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Aviation Mechanics Bulletin

JANUARY–FEBRUARY 2005

Misrigged Elevator-trim Cable Cited in Raytheon Beech 1900 Loss-of-control Accident

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Aviation Mechanics Bulletin

Dedicated to the aviation mechanic whose knowledge, craftsmanship and integrity form the core of air safety.

Robert A. Feeler, editorial coordinator

January–February 2005 **Vol. 53 No. 1**

On the cover: Pitch trim on a Raytheon Beech 1900 can be controlled by electric means or manually, as shown in this photograph of cockpit controls in an airplane that resembles the accident airplane. (Photo: U.S. National Transportation Safety Board)

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Misrigged Elevator-trim Cable Cited in Raytheon Beech 1900 Loss-of-control Accident

The problem was apparent to the flight crew within seconds after takeoff, but they were unable to regain control of the airplane, which struck water off the coast of the northeast United States.

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FSF Editorial Staff

At 1540 local time Aug. 26, 2003, a Colgan Air Raytheon Beech 1900D struck water in Nantucket Sound near Yarmouth, Massachusetts, U.S., during the first flight after maintenance personnel had replaced the forward elevator-trim cable. The airplane was destroyed, and the captain and first officer — the only people in the airplane — were killed.

The U.S. National Transportation Safety Board (NTSB) said, in its final report, that the probable cause of the accident was "the improper replacement of the forward elevator-trim cable, and subsequent inadequate functional check of the maintenance performed, which resulted in a reversal of the elevator-trim system and a loss of control in flight."

The report said that factors in the accident were "the flight crew's failure to follow the checklist procedures and the aircraft manufacturer's erroneous depiction of the elevator-trim drum in the maintenance manual."

Daytime visual meteorological conditions prevailed for the takeoff at 1538 from Barnstable Municipal Airport (HYA) in Hyannis, Massachusetts, for the repositioning flight to Albany (New York, U.S.) International Airport. Seconds after takeoff, the captain was recorded on the cockpit voice recorder (CVR) saying that the airplane had "a hot trim."

At 1538:48, the captain said, "Kill the trim kill the trim kill the trim." At 1538:50, he said, "Roll back … roll back roll back roll back roll back."

At 1539:00, the captain told the first officer to "do the electric-trim disconnect" and then to "go on the controls" with him, to retract the landing gear and to retract the flaps. The first officer replied that the flaps were "up," and the captain declared an emergency at 1539:33.

The report said, "From 1539:49 to 1540:03, the captain instructed the first officer to 'pull the breaker.' The first officer queried the captain as to its location."

At 1540:30, the captain requested clearance to land the airplane on Runway 33, and air traffic control (ATC) cleared the flight crew for landing.

The CVR recording ended at 1540:47.

Nearly 97 hours of data on the digital flight data recorder (DFDR) were used to compare the accident flight with previous flights. Because of the maintenance performed before the flight, the pitch-trim values and the elevator-position values for the DFDR were out of calibration; maintenance records said that the DFDR was inoperative. Nevertheless, the DFDR recorded data for the accident flight and provided trend information on pitch and trim, although the exact position values were not known.

A performance study using radar data and available DFDR data revealed that during takeoff, "the elevator did not leave the trailing-edge-down stop as soon and did not move in the trailing-edge-up direction as rapidly as during previous takeoffs" and that about 60 pounds (27 kilograms) of control-column pull force was required immediately after rotation — a greater amount than on previous flights.

"Once airborne, the airplane performance was consistent with the elevator pitch trim moving to the full nose-down position," the report said. "The airplane climbed to approximately 1,100 feet MSL [above mean sea level] before descending into the water. As the airspeed exceeded 200 knots during the flight and approached 250 knots during the descent, the control-column forces increased to approximately 250 pounds [113 kilograms]."

Witnesses said that they had observed the airplane in a left turn with a nose-up attitude before it pitched nose-down and struck the water "nose-first."

The captain of the accident airplane had 2,891 flight hours, including 451 flight hours as pilot-in-command of Beech 1900D airplanes and 913 flight hours as second-in-command. He held an airline transport pilot certificate, a Beech 1900D type rating and a first-class medical certificate issued March 18, 2003. He was hired by Colgan Air on July 16, 2001, and his most recent proficiency check was completed June 5, 2003.

The first officer had 2,489 flight hours, including 689 flight hours in Beech 1900D airplanes. He held a commercial pilot certificate and a first-class medical certificate issued Aug. 22, 2003. He was hired by Colgan Air on Oct. 22, 2002, and his most recent proficiency check was completed Nov. 3, 2002.

Maintenance personnel involved in replacing the elevator-trim cable included a quality-assurance inspector and two lead maintenance technicians.

The quality-assurance inspector received an airframe-and-powerplant mechanic certificate in 1986 and worked for several companies before being hired by Colgan Air in June 2002. Before that, he had no experience in Beech 1900 maintenance; after his hiring, he received 40 hours of formal training on the airplane, in addition to on-the-job training (OJT).

