adelaide and no further action was taken. The original nose leg from VH-JSI was removed, during the wing repair, and fitted to the ground incident aircraft to help restore it to flying status as soon as possible. The overhauled nose leg was fitted to JSI once the wing repair was almost complete.

Nose leg cover plate

When the box containing the replacement cover plate was delivered from Adelaide, and opened in Broome on 2 August 1996, it was found that some parts were missing. The manufacturer advised that a 36 week lead time was required to replace the missing parts. Maintenance personnel in Broome then decided to manufacture substitute parts. The operator's engineering staff, outside Broome, were not consulted. The operator's maintenance control manual required all non-approved parts to undergo a design and approval process prior to being fitted to its aircraft. A Brisbane-based contract engineer would have been responsible for this design and approval had it been requested. No action was taken to meet the design and approval requirements.

The cover plate was non-load bearing and it was reported that it did not appear to be a significant part of the nose leg structure. The original plate was shaped to provide clearance between it and the microswitches. Because of the limited manufacturing capability in Broome, the replacement cover was manufactured from flat plate and spacers were used to provide similar clearance.

The original plate was secured using counter-sunk screws. This aspect went unnoticed by the maintenance personnel although the screws were depicted in the Dash 8 parts manual. The holes in the replacement plate were not drilled to accept counter-sunk screws and it was secured using hexagonal-head bolts and washers. The use of spacers and hexagonal-head bolts and washers meant that the tops of the bolt heads protruded 8.5 mm beyond the normal position of the counter-sunk screw heads. The measured space available between the tops of the counter-sunk screws and the upper drag strut, on a serviceable Dash 8 with its nose leg retracted, was 5 mm. The difference of 3.5 mm was sufficient to cause the landing gear to jam although hydraulic pressure was able to overcome the lack of clearance on at least one occasion after takeoff.

The maintenance engineer who fitted the replacement plate to the nose leg reported that, had the holes in the plate been counter-sunk he probably would have recognised that counter-sunk screws were required. Had counter-sunk screws been used instead of hexagonal-head bolts and washers, the plate, with its spacers, would still have protruded 6.6 mm instead of 8.5 mm. That is 1.6 mm beyond the space available.

While the replacement plate was being manufactured the nose leg was refitted to the aircraft and landing gear retraction tests successfully completed. No retraction tests were attempted after the cover plate was fitted.

## Organisational issues

Three significant organisational issues were identified during the investigation. These involved project management, pressure and fatigue and loyalty and motivation.

### Project management

The repair of JSI was completed by two groups of engineers. The wing and fuselage repair was supervised by an engineer employed by the aircraft manufacturer and completed by an overseas contractor with assistance from the operator's staff. The reassembly and certification was completed by a licensed aircraft maintenance engineer, with Dash 8 approvals, using a mixture of the operator's staff from Broome, Perth and Darwin.

The operator's technical manager, who had ultimate responsibility for the work on JSI, was based in Adelaide and was only able to visit Broome on four occasions, the most resent being between the 12-16 May. It was reported that he departed on 16 May as the reassembly was essentially complete. He was not consulted about the plan to manufacture a replacement cover plate. A Broome-based licensed aircraft maintenance engineer was originally appointed to coordinate the repair but he was not given any formal project management authority. This engineer did not have Dash 8 approvals but he did have extensive experience in the maintenance and repair of large airline aircraft and was familiar with the requirement to have the correct approval for all parts fitted to transport category aircraft. The licensed aircraft maintenance engineer, with Dash 8 approvals, who assumed responsibility for reassembly and certification, was sent to Broome on temporary assignment, to provide licence cover, and arrived after the wing repair had started and the coordinating maintenance engineer had commenced his task. It was reported that this led to some conflict amongst maintenance staff. The result was that neither of the licensed aircraft maintenance engineers, or anyone else, exercised any overall responsibility for the project. At no stage was a project manager appointed to supervise the whole job. Although the maintenance personnel were aware of the maintenance control manual's requirements for non-approved parts, action was not taken to ensure that it was complied with.

Pressure and fatigue

A deadline had been set by the operator's management team for JSI to depart Broome on 18 August 1996. Reassembly and certification of JSI could not be completed until after the wing repair had been finished. Because of the complexity of the wing repair the contractor declined to give the operator a definite completion date. The wing and fuselage repair was not completed until the week commencing 12 August 1996. As a result, time to complete the whole process was limited. The nose and left main landing gear and left engine and propeller had to be reinstalled. Electrical systems, damaged during the birdstrike, had to be repaired and tested. A test flight was needed and the aircraft had to be repainted. The local engineers believed that the time required to get the Brisbane-based engineer to complete design and approval of the replacement cover plate would probably have exceeded the limited time available.

The operator's aircraft maintenance personnel were required to work on JSI as well as complete their normal maintenance activities on other company aircraft. These processes resulted in some unusually long shifts (often 15 hours but up to 28.5 hours) and the onset of significant, observed fatigue.

Loyalty and motivation

Discussion with the operator's staff provided anecdotal evidence that there was strong company loyalty and motivation to get the job done. Staff excelled themselves in order to meet demanding deadlines. Whilst this approach is laudable, research and investigation has shown that it can lead to incorrect practices if the appropriate balance is not found.

Other issues

A number of other administrative and procedural issues were noted during the investigation. These were not directly related to this accident but provided supporting evidence that a culture aimed at "getting the job done" existed amongst the operator's staff.

## ANALYSIS

It is probable that motivation, pressure and fatigue were the main factors in the decision not to complete the maintenance control manual requirements prior to manufacturing the replacement cover plate. It is likely that the maintenance engineers allowed their desire to get the job done to overcome any caution developed through experience. Limited time availability meant that ordering a replacement part, or ensuring the completion of the required design and approval process, would prevent them meeting the deadline. Fatigue may have reduced the maintenance engineer's analytical ability and possibly contributed to the flawed decision.

The lack of a project manager to supervise and audit the complete engineering process meant there was no safety net to prevent incorrect decisions or practices, emanating from the workface, having a detrimental affect on safety. The lack of a project manager and the limited presence of the technical manager also meant there was no one of authority that the maintenance engineers could readily discuss the problem with before they made their final decision.

The fact that the cover plate was not a structural component and was only a protective cover probably misled the maintenance engineers into believing that the manufacture of a similar, but not exact, replacement part would not significantly affect safety.

The ultimate safety net, landing gear retraction tests, failed when the cover plate was not fitted prior to the tests. The plate was not fitted because it was not seen as a significant part of the landing gear system and time pressure probably led maintenance personnel to believe that the tests could not wait until assembly was complete.

## SAFETY ACTION

The operator advised it has have taken action to address all of the management, administrative, procedural and maintenance issues noted during this investigation. Amended processes will be applied during the repair of damage sustained by JSI in this accident.