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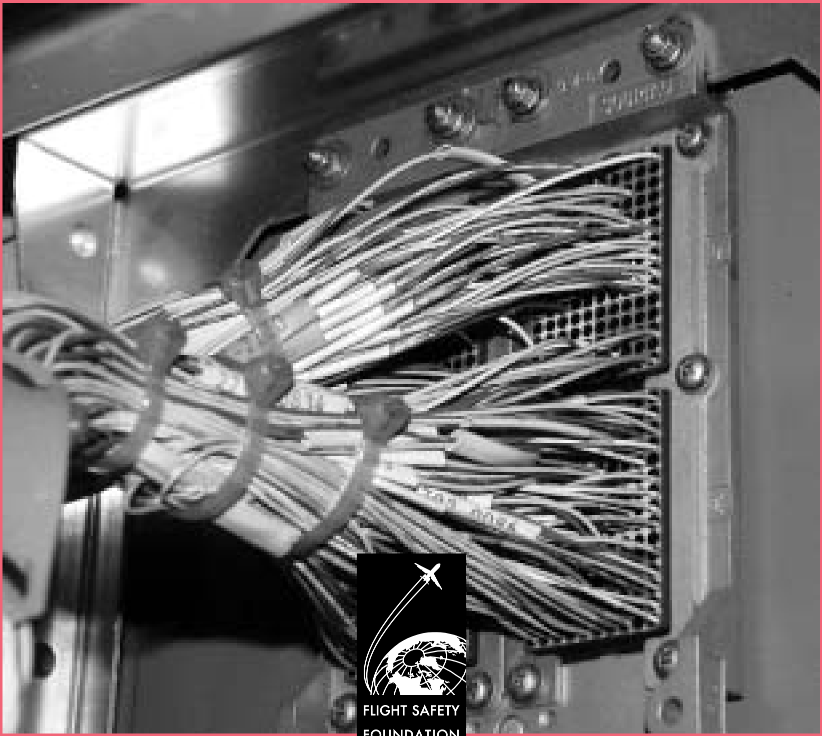

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Dedicated to the aviation mechanic whose knowledge, craftsmanship and integrity form the core of air safety.

Robert A. Feeler, editorial coordinator

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On the cover: Two pairs of wires were reversed on the plug of the elevator/aileron computer during maintenance before the March 21, 2001, incident. (Photo: German Federal Bureau of Aircraft Accidents Investigation)

Faulty Wire Installation Cited in A320 Control Problem

The airplane began banking left during takeoff from Frankfurt, Germany, and the captain was unable to correct the bank with normal use of controls. The German Federal Bureau of Aircraft Accidents Investigation said that two pairs of wires on a flight control computer were reversed during maintenance.

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FSF Editorial Staff

About 1100 local time March 21, 2001, immediately after liftoff from a runway at Frankfurt (Germany) Airport for a flight to Paris, France, an Airbus A320-200 banked slightly left. When the captain (the pilot flying) tried to correct the bank angle using the left sidestick, the bank angle increased to about 22 degrees.

The captain transferred control to the first officer, who pressed the "takeover push button," returned the airplane to a normal flight attitude and flew the airplane to Flight Level 120 (approximately 12,000 feet), where the two pilots analyzed the flight-control anomaly.

"With an input on the left sidestick, the airplane — after a short shaking and a brief bank angle corresponding to the input — suddenly reacted [in a] contrary [manner]," the German Federal Bureau of Aircraft Accidents Investigation (FBU) said in an incident report translated from German into English. "The right-hand sidestick functioned normally."

The airplane was not damaged in the incident, and none of the 121 people in the airplane was injured.

After the incident, the first officer flew the airplane back to Frankfurt, where maintenance personnel conducted a flight control check and observed that "the symbols of the ailerons on the ECAM [electronic centralized aircraft monitor] first — and for a very short moment — moved into the corresponding direction, as if everything [was] all right, before the ailerons moved into the opposite direction."