The lead maintenance technician who replaced the elevator-trim cable received an airframe-and-powerplant mechanic certificate in September 2001 and was hired by Colgan Air on Oct. 2, 2001. He received 94.5 hours of formal training on the Beech 1900, in addition to OJT. While working for a previous employer, he had replaced a forward elevator-trim cable on a Beech 1900C.

The second lead maintenance technician who assisted in replacing the elevator-trim cable received an airframe-and-powerplant mechanic certificate in September 2001 and was hired by Colgan Air on Oct. 2, 2001. He received 72 hours of formal training on the Beech 1900, in addition to OJT.

The airplane was manufactured in 1993 and had accumulated 16,503.5 hours of operation and 24,637 cycles when the accident occurred; of these, 1,219.1 hours and 1,765 cycles were completed after Colgan Air leased the airplane and placed it in service Jan. 4, 2003.

Colgan Air employed maintenance personnel who performed all required scheduled maintenance and phase inspections/checks on its aircraft. The fleet was maintained in accordance with a continuous airworthiness maintenance program developed by Colgan Air and approved by the U.S. Federal Aviation Administration (FAA). The program required a preflight inspection every four flight days, a routine inspection every eight flight days, one phase of a six-phase detail inspection every 220 flight hours and a structural inspection as required by the manufacturer. Each phase of the detail inspection involved a specific part of the airplane (wings, powerplant and nacelles, flight compartment/cabin, environmental systems, landing gear, and aft fuselage/empennage).

Elevators Not Removed During Work on Trim Actuators

On Aug. 23, 2003, an aft fuselage/empennage phase check was begun but then was interrupted, and the remainder of the phase check was deferred on Aug. 24, as permitted by the general maintenance manual. The airplane was flown later that day on 10 revenue flight legs, and the phase check was resumed in the evening and was completed Aug. 26.

The phase check included a free-play check of the left elevator-trim actuator and the right elevator-trim actuator; both failed the check.

"The failure required replacement of the actuators," the report said. "During the replacement of the actuators, the technician did not remove the elevators as required by the [maintenance program] and the AMM [aircraft maintenance manual]. Additionally, the technician did not maintain pressure on … the elevator-trim-tab cables, nor did the AMM require that the cables be blocked. Subsequently, the cable unwound off the forward [elevator-trim] drum. On Aug. 25, during the operational check of the system, the forward elevator-trim cable 'fell off' the forward [elevator-trim] drum, seized and kinked."

As a result, maintenance personnel ordered a new forward elevator-trim cable. Later that evening, they replaced the forward elevator-trim cable and the right elevator-trim actuator.

Workers on an earlier shift had removed the forward elevator-trim drum but had not left turnover notes for maintenance personnel on the next shift. (Turnover notes were not required by Colgan Air or by the AMM.)

"The two lead maintenance technicians that replaced the forward elevator-trim-tab cable did not use a lead wire as instructed by the AMM," the report said. "They marked the topmost cable pulleys with a 'T' instead. A lead maintenance technician and the quality-assurance inspector stated that following the maintenance, a successful operational check of the system was completed."

The operational check included operating the manual elevator trim and the electric elevator trim several times; the quality-assurance inspector was stationed in the cockpit and at the airplane's tail during different parts of the operational check.

The airplane was returned to service Aug. 26.

AAM Illustration of Trim Drum Was Backward

The report said that the two lead maintenance technicians who replaced the elevator-trim cable had referred to the AMM and that they "were not confused handling the [elevator-trim] drum or interpreting the drum illustration [in the AMM]."

A review of AAM Chapter 27-30-04, "Elevator Trim Tab Cables — Maintenance Practices," found that a depiction of the elevator-trim drum was backward.

"Although the [elevator-trim] drum could not be installed backwards, it was possible to misroute the cable around the drum and reverse the trim system," the report said. "The depiction in the maintenance manual showed the nose-up trim-tab cable emanating from the aft end of the drum, rather than the forward end. It also showed the nose-down cable emanating from the forward end of the drum rather than the aft [end]. However, the 'FORWARD AS INSTALLED' arrow included in the depiction would have to be ignored, and the cables would have to be crossed once along the cable run to reverse the system and secure the cable ends into the turnbuckles [links with screw threads at both ends, or with screw threads at one end and a swivel at the other]."

The review of the AMM also found no discussion of an operational check in Chapter 27-30-04 and no referral to a separate chapter titled "Elevator Trim — Maintenance Practices … Elevator Trim Operational Check," which contained discussion of the procedure for an operational check of the elevator trim system.

Elevator Trim Actuators Were in Full Nose-down Position

Most of the wreckage, including most components of the elevator and the elevator trim system, was recovered Aug. 28, 2003, from 18-foot-deep (five-meter-deep) water about 300 feet (92 meters) from shore.

