AVIATION OCCURRENCE REPORT

LOSS OF WHEELS ON LANDING

INTER-CANADIEN FOKKER F-28 MK1000 C-FCRI
QUEBEC/JEAN LESAGE INTERNATIONAL AIRPORT, QUEBEC
09 JUNE 1996

REPORT NUMBER A96Q0083

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Summary

The Fokker F-28 aircraft (serial number 11043) (Inter-Canadien flight 1661) was on the downwind leg for a landing on runway 06 at Jean-Lesage international airport, Québec, Quebec. During the approach, the crew lowered the landing gear and prepared to land. Shortly after touchdown, the crew felt side-to-side oscillations. The captain, who was flying the aircraft, applied heavy braking; the oscillations stopped, but then began again. The captain modulated the braking to try to reduce the oscillations, but without success. The inboard wheel of the right main landing gear strut separated from the landing gear, followed shortly thereafter by the outboard wheel of the same main gear. The crew noted the aircraft's change in attitude, and the captain applied the left wheel brake to keep the aircraft on the runway, while controlling the nose wheel. When the aircraft came to rest, on the runway, the order to evacuate was given, and the passengers evacuated the aircraft by the service/emergency door and the emergency exits located over the wings. There were no injuries during the evacuation.

Ce rapport est également disponible en français.

Other Factual Information

The flight crew was certified and qualified for the flight in accordance with existing regulations. The pilot had obtained his Fokker F-28 type rating on 24 April 1996 and had a total of 125 flying hours on type. The copilot had obtained his type rating on 02 May 1996 and had a total of 70 flying hours on type.

The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The aircraft's weight and centre of gravity were within the prescribed limits. The flight crew operated the aircraft in accordance with Inter-Canadien standards and approved procedures.

The crew of two pilots and two flight attendants had come on duty at around 0730 eastern daylight time (EDT), and had carried out the customary checks. Flight 1660 left Dorval, Quebec, at 0830 for Québec, Sept-Îles, Quebec, and Wabush, Newfoundland. From that point on, the flight was called flight 1661 and retraced its route to return to Dorval.

When flight 1661 left Sept-Îles for Québec, all the aircraft systems were operating normally, and the captain was flying the aircraft. The flight was somewhat behind schedule when it left Sept-Îles, but was to land in Québec at 1550 as scheduled. The weather report for Québec indicated a few clouds at 3,000 feet and winds from 050 degrees magnetic at 6 knots.

According to the crew, when on short final for runway 06, the aircraft was showing a reference speed of 116 knots (V_{ref}), with the flaps extended 42 degrees; the aircraft touched down at a speed of 113 knots. The flight attendants described the touchdown as firm, and the pilots described it as soft. The oscillations began shortly after touchdown. The cockpit voice recorder (CVR) information shows that the approach proceeded without incident.

The flight data recorder (FDR) data show that on touchdown the indicated speed was 125 knots, higher than on previous flights. Also, after touchdown there was a two-second delay before the thrust levers were placed in the idle position. The oscillations began about four seconds after touchdown. Runway 06 is 9,000 feet long. The oscillation marks began 1,800 feet from the runway threshold and were 630 feet long (see Appendix A). They are essentially parallel S-shaped marks made by the right landing gear. The second series of S-marks began 4,257 feet from the runway threshold and continued for a distance of 83 feet. During this second series of marks (19 seconds after touchdown), the inboard wheel separated from the right landing gear, followed by the outboard wheel; the speed at that time was 64 knots. The aircraft continued on the landing gear strut for another 340 feet before coming to rest on a heading of 96 degrees

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[1] All times are EDT (Coordinated Universal Time minus four hours) unless otherwise stated.

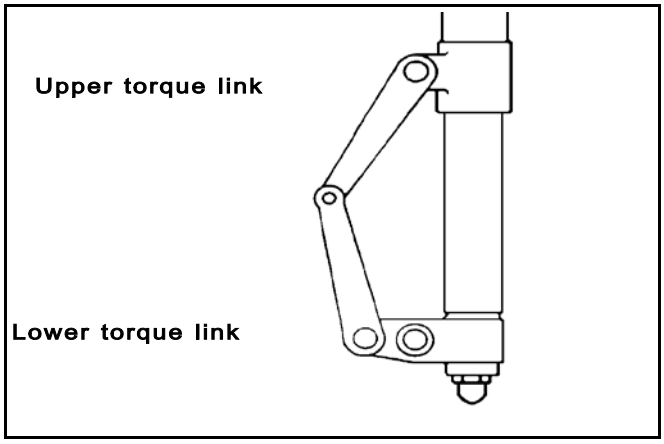
magnetic, 4,680 feet from the threshold of the 9,000-foot runway. During this time, the two tires continued to roll; both crossed taxiway Alpha before coming to rest, one 7,045 feet from the runway threshold and the other 7,708 feet from the runway threshold. There was no fire during the occurrence.