The BFU said, in its final report, that the incident occurred for the following reasons:

- "During repair work on the plug of the elevator/aileron computer (ELAC; part of the A320 fly-by-wire control system) no. 1, two pairs of wires had been [reversed];
- "The error remained undetected; [and,]
- "The error was not recognized by the flight crew during the flight control check."

BFU said that the following factors contributed to the incident:

- "Unclear and difficult-to-handle documentation, so that [an incorrect] wiring diagram was used;
- "Diversion from the manufacturer's data by maintenance support [personnel];
- "Manufacturer's instructions, which are not formulated unambiguously [i.e., which are ambiguous];
- "Functional check by the cross-checking staff member was carried out incorrectly;
- "Insufficient functioning of the quality assurance [system];
- "Lack of supervision of the maintenance organization by the operator [which was not identified by the report];
- "Quantitatively and qualitatively insufficient supervision of the maintenance organization and the operator by the supervising authority; [and,]
- "Deficiencies in the 'After-start Checklist' for the conduct of the 'Flight Control Check.'"

Flight Was the First After Maintenance

On the day of the incident, the crew flew two flights in another aircraft before a scheduled aircraft change at Frankfurt. The incident airplane had been undergoing maintenance for two days, and entries in the technical logbook indicated that all prior reported anomalies had been resolved and that the airplane had been released to service in accordance with regulations.

The crew arrived at the airplane about 50 minutes before departure to complete preparations for the flight. After starting the engines and before taxiing the airplane to the departure runway, they conducted the "After-start Checklist," including the flight control check, and found no anomalies. They observed no anomalies during taxi or the takeoff run, but as the captain rotated the airplane for takeoff, he observed the increasing left bank angle.

The A320-200, manufactured in 1990, is a fly-by-wire aircraft, in which seven computers are used for primary control of the airplane's flight controls. The computers include two ELACs for elevator and aileron control; the ELACs also control three spoiler/elevator computers (SECs), which control the spoilers and are available as backups for elevator and stabilizer control. In addition, two flight augmentation computers (FACs) stabilize the airplane's flight attitude.

Two sidesticks — one for the captain and one for the first officer — allow for manual control inputs; the sidesticks are not linked mechanically with each other. When one of the pilots moves a sidestick, the movement is translated into electrical signals that are transmitted to the corresponding computers. For one pilot to take control, he or she must depress the take-over push button on the sidestick and continue to press the button for more than 30 seconds.

Operator Had Not Monitored Maintenance Organization

Because the operator did not have a maintenance organization, all maintenance — including this repair work — was performed by an outside maintenance organization under contract with the operator. Joint Aviation Requirements–Operations (JAR–OPS) 1.900 requires operators to monitor contracted maintenance work to ensure that the work is performed properly and in compliance with approved procedures. For this purpose, an audit plan must be submitted annually to the Luftfahrt-Bundesamt (LBA), the German civil aviation authority.

"The operator had not audited the maintenance organization, and thus the quality system of the operator was not in a position to recognize systematic faults with the procedural organization in time," the report said.

The report said that the LBA had said several times — most recently in the context of its extension of the operator's air operator certificate — that the operator lacked sufficient personnel to perform the required monitoring activity.

The contracted maintenance organization [which was not identified by the report] was granted JAR-145 approval by the LBA in 1992. (JAR-145 approval requires maintenance organizations to comply with the regulations of JAR-145 and to accomplish procedures in accordance with a plan approved by LBA.)

The report said that the LBA also lacked sufficient personnel to perform adequate oversight of the maintenance organization. Oversight of the operator's contracted maintenance organization was conducted by one LBA technical inspector until one month before the incident, when an additional inspector was assigned to help oversee the organization.

"It does not seem to make sense that such a large organization … falls within the purview of only one technical inspector of the LBA, who is also responsible for several other organizations," the report said. "For reasons of capacity, the technical inspectors are not in a position to check the organizations more thoroughly. Especially in the organization concerned, plenty of internal provisions had been compiled in the course of the years, the contents of which were not sufficiently known to the technical inspectors. Up to February 2001, only one technical inspector of the LBA was responsible for the operator, as well as the maintenance organization; now this task is shared by two LBA staff members, which, however, still seems to be insufficient."