"The right and left elevator-trim actuators were found near the full nose-down elevator-trim position," the report said. "The electric elevator-trim servo was found attached to the base of the horizontal stabilizer. The left and right trim-tab cables remained wrapped around their respective trim-actuator drums. Elevator-trim continuity was confirmed from the elevator-trim tabs to the cargo door area. Due to fragmentation forward of the cargo door area, trim-cable continuity could not be confirmed from the elevator to the cockpit pedestal. However, the cockpit pedestal with elevator-trim drum and manual-trim wheel was recovered. Further examination of the manual-trim wheel revealed that it was found near the 6.5 units of nose-up-trim position."

Five sections of cable were recovered. An examination indicated that the forward cable had emanated from the trim drum that terminated at the right turnbuckle instead of at the left turnbuckle.

During the investigation, a misrigging demonstration was conducted at the aircraft manufacturer's facilities using a manual trim wheel indexed to "0" with elevator-trim tabs in the neutral position; the system was intentionally misrigged.

Performance of an operational check of the elevator-trim system revealed the error: "When the cockpit trim wheel was positioned nose-down, the elevator-trim tabs moved in a nose-up direction. When the cockpit trim wheel was positioned nose-up, the elevator-trim tabs moved in a nose-down direction. When the electric-trim motor was activated in one direction, the elevator [trim] tabs moved in the corresponding correct direction, but the trim wheel moved opposite of the commanded electric-trim direction."

In addition, when the manual trim wheel was moved in the nose-down direction, the cockpit trim indicator moved "well past the nose-down limit, and the trim tabs were in the full nose-up position," the report said. "When the manual trim wheel was moved in the nose-up direction, the trim indicator did not reach the nose-up limit. Rather, the indicator stopped near positive "3" units, and the trim tabs were in the full nose-down position."

Further tests involved simulations of the accident flight using a Beech 1900 full-motion simulator, with the chief pilot of Colgan Air and an FAA inspector manipulating the controls.

"During all simulations, the elevator trim was positioned full nose-down shortly after takeoff," the report said. "The simulator pilot attempted to maintain aircraft control using different power settings to obtain different airspeeds. Five of the six simulations resulted in an uncontrolled descent into terrain. On the sixth test, the simulator pilot was able to partially maintain control of the airplane [simulator] by gradually reducing engine power and maintaining airspeed of approximately 170 knots. However, he had to return to the airport area at 170 knots and touch down at 180 knots. The airplane [simulator] did not land on a runway and subsequently impacted terrain."

Procedures Required Captain's Review of Maintenance Log Entries

Colgan Air's flight operations policy and procedures manual (FOPP) said that the captain was responsible for reviewing entries in the aircraft maintenance and flight log dating to the most recent valid airworthiness release to ensure that discrepancies between the airworthiness release and the current log page had been corrected or had been properly deferred.

The aircraft maintenance and flight log entry for the accident flight indicated a discrepancy: "Flt. data recorder needs downloading due to mx [maintenance]. Replacement of elevator trim cable (fwd. most)." The entry was signed by a maintenance technician; the report said that, in accordance with requirements for the approved minimum equipment list (MEL), the discrepancy was "released and signed by the same maintenance technician."

"The captain noted to the first officer that the DFDR was an open item on the MEL; however, there is no record of the captain mentioning the replacement of the forward elevator-trim cable," the report said.

The Colgan Air Beech 1900 flight manual contained expanded normal checklist procedures and guidance for their use to "ensure all safety items are accomplished."

The manual also discussed how pilots should respond in the event that performance of a checklist was interrupted.

"Interruptions to checklists increase the possibility of items being missed, which in turn may create hazards to flight operations," the manual said. "When interruptions occur, the crew must give consideration to restarting the checklist from the beginning, taking into consideration such factors as the length and type of interruption."

The report cited several checklist items that should have been performed by the flight crew, including the following:

- The "Preflight" checklist included an item that said, "Elevator, Elevator Tab, Static Wicks (4 each side) — Check and Verify Tabs are in Neutral Position";

- The "Before Start" checklist said that the captain must review and sign the dispatch release, and review the maintenance and the dispatch release with the first officer;
- The "First Flight of the Day" checklist, required after engine start, included several elevator pitch trim checks to ensure that the elevator trim switch was "ON" and functioning correctly, and that the trim disconnect switch and the "PITCH TRIM OFF" annunciator were functioning correctly; and,
- The "Taxi" checklist said that trims should be set and that the flight crew should verify proper trim-indicator positions.

A review of the CVR recording found that the flight crew completed the "Before Start" checklist between 1523 and 1530. During that time, the first officer said, "maintenance log, release, checked the aircraft," and the captain replied, "uhhh, maintenance and release on aircraft." The captain subsequently said that the DFDR was inoperative and confirmed that the DFDR was an open item on the MEL.

At 1525, as the captain began to start the right engine, he was interrupted; about one minute later, after talking on the radio with maintenance personnel, he resumed engine-start procedures. At 1529, as the captain was starting the left engine, he and the first officer began a "nonpertinent conversation, which lasted about 30 seconds," the report said. The crew then conducted the "After Start" checklist and resumed the nonpertinent conversation.