The Québec tower controller alerted the emergency services as soon as the crew advised of the occurrence. The emergency vehicles headed for taxiway Alpha to go up runway 06. They had to stop for a few seconds because they were told that the aircraft's tires were about to cross taxiway Alpha.

After the aircraft came to rest and the check-list was completed, the captain gave the order to evacuate the aircraft. The flight attendant responsible for the forward exits was not able to open the left forward main door because the opening mechanism electric assist had been lost, and because the aircraft was leaning to the right, requiring additional force to open the door. The emergency exits over the wings and the right forward emergency exit were quickly opened. The evacuation was completed within a reasonable time. Approximately 80 per cent of the passengers used the right forward exit; the other passengers used the exits over the wings. A survey of a number of passengers indicated that the evacuation was orderly, in spite of the element of surprise surrounding the incident. However, a number of passengers were determined to take their hand baggage with them, and some were successful.

After the passengers had been evacuated, the crew opened the left forward main door and exited the aircraft. The passengers were evacuated to the runway edge and then transported to the air terminal.

Each main landing gear unit on the F-28 is equipped with an upper and a lower torque link, mounted behind the landing gear and connecting the lower strut to the main strut. Because it is hinged at a central point (the apex), the torque link allows the lower strut to move up and down while keeping the landing gear wheels in proper alignment. Each landing gear unit has an inboard wheel and an outboard wheel.



The TSB Engineering Branch examined the aircraft's right landing gear unit. The failure of the landing gear upper torque link was attributed to mechanical overload. The failure of the landing gear upper torque link was attributed to the overload extension of three small zones of precracking at a location known

to have been previously associated with fatigue crack formation. The zone between the precracking and overload revealed fine microstriations consistent with loading having occurred at higher-than-normal service loads. This indicates that the precracks only served to locate the initiation of the overstress fracture.

The clearances between the upper torque link pin and the bushes in the upper torque link attachment lugs on the main fitting, between the upper torque link pin and the bushes in the upper torque link, between the lower torque link pin and the bushes in the lower torque link attachment lugs on the sliding member and between the lower torque link pin and the bushes in the lower torque link exceeded their respective in-service wear limit. Two days before the occurrence, a crew had reported strong vibrations from the landing gear. After checking the landing gear in accordance with the Fokker F-28 Maintenance Manual, the maintenance unit judged that the landing gear met standards.

The shock absorber was found to contain 10.7 litres of hydraulic fluid, whereas the amount specified in the manufacturer's *Component Maintenance Manual* is 13.3 litres. After other shock absorbers were checked and volume calculations were done by the Dowty company (the manufacturer), it was shown that there was an error in the maintenance manual, and that the actual capacity of the shock absorber was in the area of 10.7 litres of hydraulic fluid. The quantity of liquid measured in the examination thus matches the shock absorber's actual capacity, and the manufacturer stated that it would make the necessary changes to the maintenance manuals.

The examination by the TSB Engineering Branch found that the nitrogen pressure in the landing gear shock absorber was 325 pounds per square inch (psi). Because of its type of air operations, Inter-Canadien may land at several airports in the same day, at outside (operating) temperatures varying considerably from airport to airport. According to the Fokker, F-28 Maintenance Manual, the nitrogen pressure which should be applied when servicing at 15 degrees Celsius varies between 205 psi (for operating temperatures of 15 degrees Celsius) and 376 psi (for operating temperatures of minus 40 degrees Celsius). At low operating temperatures, the nitrogen pressure of 205 psi should not be used because it does not provide sufficient stroke and the shock absorber may bottom under certain conditions.

Previous investigations of torque link failures on this aircraft type have often identified, as contributing factors, insufficient hydraulic fluid or excessive nitrogen pressure in the shock absorber. High nitrogen pressure has the effect of keeping the strut extended longer during the landing, thus reducing the mechanical advantage of the torque links in keeping the landing gear wheels in proper alignment.