ELAC Replaced Three Days Before Incident

On March 17, 2001, three days before the incident, the no. 2 ELAC was replaced after it failed in Hamburg, Germany. In subsequent tests, the unit functioned properly.

On March 18, 2001, an error message involving the no. 2 ELAC appeared while the airplane was being taxied at Frankfurt. The report said that "by briefly pulling the circuit breakers of the ELAC no. 2, the crew made a 'RESET,' after which no further error message appeared."

Later that day, however, after the engines were started at the airport in Moscow, Russia, another no. 2 ELAC error message appeared.

"The airplane was parked again and [the engines were] shut down," the report said. "As a corrective action, ELAC no. 1 and ELAC no. 2 were interchanged. The defect, however, persisted on position 2. Therefore, the corresponding circuit breakers were pulled pursuant to the operational maintenance procedure (OMP) and in accordance with the minimum equipment list (MEL), so that the defect was now on position 1. The return flight [to Frankfurt] was conducted in accordance with the MEL with a functioning ELAC no. 2."

The defect was entered in the technical logbook, and the airplane was delivered to maintenance personnel at Frankfurt Airport on March 18.

During their inspection, maintenance personnel found a bent connection pin (pin 6K) in a plug segment (segment AE) of the socket for the no. 1 ELAC.

"The attempt to replace the connection pin without replacing the whole plug segment was not successful," the report said. "A safety spring of the connector pin had come out and could not be inserted again. Therefore, it was decided to replace the plug segment AE, but there was a problem: [There] was no suitable spare plug segment for this series of airplane [in] stock. Consequently, it was decided to replace all four plug segments — AA, AB, AD and AE. This meant that in a most confined space, approximately 420 connector pins had to be reconnected."

The report said that the process of reconnecting 420 connector pins involved "a high risk of errors" and that manufacturer's instructions required that each wire be measured. When maintenance personnel asked the Maintenance Support Department whether they should measure each wire, however, they were told that there was no reason to measure the wires because "the functional test to be performed after completion of the work would reveal wiring errors." At the time, the organization's *Standard Practices Manual* erroneously said that such decisions should be made at the discretion of the Maintenance Support Department, the report said.

The airplane was taken out of service, and the repairs were begun "without having a maintenance job order, which would have been required according to … procedural regulations," the report said. "The maintenance job order was established on [March 20, 2001], after the [repair work] had already started, indicating a certain carelessness in the realization of the prescribed working procedures."

The report said that maintenance personnel used the "one-to-one" method of replacing the wires so that "the wires were disconnected one after the other from the old plug and immediately connected to the new one." The work was performed by qualified aircraft electronics technicians on the morning shift and on the late shift on March 19. For reference, the electronics technicians used Aircraft Wiring List (AWL) 91-20-33 and the *Aircraft Wiring Manual* (AWM) 27-92-19.

"The staff members were not sure which page of the *Aircraft Wiring Manual* was the effective one, as there were two pages which could be applicable for the airplane concerned and which could only be assigned on the basis of the accomplished service bulletins [SBs]," the report said. As a result, they used the wrong page, the report said.

Another complicating factor concerned the wiring between the sidestick plug and the ELAC.

"All pairs of wires consist of a red [wire] and a blue wire which are twisted round each other," the report said. "The twisted pairs are always assigned in an alphanumerical sequence of the plug segment coordinates in the order red/blue, except for the twisted pairs 0603 and 0597, which were — opposite to the normal arrangement — assigned to the pins 3C/3D and 15J/15K in the sequence blue/red."

(The report said that Airbus Industrie planned to adopt a uniform wiring system with uniform colors for all fly-by-wire airplanes. The incident airplane was among the aircraft in a "transition series" in which an interchange of wire colors was acceptable for a specified time period.)