There was no record that they conducted the "First Flight of the Day" checklist.

At 1535, while conducting the "Taxi" checklist, the first officer said, "Three trims are set," and then called the "Taxi" checklist "complete."

The crew began a nonpertinent conversation about a landing aircraft that continued for about 87 seconds.

At 1537, the captain said, "All right, forty-six [Flight 9446] is ready," and the crew announced several items that were identified as items on the "Before Takeoff" checklist; the checklist itself was not called for, the report said.

Company Expanded Trim-check Provisions

During the investigation, Raytheon Aircraft issued Temporary Revision (TR) 27-9 ("Manual Elevator Trim Operational Check") of the AMM, followed by Safety Communiqué 234 and TR 27-10, which revised AMM Chapter 27-30-04 and updated the depiction of the forward trim drum. FAA subsequently issued Airworthiness Directive 2003-20-10, which told operators to incorporate TR 27-9 and provided a change in the illustration of the forward trim drum.

After the accident, Colgan Air issued an alert to employees about possible trim problems and expanded the trim-check procedures on the "First Flight of the Day" checklist and the "Taxi" checklist.

As a result of the investigation of this accident and the investigation of a Jan. 8, 2003, accident involving incorrect rigging of an Air Midwest Raytheon Beech 1900D,[1] NTSB issued 21 safety recommendations, including 14 safety recommendations involving maintenance of air carriers operated under U.S. Federal Aviation Regulations Part 121 ("Air Carriers and Commercial Operators"). Of the 14 recommendations, one said that FAA should "ensure that Raytheon Aircraft Co. revises the maintenance procedures for critical flight systems in its Beech 1900, 1900C and 1900D [AMMs] to ensure that the procedures can be completely and correctly accomplished."

FAA said that the revisions were completed in January 2005.♦

[FSF editorial note: This article, except where specifically noted, is based on U.S. National Transportation Safety Board report NYC03MA183. The 608-page report contains illustrations.]

Note

1. FSF Editorial Staff. "Misrigged Elevator and Aft Loading Cause Loss of Control of Raytheon Beech 1900D." *Accident Prevention* Volume 61 (May 2004).

   The Air Midwest airplane struck a maintenance hangar and terrain during takeoff from Charlotte-Douglas International Airport in Charlotte, North Carolina, U.S. The airplane was destroyed; all 21 people in the airplane were killed, and one person on the ground received minor injuries. The U.S. National Transportation Safety Board said, in its final report, that the probable cause of the accident was "the airplane's loss of pitch control during takeoff [that] resulted from the incorrect rigging of the elevator-control system, compounded by the airplane's aft center of gravity, which was substantially aft of the certified aft limit."

Further Reading From FSF Publications

FSF Editorial Staff. "Documentation, Inspection, Workload Problems Cited in Incorrect Installation of Aileron-trim Cables." *Aviation Mechanics Bulletin* Volume 49 (January–February 2001).

Crotty, Bart J. "Improperly Installed Trim Actuators Blamed for Takeoff Accident." *Aviation Mechanics Bulletin* Volume 48 (September–October 2000).

Misconnection Causes In-flight Fuel Leak

The Airbus A330-300, with a crew of six and 92 passengers, departed from Vancouver (British Columbia, Canada) International Airport on a flight to Calgary, Alberta, Canada. Soon after takeoff, air traffic control told the pilots that the pilots of another aircraft had reported a large quantity of smoke or vapor emerging from the no. 2 engine of the A330. Although there were no abnormal engine indications or warnings, the pilots declared an emergency and returned the aircraft to the departure airport.

After the landing, the pilots shut down the no. 2 engine. Aircraft rescue and firefighting services told the pilots that fuel was leaking from the engine. The aircraft was towed to the terminal. There were no injuries and no damage to the aircraft in the Nov. 6, 2003, incident.

The investigation found that during a routine service check the previous day, maintenance technicians had discovered a fuel leak in the air/oil heat exchanger of the no. 2 engine, a Rolls-Royce Trent 700. The technicians entered the defect, including the corrective action required, into the maintenance logbook and removed the aircraft from service.

"A notation was made, by mistake, on the maintenance-office duty board, indicating that the aircraft required a fuel/oil heat exchanger replacement instead of the air/oil heat exchanger, as had been written in the aircraft logbook," said the report by the Transportation Safety Board of Canada. The technicians assigned to perform the replacement noticed the discrepancy and decided to inspect the fuel/oil heat exchanger first.

"They disconnected a low-pressure (LP) inlet coupling to the fuel/oil heat exchanger, and fuel sprayed from the disconnected line," said the report. Having confirmed that the fuel/oil heat exchanger was not the source of the reported leak, they reconnected the line.

"However, a retainer, a crucial component to the security of the coupling, was omitted," said the report. The retainer, which cannot be detached from the fuel line, slid down the fuel line to a position where it could not be seen. The LP retainer was therefore not in place when the coupling was reassembled.