A number of FDR data items found in investigations of similar accidents were studied to determine whether non-deployment of lift dumpers could have been the only cause of similar occurrences in Canada. When the lift dumpers are deployed, the weight is transferred from the wings to the wheels, and the upper and lower torque links regain their mechanical advantage. For the lift dumpers to deploy automatically, the system must be engaged, the engine thrust levers must activate the lift dumper microcontacts (between 65 HP and 80 HP), and one pair of wheels must be rolling at more than 50 knots. Research has shown that non-deployment of the lift dumpers is not the only cause of this type of occurrence. Other factors, such as excessive indicated speed on landing, can also slow the weight transfer to the landing gear, preventing the torque links from exerting their mechanical advantage and favouring the appearance of oscillations.

Analysis

The flight crew was certified and qualified for the flight in accordance with existing regulations. The weather conditions were favourable for the flight as planned.

During the evacuation, the main door could not be opened by the flight attendant because of the additional force required when the aircraft was leaning and the electric assist had been lost. The evacuation was orderly and was completed in a reasonable time, but not all the available exits could be used. The determination of a number of passengers to take their hand baggage with them could have had serious consequences if the evacuation had not gone so smoothly.

Two days before the occurrence, vibrations had been reported to the company's maintenance unit. The aircraft had been returned to service after an inspection found that everything was within standards. However, the laboratory examination showed that there was excessive wear on the attachment between the lower torque link and the lower strut, and that the nitrogen pressure in the cylinder was high, so that the landing gear strut remained in the extended position for a longer time.

On landing, the lift dumpers could not deploy quickly because the thrust levers had not been pulled sufficiently to activate the microcontacts. Late deployment of the lift dumpers and the higher landing speed are conditions which contribute to the development, the amplitude and the duration of oscillations. The extension of the landing gear strut reduced the mechanical advantage necessary for the torque links to keep the landing gear wheels in line with the aircraft's longitudinal axis. The main landing gear upper torque link therefore failed in overload, and the right main landing gear wheels separated from the aircraft.

The following laboratory reports were completed:

LP 76/96 - *FDR/CVR Analysis*
LP 79/96 - *MLG Linkage Examination*
LP 84/96 - *Effect of Lengthening F-28 Torque Links*

Findings

1. The main door of the aircraft could not be opened by the flight attendant.

2. A number of passengers were determined to take their hand baggage when they evacuated the aircraft, and some were successful.

3. Strong vibrations of the aircraft's main landing gear had been reported two days before the occurrence.

4. The clearances between the upper torque link pin and the bushes in the upper torque link attachment lugs on the main fitting, between the upper torque link pin and the bushes in the upper torque link, between the lower torque link pin and the bushes in the lower torque link attachment lugs on the sliding member and between the lower torque link pin and the bushes in the lower torque link exceeded their respective in-service wear limit.

5. The upper torque link failed in overload.

6. Fatigue cracking of sub-critical dimensions served to locate the initiation of the overload fracture.

7. The nitrogen pressure within the cylinder was higher than the standard.

8. The lift dumpers were deployed late.

9. The aircraft's actual landing speed was higher than V_{ref}.

Causes and Contributing Factors

The upper torque link failed in mechanical overload. Contributing to the failure was the high nitrogen pressure in the main landing gear, the late deployment of the lift dumpers, the high landing speed, and the exceeded in-service wear limits found between the upper and lower torque link pins and the respective bushes.

Safety Action

Action Taken

Dowty, the landing gear designer, acknowledges that there is an error on page 9 of *Component Maintenance Manual* 32-10-03, and that it is now changing the manual to correct the error. The manual will be amended by removing the figure 13.306 as the quantity of hydraulic fluid. Also, the document explains that the company is studying the data relating to the occurrences of 09 June 1996 and 01 November 1995, which are similar cases, involving Canadian Regional Airlines Ltd.

In early August 1996, the Fokker company issued a letter to all F-28 operators concerning the main landing gear. It notified operators of the publication of bulletin SB F28/32-151. This bulletin is in two parts: modifications to the maintenance program and the introduction of a damper for the torque links. Shortly after, the Netherlands issued Airworthiness Directive BLA 1996-103 indicating that bulletin SB F28/32-151 was mandatory.

Since the F-28 aircraft from Canadian Regional Airlines Ltd encounter considerable differences in ground temperatures during the same flight, Fokker sent them a facsimile in October 1996 indicating that a pressure of 290 psi should be used in the landing gear during the winter. Fokker also plans to publish another pressure figure for the summer.

Inter-Canadien confirmed the implementation of seven changes, dealing mainly with maintenance and staff training.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 22 April 1998.

Appendix A - Québec Airport (not to scale)