Post-repair Checks Were Insufficient

After the wiring work was completed during the night shift that ended early on March 20, maintenance personnel conducted a functional check. During that check, an error message appeared that involved the no. 1 ELAC. (The error message did not relate to the reported anomaly.) Maintenance personnel identified and corrected a faulty connection of the bridge on the AA plug segment.

A functional check and a control system check were conducted simultaneously by two airplane electronics technicians. The report said that the functional check and the control system check should have been conducted separately.

"The person who had conducted the double inspection and thus was the last to have the chance to find the interchanged connection had not been informed sufficiently about the previous work flow," the report said. "Presumably, it was not known to him that the staff members of the late shift had by direction of the Maintenance Support [Department] not measured the reconnected wires, as actually required."

In addition, the functional check and the control system check were not complete and did not include a visual check of the control surfaces of the airplane.

"The functional check was conducted on the right-hand sidestick only, although the wiring on the left side was affected as well," the report said. "The check was carried out using the *Aircraft Maintenance Manual (AMM).* The following instruction had to be adhered to: 'Push the FLT CTL ELAC 1 (2) pushbutton switch. Move the sidestick around in its two axes from stop to stop.'"

The report said that when investigators asked why the checks were conducted using the right-hand sidestick, the answer was that the selection of the sidestick "did not matter. … As both ELACs were connected to each other, possible faults of the one or the other ELAC would surely be indicated."

The report said that this answer indicated that the technicians lacked knowledge of the system.

The report said, however, that the manufacturer's instructions were ambiguous about which sidestick should be used in the checks — or whether both should be used.

After additional related checks were conducted, the airplane was released to service.

The report said that several additional errors occurred during checks of the airplane.

"Presumably, the aircraft mechanics … who carried out the checks underestimated the significance of the previous action," the report said. "There is no other explanation for the fact that the cross-checking staff member had conducted the required cross-check using the working documents which [were] aboard the aircraft and [which] had already been used by the staff member having conducted the first check, although according to the regulations, he would have had to use his own impartial documents. Obviously, the importance of the cross-check to this repair had not been realized. In this case, … the independence of the cross-check was the crucial factor."

The flight crew also failed, during their preflight check of the airplane, to observe the anomaly.

"The fact that the malfunction had not been recognized during the flight control check by the crew is due to the fact that the ailerons had only been checked for full deflection, as described in the checklist, but not for the correct direction of deflection," the report said.

The report said that maintenance personnel also erred in incorrectly copying the reference number for the report of the anomaly into the ground logbook and that although the error "was not directly related to the cause of the confusion of the pairs of wires, it indicates that the quality system did not work optimally."

In-flight Incident Led to Changes by Operator, Maintenance Organization

Based on its investigation of the incident, the BFU recommended that the LBA and the operator amend the procedures and checklists for fly-by-wire airplanes "in such a way that during the flight control check, attention is [given] to the correct direction of movement of the ailerons and roll spoilers as recommended by the manufacturer."

The maintenance organization ordered several actions intended to prevent a recurrence of the problem, including the following:

- Instructions were issued to require that functional checks and control system checks on fly-by-wire aircraft be performed using both sidesticks; the *Standard Practices Manual* and job cards were amended to include that requirement. (The report said that Airbus was requested to "correspondingly amend unclear wordings in the *Aircraft Maintenance Manual*.");
- Quality assurance procedures and rules for documenting maintenance actions were reviewed and modified, and continuing training was intensified for employees of the maintenance organization;
- Actions were taken to increase the familiarization of new employees with operational procedures and to document the familiarization process; and,
- An anonymous reporting system was established to permit employees of the maintenance organization to "complain about [un]acceptable requirements or technical [conditions] and other conditions without taking a risk of personal disadvantages."

The report said that the maintenance organization's long-term objective was to achieve "a positive change in the attitude to work and working ethics intended to lead to an improved working culture."