"The technicians who removed the LP fuel line on the fuel/oil heat exchanger were unfamiliar with the style of coupling used and did not refer to the Airbus A330 TSM [troubleshooting manual], nor did they refer to all relevant sections and pages of the aircraft maintenance manual (AMM) when removing or reinstalling the LP fuel line," said the report. "In addition, the removal and reinstallation of the LP fuel line was not recorded on any maintenance documents, contrary to [the operator's] maintenance policy manual and Transport Canada regulations."

The technicians resumed troubleshooting the leak, now referring to the TSM, and determined that the air/oil heat exchanger was the source, as noted in the logbook. They replaced the defective air/oil heat exchanger and ran the engine at idle for six minutes.

"Once the engine run was complete, the connections were inspected for leaks from the ground," said the report. "The air/oil heat exchanger may be inspected from the ground, but an inspection of the LP fuel-line connection on the fuel/oil heat exchanger requires the use of an elevated platform, as required by the A330 AMM. The A330 AMM also requires the use of a special developer on the reassembled components that aids in detecting fuel leaks. Neither an elevated platform nor a developer was used for the inspection of the fuel fittings and detection of leaks."

A high-power engine run (which was not required by the engine manufacturer) "would have produced conditions similar to those that caused the LP fuel line to detach from the fuel/oil heat exchanger on takeoff," said the report. "A high-powered engine run could decrease the risk that a leak or mis-installed component would go undetected."

The paperwork was completed, and the aircraft was returned to service.

"During the required idle-engine run, the fuel pressure and low fuel-flow rate, combined with minimal engine vibration, were insufficient to simulate in-flight conditions," said the report. "As the engine-power levers were advanced for takeoff [on the actual flight the following day], an increase in fuel pressure, flow rate and perhaps engine vibration caused the LP fuel line to detach from the fuel/oil heat exchanger because the retainer was missing. The fuel leak resulted in a large vapor trail … ."

The report said that the operator had not implemented Airbus service bulletin (SB) A330-28-3080 (which was not required by regulations), instructing A330 operators on how to activate fuel-leak-monitoring software that would issue a warning if there was a discrepancy of 3,500 kilograms (7,716 pounds) or more between the initial fuel on board (FOB) and the current FOB plus fuel used. [The service bulletin was issued by Airbus following a fuel-exhaustion incident in which pilots of an Airbus made a "dead stick" landing.]

"Implementation of this SB would reduce the risk of fuel exhaustion, engine shutdown and fire," said the report. "On [the incident] flight, a fuel loss totaling 3,500 kilograms occurred in fewer than five minutes following departure."

Depressurization Traced to Missing Moisture Shield

During a flight from Townsville, Queensland, Australia, to Brisbane, Queensland, at flight level (FL) 330 (about 33,000 feet), the flight crew of the Boeing 737-300 observed that the master caution light, the cabin pressurization auto-fail light and the pressurization standby light had illuminated. The crew completed the prescribed abnormal procedure and, because cabin pressurization was being maintained, they decided to continue the flight to Brisbane.

The crew then experienced physiological sensations that indicated that the flight deck was depressurizing. The pilots donned their oxygen masks, and the first officer observed that the cabin rate-of-climb indicator was displaying a rate of climb of 4,000 feet per minute.

"Shortly afterwards, as the cabin altitude climbed through 10,000 feet, the crew observed that the master caution light and passenger-oxygen ON light had illuminated and heard the cabin-altitude warning horn," said the report by the Australian Transport Safety Bureau. "The flight crew completed the [abnormal] procedure for a rapid depressurization and emergency descent and advised air traffic control that the aircraft had left the cruising level due to a depressurization."

The aircraft was leveled at 10,000 feet and the crew continued the flight to Brisbane at that altitude. An uneventful landing was made, and there were no injuries in the Dec. 2, 2001, incident. (The report was released Feb. 11, 2004.)

"Following the incident, the electrical/electronic (E/E) bay was inspected and water was found to be dripping from the forward-galley floor into the bay," said the report. "There was also evidence of moisture leakage under the forward passenger door and service door. Moisture stains were found on the racks and ducting within the bay."

Investigation revealed that the moisture shroud was missing from above a rack in the forward part of the E/E bay, and the pressurization controller, the yaw-damper coupler, the autothrottle computer and two stall-warning computers exhibited evidence of water damage, the report said.

The incident aircraft had been acquired from another Australian operator in October 2001. The report said, "Between December 2000 and January 2001, the aircraft underwent modification and heavy maintenance work at an overseas engineering facility before entering revenue operations in Australia. The modifications included the removal of [airstairs] from under the forward passenger-entry door. During that work the [airstairs] drip pan and the cloth moisture shroud were removed from the E/E bay.

"The documentation covering the removal of the airstairs specified that the moisture shroud was to be replaced following the modification work. However, the shroud was not installed because the kits were temporarily unavailable from the manufacturer. One of the operator's engineers, [who was] authorized by the [Australian] Civil Aviation Safety Authority to approve a design modification or repair, assessed that the absence of the moisture shroud would not affect the safety of the aircraft. The engineer approved an amendment to the engineering release that permitted the installation of the shroud within 12 months of receipt of the parts."

