Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

# AVIATION INVESTIGATION REPORT

# A02O0131

# NOSE LANDING GEAR ACTUATOR FAILURE

## VOYAGEUR AIRWAYS

## BEECHCRAFT KING AIR A100 (BE-10) C-GISH

## NORTH BAY AIRPORT, ONTARIO

## 18 MAY 2002

Canada

# Aviation Investigation Report

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## *Summary*

At 1216 eastern daylight time, C-GISH, a Voyageur Airways Beechcraft King Air A100 (BE-10) aircraft, serial number B152, with two pilots and one non-revenue passenger on board, departed from Oshawa Municipal Airport, Ontario, on an instrument flight rules (IFR) ferry flight to North Bay. Just after take-off, upon selecting the landing gear handle to the up position, the flight crew heard a loud grinding sound. The sound seemed to originate from the nose landing gear, and the red warning light in the landing gear handle was illuminated. The flight crew also observed the reflection of the nose landing gear on the engine nacelle, confirming that the nose gear was only partially retracted.

The captain decided to climb to the filed cruising altitude of 15 000 feet above sea level (asl) and proceed to North Bay. Once en route, the flight crew lowered the landing gear. The red warning light in the landing gear handle remained on, and the green nose gear safe light did not illuminate. The flight crew selected the landing gear handle to the up position, but the nose gear still failed to retract. The flight continued to North Bay and landed on Runway 08 with the nose landing gear partially extended. The nose gear collapsed on touchdown, and the nose gear doors and the two four-bladed propellers were substantially damaged when they struck the runway. The flight crew and the passenger were not injured.

*Ce rapport est également disponible en français.*

# *Other Factual Information*

The captain of the occurrence flight held a valid Canadian Airline Transport Pilot Aeroplane Licence and a valid type rating for the BE-10 aircraft. He had accumulated 2350 hours total time in aeroplanes, of which 1400 hours were on the BE-10 aircraft.

The first officer held a valid Canadian Commercial Pilot Aeroplane licence and was a Canadian Forces helicopter pilot. He held a valid type rating for the BE-10 and had accumulated over 3000 hours total flight time.

At 1200 eastern daylight time (EDT)[1], the weather at the North Bay Airport was reported as follows: overcast cloud 2800 feet above ground level, visibility greater than 15 statute miles, temperature 2°C, dew point -6°C, winds variable 070 to 360° magnetic at 9 gusting to 16 knots, and altimeter setting 30.02 inches of mercury.

The aircraft was manufactured in 1973 and had accumulated 18 789 hours before the accident. The aircraft was equipped for instrument flight rules and was used by the operator mainly for general aircraft charters. Records indicate that the aircraft was equipped and certified in accordance with existing regulations. There were no known defects before the flight, and the aircraft's weight and centre of gravity were within approved limits.

The flight crew attempted all approved procedures in the company's operations manual and the aircraft manufacturer's emergency and abnormal checklists to fully extend and lock down the nose landing gear before landing. The Voyageur Airways' quick reference handbook refers to the failure faced by the flight crew as a "TYPE 3 MAIN GEAR DOWN - NOSE GEAR UP" landing gear failure.

Emergency landing gear extension is provided through a separate, manually powered, chain drive system. Although the flight crew was using the appropriate checklist for the emergency, the captain tried to extend the nose landing gear by attempting to engage the manual emergency landing gear handle. He was unable to move the handle because the handle is only capable of moving all three landing gear at the same time and only in the down direction. Since the main landing gear were already down and locked, the emergency gear extension could not lower the nose landing gear without pushing the main landing gear past the stops. The emergency gear handle moves with ease until the gear reaches its stops; once the stops are reached the handle becomes impossible to move giving a secondary indication that the landing gear is extended to full travel. The flight crew assumed that the emergency landing gear handle had seized when, in fact, the emergency system was operating as designed. Since the problem with the nose landing gear actuator was downstream of the emergency system input, the system could not lower the nose landing gear.

The crew declared an emergency after the second attempt to lower the nose landing gear was unsuccessful. In addition, the flight crew attempted a number of positive and negative G manoeuvres in an attempt to lock the nose landing gear in position. The aircraft was flown past the North Bay Flight Service Station, and personnel on the ground visually confirmed that the nose landing gear was partially extended. To facilitate keeping as much weight off the nosewheel as possible during the landing roll, the first officer removed several passenger seats

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

from the cabin, moving the aircraft's centre of gravity aft. The seats were securely placed behind the cargo netting in the aft cargo compartment. The crew fully briefed each other on the approach, the manipulation of power levers, the propellers, and the condition levers before and after touchdown. The passenger was briefed regarding the evacuation of the aircraft and applicable commands.