The LBA, in agreement with the German Federal Ministry of Transport, Building and Housing, took action to improve supervision of approved maintenance systems and requested additional funds for personnel in 2003.

As a result of the investigation, BFU recommended the following:

- The actions of the LBA should continue "for an unlimited period beyond the year 2003 in order to achieve a permanent qualitative and quantitative improvement of the audits to be performed with the aircraft operators and the maintenance organizations";
- "The aircraft operator should provide the organizational and

personnel conditions in order to ensure compliance with the quality requirements for the maintenance of aircraft in the maintenance organization in accordance with the requirements of [the Joint Aviation Requirements; and,]

- "The system of the procedural instructions in the maintenance organization should be amended and rearranged so that procedural instructions are clear, unambiguous and readily findable for all users."♦

[FSF editorial note: This article, except where specifically noted, is based on Investigation Report 5X004-0/01 by the German Federal Bureau of Aircraft Accidents Investigation. The 32-page report includes photographs and illustrations.]

Further Reading From FSF Publications

FSF Editorial Staff. "Improper Assembly of Trim Actuator Causes In-flight Separation of Stabilizer." *Aviation Mechanics Bulletin* Volume 49 (July–August 2001).

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).

Crotty, Bart J. "Omission of Oil-plug Seals Leads to In-flight Engine Shutdowns." *Aviation Mechanics Bulletin* Volume 47 (July–August 1999).

Crotty, Bart J. "F-117A Accident During Air Show Flyover Caused by Omission of Fasteners in Wing-support Structure." *Aviation Mechanics Bulletin* Volume 46 (September–October 1998).

MAINTENANCE ALERTS

Cylinder-support Frame Failure Leads to Emergency Landing

The McDonnell Douglas DC-10-10, operated as a scheduled domestic cargo flight, was being flown on the approach to Tampa (Florida, U.S.) International Airport. During the base leg, the captain commanded the lowering of the landing gear. "We heard a loud bang, and the airplane shuddered seriously," the captain later told investigators. "The no. 3 hydraulic-system quantity decreased to zero and 'LEFT MAIN LANDING GEAR UNSAFE' lights illuminated on both pilots' and engineer's panel[s]."

The flight crew declared an emergency and conducted the required emergency checklists and abnormal checklists. Unable to determine the position of the landing gear, the flight crew performed the "Landing Preparation With Gear Up or Partial Gear Down" checklist and the "Landing With One Gear Up or Unsafe" checklist and proceeded to the destination airport.

"The left gear touched down with a loud crunch, and I thought the gear was collapsing," said the captain. "I shut down the engines in accordance with the checklists. We then accomplished the 'Emergency Quick Evacuation' checklist and evacuated the aircraft."

The airplane's four occupants — the captain, first officer, second officer and a pilot riding in the jump seat — were not injured in the Aug. 10, 2002, incident.

Maintenance personnel examined the landing gear and discovered a failure of the left main-landing-gear retract-cylinder support frame (part no. ARB0642-501) at the point of attachment to the left main-landing-gear retract cylinder, said the report by the U.S. National Transportation Safety Board (NTSB).

"Upon landing-gear extension … the gear extended when the landing-gear door that was supporting the gear opened, breaking the hydraulic lines attached to the retract cylinder, dumping no. 3 hydraulic-system fluid overboard," said the operator's manager of aircraft maintenance. "The proximity-switch target that activates both the pilots' and the second officer's displays broke off due to the inertia of the unrestricted extension of the left-main landing gear. Thus, both red 'UNSAFE' lights would not extinguish."

When the flight crew performed the "Landing With One Gear Up or Unsafe" checklist, the antiskid protection became inactive when electrical power was lost as a result of the engines being shut down and the fire handles being pulled, the report said. The report said that the probable cause of the incident was "the failure of the left main-landing-gear retract-cylinder support frame due to fatigue."

The failed part had a total of 67,913 flight hours and 27,081 cycles since it was installed when the airplane was manufactured, the report said.