The moisture-shroud kits were ordered and were scheduled for delivery in November 2001. Meanwhile, the aircraft was operated in passenger service without the moisture shrouds and, when it changed operators in October, the new operator was unaware that the shrouds had not been installed, the report said.

"The reason for the cabin depressurization was likely to have been due to the moisture shrouds not being fitted after the removal of the airstairs," said the report. "This permitted the ingress of water into the E/E bay and the pressurization controller, resulting in a malfunction of the operating modes of the unit."

During the investigation, the aircraft manufacturer said, "Boeing advises that these shrouds are required in order to ensure the airworthiness of the airplane."

The operator's maintenance provider designed and manufactured an approved aluminum moisture shroud, which was installed in the E/E bay, the report said.

Stabilizer Winglet Separates in Flight

On Jan. 28, 2004, a Bell 206-L4 helicopter was substantially damaged during a forced landing that followed loss of directional control while in cruise flight near Patterson, Louisiana, U.S. The pilot and five passengers were not injured.

On a flight from an offshore oil-drilling platform, at an altitude of 500 feet, the pilot heard a loud bang, which was followed by severe and constant vibration of the airframe. The pilot said that the pedal inputs seemed to have no effect on the aircraft, which was yawing. He initiated an autorotation; declared "mayday," a distress condition; and was able to level the helicopter between 150 feet and 100 feet. After the helicopter was landed, the main-rotor blade struck the tail boom.

"Examination of the wreckage by the operator and a [U.S. Federal Aviation Administration] inspector, who responded [at] the accident site, revealed structural damage to the tail boom," said the report by the U.S. National Transportation Safety Board (NTSB). "Strike marks on the tail boom, corresponding to the main-rotor blade top-path plane, were found adjacent to the no. 7 tail-rotor drive-shaft segment. … Further examination revealed a 10-inch [25-centimeter] crack in the fixture securing the left winglet to the horizontal stabilizer."

The left horizontal winglet was not recovered, but the right winglet fixture also had a pre-existing crack, the report said.

"The cracks were not visible during a visual inspection, and the crack area is under a line of structural adhesive used during manufacture of the horizontal stabilizer, and can only be seen when the winglet is removed," said the report. "According to the operator, the 10-inch crack that was discovered on the left winglet [fixture] appeared to have existed for some time."

NTSB determined that the probable cause of the accident was "the in-flight separation of the helicopter's left winglet due to pre-existing cracks, resulting in the winglet striking the tail rotor in flight, and subsequent loss of directional control."

Lack of Maintenance Cited in Skid Failure

An Irish Aviation Authority (IAA) authorized flight examiner was conducting an annual proficiency check on the pilot flying the Bell 206B at Weston Airport, County Kildare, Ireland. During one exercise in which a tail-rotor failure was simulated, the helicopter contacted the ground. "The [flight examiner], who felt that there may have been some slight forward speed but with relatively mild ground contact, was therefore quite surprised that part of the right-rear skid broke off on landing in those circumstances," said the report by the Irish Air Accident Investigation Unit (AAIU).

Neither pilot was injured in the March 31, 2003, incident. The report said, however, that "the crew were fortunate that the aircraft maintained its equilibrium on landing. It is clear from the engineering analysis of the evidence that the incident that occurred could have had a less than benign outcome on a different occasion."

At the time of the incident, the helicopter had been flown 268 hours since the skid was installed on Aug. 23, 1999, when another operator owned the aircraft.

"A maintenance manual was provided with the landing gear at the time of sale, and the vendor states that it was the owner's responsibility to maintain it with the aircraft documentation," said the report. "The helicopter was re-registered to its present owner on [Oct. 23,] 2002."

AAIU sent the fractured skid to a metallurgist, who reported the following:

- "The aluminum tube of the skid suffered severe exfoliation [peeling off in flakes or scales] corrosion at/adjacent to the holes in the tube, through which fixing of the plates was made;
- "This extended around more than 40 percent of the circumference, and would have weakened the tube significantly;
- "High-strength aluminum alloys are prone to this type of corrosion, particularly in marine environments. [The] attack occurs at locations where a part is machined such that the transverse grain structure is exposed, as at machined holes; [and,]
- "It would appear that the holes in the tube were not adequately protected to prevent the attack."

The manufacturer of the skid tube had received two previous reports of skid-tube cracking on 206B helicopters, and both instances were related to corrosion, the report said. The fractured tube from this latest incident was sent to the manufacturer for examination. The manufacturer reported that, in addition to the exfoliation corrosion, two other types of corrosion were present:

- Galvanic corrosion: "Accelerated corrosion resulting from the aluminum in contact with steel and exposed to a wet saline environment. In such situations, the aluminum is more rapidly corroded than it would be in the absence of the dissimilar material; [and,]
- Stress corrosion: "Time-dependent cracking under the combined influence of sustained tensile stress and a corrosive environment."