The aircraft touched down on the centreline, within the first 2000 feet of runway. After the main landing gear touched down, the condition levers were moved to "cut off" and both propellers were feathered. The captain delayed lowering the nose for as long as possible. The nose landing gear collapsed as soon as it made contact with the hard surface runway. The aircraft then rolled approximately 1800 feet down the runway before coming to a stop, with approximately 6200 feet of runway remaining. The passenger, the first officer, and the captain immediately evacuated the aircraft. Airport Emergency Response Services arrived but were not required. No post-landing fire occurred.

The aircraft was subsequently towed to the operator's maintenance hangar and placed on jacks. It was determined that the nose landing gear actuator had failed. Before removing the actuator, it was determined that there was no binding of the nose landing gear installation. The propellers were substantially damaged. The power sections of both PT6A-28 engines were sent for inspection and repaired as necessary due to the sudden stoppage.

The landing gear of the BE-10 aircraft is a fully retractable tricycle configuration, driven by a 28-volt motor located on the forward side of the main spar. The main gear actuators are driven from the motor gearbox through torque shafts. The nose-gear actuator is driven by a duplex chain from a sprocket on the motor gearbox. The input shaft to the nose-gear actuator drives a series of rotating gears inside the actuator. These gears rotate a screw into and out of a lubricated aluminum-bronze alloy nut. The movement of the screw through the lubricated nut extends and retracts the nose landing gear.

The failed nose landing gear actuator was identified by the data plate as part number 50-820208-5, serial number ALG 4413. The actuator had accumulated 2013 cycles since overhaul. The cycle limit is 7500 cycles between overhauls. No anomalies were noted with the landing gear system other than the failed nose landing gear actuator.

Every 1000 cycles, the nose landing gear actuator must be removed from the aircraft and tested. The test, referred to as a "total end-play check", is described in the Beech King Air 100 Series Maintenance Manual.

Chapter 5-20-00 page 302, item 35 (Landing Gear Actuators) states:

> Perform a screw end-play check. (Removal from aircraft required) Refer to Chapter 32-30-00.

Chapter 32-30-00, page 201, details the total end-play check as follows (in part):

> Each actuator should be bench-checked for total end-play. Refer to Chapter 5 for inspection intervals.
>
> Using an extension rod paralleled to the nut assembly, ... clamp a dial indicator to the nut assembly shaft so that the deflector lever of the dial

> indicator rests against the gear housing of the actuator. Flatten the extension rod where it contacts the nut assembly shaft to ensure firm clamping.
>
> Apply approximately 100 pounds of force in either direction. Pull the nut assembly shaft in and out several times while measuring by dial indicator the distance over which the nut assembly may be pushed in and out of the actuator housing.
>
> Check the actuator end-play with the actuator nut fully in and backed off one turn, with the nut half extended, ... and with the nose-gear actuator extended 11.25 inches.

This test is designed to measure the amount of travel or "play" between the lubricated aluminum-bronze alloy nut and the steel screw. The amount of travel allowed is less than 0.018 inch. If end-play reaches 0.018 inch, the actuator should be overhauled or replaced.

The failed nose landing gear actuator was not removed from the aircraft until TSB investigators arrived. Externally, the actuator was undamaged with some accumulation of dirt and debris. During the examination of the actuator, it was noted that rotation of the screw within the aluminum-bronze alloy nut was possible, but no actual extension or retraction of the screw through the nut threads could be produced. The screw was removed from the aluminum-bronze alloy nut assembly, and the nut assembly was sectioned longitudinally. It was discovered that the threads of the nut assembly had failed. Grease was found adhered to the walls of the nut assembly, but no grease was found in the travel area of the threads themselves. The remainder of the threads from the nut were found on the threads of the screw and broken into several pieces. In some areas, pieces of the failed threads had doubled up on one another. Individually these pieces measured .031 inch thick. The distance between the threads on the screw was measured at .069 inch. Threads that are known to have failed in overload generally remain in a continuous thread and retain a coil-like appearance. Those that fail as a result of wear tend to be broken into several pieces, as in this occurrence. The failed nut assembly was submitted to the Materials Analysis Division of the TSB Engineering Branch to determine if the composition of the nut assembly complied with the manufacturer's specifications. The nut was determined to be of the aluminum-bronze alloy specified by the manufacturer.

On 03 December 1997, the occurrence actuator had reached its maximum number of cycles before overhaul and was removed from a Voyageur Airways Beech King Air, C-FAPP. It was sent to Global Aerospace Corporation for overhaul. After overhaul, the actuator was returned to Voyageur Airways and installed on another Beech King Air, C-GIND, on 19 December 1997. On 28 October 1998, the actuator failed the end-play check at 994 cycles since overhaul. It was removed from C-GIND and returned to Global Aerospace for repair. Upon return of the actuator to Voyageur Airways, company maintenance personnel discovered that two bushings were missing, and the actuator was sent back to Global Aerospace for rectification. The missing bushings were installed, and the actuator was placed in Voyageur Airways stores for later use. On 27 January 2000, the actuator was installed on the occurrence aircraft, C-GISH. The next required end-play check was completed on 19 March 2002, and all measurements were found to be within limits. However, 89 cycles later, on the occurrence flight on 18 May 2002, the actuator failed on gear retraction.