The manufacturer said, "The corrosion-inspection requirements [Instructions for Continued Airworthiness (ICA) Report no. AA-01143] for the subject skid tubes are established to ensure that any corrosion problems are periodically treated so that the tube will remain airworthy. Because helicopters often operate in harsh environments, these inspection requirements are relatively frequent (100 hours or six months, whichever comes first). There was no indication on the skid-tube sample that any corrosion or crack repair had ever been made."

The helicopter was serviced on a contractor's premises in November 2002. "This included an examination of the 'skid tubes for damage and doublers for corrosion, debonding and loose rivets,'" said the report. "Neither the new owner of the helicopter nor the contractor were aware of the skid manufacturer's specific Instructions for Continued Airworthiness."

The report quotes the IAA-approved flight manual for the helicopter, which says, "The registered owner shall ensure that a subscription service is in place for all flight-manual amendments and that the manual reflects the latest revision status, including all applicable supplements."

The investigator in charge asked the incident aircraft manufacturer for the name and address of the owner to whom they were sending amendments. The manufacturer's database provided the name that was registered prior to the transfer of ownership in October 2002, the report said, and the manufacturer's database was the source of maintenance documents, service bulletins and servicing letters directed to operators. The current owner was unknown to the manufacturer.

"When change of ownership of aircraft occurs through re-registration with the IAA, the new owner may not be personally aware of the requirement to notify the aircraft manufacturer of the change of ownership, so that he/she may avail of their service to supply ongoing operational and maintenance documentation," said the report. "The investigation notes that this is not the first occasion on which a time lapse has arisen in the notification of change of ownership to the manufacturer. The non-availability of updated instructions for continued airworthiness, for instance, can lead to serious flight safety implications."

Unapproved Sealant Found in Failed Clutch Shaft

On Sept. 28, 2003, a Robinson R-22 helicopter was being used in aerial mustering operations in an area 93 kilometers (58 statute miles) south of Derby, Western Australia, Australia. When the pilot of another R-22, also engaged in mustering operations, had not received any radio transmissions for about 10 minutes, he began a search.

The wreckage of the first helicopter was located, and the pilot of the second aircraft landed his helicopter nearby to assist the two occupants. Because of the extent of their injuries, he decided to seek medical assistance at Derby. About 80 minutes later, the pilot returned from Derby with a doctor, but in the meantime both occupants had died.

"The helicopter had impacted the ground heavily, with little forward speed," said the report by the Australian Transport Safety Bureau (ATSB). "During the impact sequence, the tail rotor struck the ground at high rotational speed and was destroyed, with sections of the tail rotor found approximately 40 meters [131 feet] from the [impact] site. The clutch assembly exhibited signs of high-speed rub damage due to contact with the clutch linear-activator mechanism."

Examination of the clutch mechanism revealed an apparent pre-impact failure of the clutch shaft, which had been installed in the helicopter on Oct. 30, 2002, and at the time of the accident had 886.2 hours in service.

"The clutch shaft had fractured at the point of connection to the main-rotor gearbox flex-plate yoke," said the report. "The fracture surface indicated pre-existing torsional fatigue cracking, which followed a spiral path from the yoke connection … . Those crack-propagation features were consistent with the initiation and progressive growth of the crack during multiple shaft-load cycles prior to the accident flight."

A technical analysis of the fractured clutch shaft attributed the fatigue cracking to the looseness of the shaft–yoke connection, the report said. The analysis included the following factors as contributing to the failure:

- "At the last installation, the … clutch shaft was assembled with the … yoke using a soft jointing compound in lieu of the zinc chromate or epoxy primer specified by the aircraft manufacturer;
- "At the last installation, the clutch shaft–yoke connection was assembled with the external bolting blocks placed over the painted yoke surfaces;
- "The movement of the connection under applied torsional loads created point loading within the shaft-bolt holes, producing fretting damage and creating localized stress conditions conducive to the initiation of fatigue cracking; [and,]
- "Growth of fatigue cracking occurred beneath the yoke sleeve, preventing visual identification until the cracking was well advanced and near to critical size."

During the investigation, ATSB issued an urgent safety recommendation to the Australian Civil Aviation Safety Authority (CASA) for an inspection of the R-22 and Robinson R-44 Australian helicopter fleet. CASA issued airworthiness directives requiring inspections of the shaft assemblies of those aircraft to look for damage and to remove any that had been assembled using an unapproved sealant.

"Following the issue of the airworthiness directives, information from CASA and the industry indicated that the use of nonapproved mating compounds on the shaft-to-yoke mating surfaces was apparently widespread," said the report. "The manufacturer advised that it would be revising the maintenance manuals and maintenance-training courses for the R-22 and R-44 model helicopters to ensure that the instructions for the assembly of the shaft-to-yoke joint were clarified."♦

NEWS & TIPS

Tape Prevents Smoke's Escape

An aerospace tape from Tyco Plastics & Adhesives, Polyken 296FR, is designed for seam sealing and repair of cargo-compartment liners where high adhesion and flame resistance are critically important. When properly applied and maintained, the product helps prevent the proliferation of fire and smoke, as well as the escape of extinguishing agents such as Halon, the manufacturer says.

The tape, consisting of fiberglass-cloth backing with an acrylic adhesive, meets Boeing, Airbus, U.S. and European flame-retardant-content testing requirements, the manufacturer says. It conforms to a recent European Union directive (EU 76/769/EEC) eliminating some fire-retardant materials.

Aerospace Tape

Polyken 296FR is said to be highly flexible to accommodate angles and turns, while being repositionable so as to be capable of being reapplied. The tape's fiberglass-cloth construction resists flame penetration, and its high-adhesion properties are said to eliminate lifting and curling.

For more information: Tyco Adhesives, 25 Forge Parkway, Franklin, MA 02038 U.S. Telephone: 1 (800)

343-7875 (U.S.); +1 (508) 346-3600; +39 0321 540 201 (Belgium).

Warm Air Is Forecast

Airscrew Modular Aircraft Heaters from Ametek Aerospace & Defense can be used alone or with a fan for applications that include cargo bays or animal bays, crew-rest areas, galley areas, cockpits, door-draft areas and other locations where supplementary heating is desired.

Silicone Heater

The heaters use silicone heating elements between two thin layers of fiberglass-reinforced silicone, which are connected to aluminum tubes that are the heat-transfer medium. The tubes are arranged in concentric circles with an air gap, and air is warmed as it flows through the unit.

The unit has a large heating-surface area in contact with the air, which is said to enhance response time and to enhance reliability. Integral safety devices include a fuse to prevent overheating.

For more information: Ametek Aerospace & Defense, 50 Fordham Road, Wilmington, MA 01887 U.S. Telephone: +1 (978) 988-4639.

Software Reduces Manual Labor

Software from Aviation Intertec Services is designed to make easily accessible such documents as aircraft-specific inspection manuals. Maintenance planning and inspection record keeping are also facilitated, the manufacturer says.

Inspection Document Manager (IDM) enhances the ease of various maintenance tasks by the following means, the manufacturer says:

- Retaining data such as accomplishment instructions, personnel-hours requirements, access-panel requirements, reference materials and part requirements;
- Centralizing management of inspection document amendments;
- Using inspection-item history to predict non-routine findings, including parts and labor requirements; and,
- Printing task sheets in PDF format and distributing updates via e-mail.

IDM has been designed to manage data from virtually any inspection document, the manufacturer says.

For more information: Aviation InterTec Services, Suite 405, 200 South Syndicate Ave., Thunder Bay, Ontario P7E 1C9 Canada. Telephone: +1 (807) 625-9260.

Lose Weight While Spray Painting

Spray-gun finishing, touch-up painting or complete repainting of aircraft can be performed with greater comfort using the DeVilbiss JGP/V Production Gun, the manufacturer says. The unit is constructed of a lightweight, solvent-resistant composite material, designed to be easier to handle during paint application.

The reduced weight, compared with aluminum spray guns, is said to

Lightweight Aluminum Spray Gun

reduce operator fatigue and lessen the risk of cumulative muscle stress, while maintaining the spray consistency of conventional units.

For more information: DeVilbiss Industrial Finishing, 195 Internationale Blvd., Glendale Heights, IL 60139 U.S. Telephone: 1 (800) 992-4657 (U.S.); +1 (630) 237-5000.

Aircraft Glass Changes Outlook

SPD-Smart aircraft windows, sun visors and cabin partitions from Research Frontiers Inc. (RFI) incorporate a new light-control technology that controls glare by changing the shade of the glass. Suspended-particle device (SPD) glass enables passengers or crewmembers to select a desired level of light penetration. Centralized control for flight crewmembers also can be provided.

With no moving parts, SPD-Smart cabin windows minimize maintenance required, and the overall reduction in weight contributes to better fuel efficiency, the manufacturer says.

For more information: Research Frontiers Inc., 240 Crossways Park Drive, Woodbury, NY 11797 U.S. Telephone: 1 (888) 773-7337 (U.S.); +1 (516) 364-1902.♦

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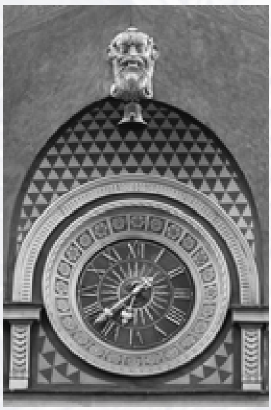

Warsaw, Poland

To receive agenda and registration information, contact Ahlam Wahdan, tel: +1(703) 739-6700, ext. 102; e-mail: wahdan@flightsafety.org.

To sponsor an event, or to exhibit at the seminar, contact Ann Hill, tel: +1(703) 739-6700, ext. 105; e-mail: hill@flightsafety.org.

Want more information about Flight Safety Foundation?

Contact Ann Hill, director, membership and development, by e-mail: hill@flightsafety.org or by telephone: +1 (703) 739-6700, ext. 105.

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