Voyageur operates King Air 100 and 200 aircraft and both have the same nose-gear actuator (part number 50-820208-5). The procedures to complete the end-play check found in the King Air 200 Maintenance Manual, Chapter 32-30-00, page 210 - 211, are the same as those found in the King Air 100 Maintenance Manual with minor exceptions. The procedure in the King Air 200 Maintenance Manual is prefaced by the statement, "Ensure that each actuator is bench checked for total end-play. Check each actuator as follows before disassembly for lubrication." Also, the last step in the King Air 200 Maintenance Manual is not included in the King Air 100 Maintenance Manual and it states, "After the actuator has been lubricated, recheck the total end-play to ensure that the unit has been correctly reassembled following lubrication."

When asked about the different procedures for the same actuator part number, Raytheon Aircraft personnel stated that the procedures should be identical and the procedure should not include disassembly and lubrication. Raytheon provided two communiques, issued in 1989 and 1990, that referred to the internal lubrication or repacking of the landing gear actuators on the King Air 200/300 and 90/100 aircraft respectively. Both communiques stated the following:

> The repacking of mechanical gear actuators is no longer required in Air Transportation Association (ATA) 5. We dropped the internal lubrication (actuator repack) due to the inability of most facilities to adequately test the unit after re-assembly. ATA 12 and 32 still make reference to lubricating the actuator. The actuator should not be repacked unless it is leaking. If visual inspection indicates no leakage, do not open and repack!

On 28 June 2002, Global Aerospace Corporation sent a letter to Voyageur Airways noting that the nose landing gear actuator (part number 50-820208-5) nut became worn beyond limits within approximately 1200 cycles, and that a lack of grease inside the actuator nut possibly contributed to the wear of the nut. Global Aerospace noted that the lack of grease could have been the result of removing the nut from the actuator and cleaning away the grease during a field inspection, grease propagating from the nut, or incorrectly filling the nut with grease during overhaul. Global Aerospace requested that Voyageur Airways return their actuators to be cleaned, repacked with grease and end-play checked at no charge to Voyageur Airways.

In a letter to Voyageur Airways dated 28 January 2003, Global Aerospace noted that only one main gear actuator was returned for this inspection in the first few weeks following the 28 June 2002 letter. Six months later, three nose-gear actuators were removed for either a binding snag or grinding sound. Two actuators were sent to another overhaul shop and one was returned to Global Aerospace for inspection. It was determined that the nut on each assembly was worn. Since these actuators were not returned to Global Aerospace for the free inspection, it could not be determined if the damage was caused by a lack of lubrication as a result of the nut being incorrectly filled with grease during the last overhaul by Global Aerospace.

## *Analysis*

The nose-gear actuator failed 89 cycles after it had undergone an end-play check in which it was determined to be within limits. It was discovered during the tear down of the occurrence actuator that the aluminum-bronze alloy nut and steel screw were relatively free of grease. Without lubrication, the steel screw, under load and moving through the aluminum-bronze alloy insert, would produce a high wear rate resulting in premature failure. It was concluded that lack of lubrication resulted in excessive wear of the nut assembly and premature failure. It could not be determined if the lack of lubrication was due to removing the nut from the actuator

and cleaning away the grease during a field inspection, grease propagating from the nut, or incorrectly filling the nut with grease during overhaul. Although Voyageur Airways used approved procedures in completing maintenance tasks related to the nose-gear actuator, differences between the King Air 100 and 200 Maintenance Manuals may have resulted in inconsistent maintenance practices.

Although Raytheon Aircraft issued communiques in 1989 and 1990 stating that the internal lubrication (actuator repack) was no longer required in ATA 5, the King Air 100 and 200 Maintenance Manuals were not amended. Therefore, the procedure in the King Air 200 Maintenance Manual, which refers to disassembly and lubrication, could result in maintenance personnel following a procedure that was no longer required or recommended.

## *Findings as to Causes and Contributing Factors*

1. The nose landing gear actuator failed prematurely due to excessive wear of the nut assembly as a result of lack of lubrication. The cause of the lack of lubrication could not be determined.

## *Other Findings*

1. Although the King Air 100 and 200 have the same nose-gear actuator part number, the procedures to complete the end-play check in the two maintenance manuals are slightly different. This could lead to inconsistent maintenance practices, despite the fact that Raytheon published communiques in 1989 and 1990 stating that internal lubrication of the actuators was no longer required.

## *Safety Action Taken*

Voyageur Airways designed and fabricated an end-play checking tool that exceeds the manufacturer's requirements. This equipment provides an accurate means of measuring landing gear actuator end-play. Voyageur Airways also completes all end-play checks in the component shop.

*This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 03 May 2004.*