On Aug. 12, 2002, the operator issued a fleet campaign directive to inspect all DC-10/MD-10 main-landing-gear retract-cylinder support assemblies. As a result of the Aug. 10 incident, eddy-current inspection of landing gear was undertaken. During a subsequent fleet inspection, two other support frames were found to be cracked on aircraft that had 15,904 flight hours and 39,559 flight hours, respectively.

Engine-vane-bleed Control Unit Eludes Troubleshooting

On Jan. 8, 2002, a Boeing 767-238 being operated as a scheduled domestic passenger flight was on the landing roll at Sydney (New South Wales, Australia) Airport when the left-engine revolutions per minute (rpm) decreased as reverse thrust was selected. There was no engine surge. The flight crew selected the "CUTOFF" position on the left-engine fuel-control switch and completed the landing. After fire crews had inspected the engine externally, the aircraft was taxied to the terminal using the right engine. There were no injuries to passengers or crewmembers.

"The operator removed the aircraft from service and conducted extensive troubleshooting of the left engine, utilizing assistance from the engine manufacturer," said the report by the Australian Transport Safety Bureau (ATSB). The report did not specify the manufacturer or model of the engine.

The report said, "That troubleshooting led to the replacement of the left engine-vane-bleed control (EVBC) unit and the turbine-temperature (TT2) sensor. Following a test flight, the aircraft was returned to service."

The investigation revealed that the left-engine EVBC (part no. 776555-7) had been replaced in a scheduled maintenance on Dec. 14, 2001. Since that replacement, the aircraft had completed seven flight sectors, in two of which there had been left-engine anomalies.

On Jan. 4, 2002, the left engine flamed out during a landing flare.

"The flight crew reported that the engine exhaust gas temperature (EGT) remained high and selected the left-engine fuel-control switch to the 'CUTOFF' position and completed the landing," said the report. "After a visual inspection by fire crews at a nearby taxiway, the aircraft was taxied to the terminal."

Maintenance personnel inspected the engine and conducted functional checks. All engine parameters were found to be within prescribed limits, and the aircraft was returned to service.

The next day, Jan. 5, 2002, air traffic controllers in the tower saw fire coming from the left engine following the landing roll.

The report said, "[Air traffic control] advised the flight crew of the situation and called for emergency services. The aircraft came to a stop on a nearby taxiway. By the time emergency services arrived, the fire had extinguished. … Maintenance personnel conducted troubleshooting using the engine manufacturer's troubleshooting procedures. The left-engine fuel-control unit and fuel pump were subsequently replaced. After completing test runs of the engine, the aircraft was returned to service."

On Aug. 8, 2001, the manufacturer had repaired the EVBC. It had been removed because of a thrust-lever discrepancy, inability to close the 3.0 bleed valve and an EGT difference between engines of 120 degrees Celsius (216 degrees Fahrenheit). When third-party contract maintenance personnel installed the EVBC on Dec. 14, 2001, the unit had accumulated 511,399 flight hours since new, 506,732 cycles since new, 5,139 flight hours since overhaul and 3,315 cycles since overhaul. The engine was test-run for three hours on Dec. 30, 2001, the results were examined and the engine was considered to have met all applicable parameters.

Nevertheless, after the Jan. 8 incident, the plotted data from the engine run were reviewed, and several plotted points "fell slightly within the lower limits of the acceptable trim band," said the report. "The EVBC was initially bench tested at the operator's facility but failed the testing and was then sent to the manufacturer for further examination. The operator reported that the manufacturer's testing confirmed that the EVBC and bleeds were operating out of tolerance. The unit was subsequently disassembled and overhauled."

In summarizing the analysis of the incident, the report said, "During power reductions for landing, the engine-compressor air scheduling to the left engine was incorrect. That resulted in disrupted airflow throughout the engine and subsequent stalling. The discrepancy in the air scheduling of the engine was due to the incorrect performance of the engine-vane-bleed control unit. This anomaly could also have resulted in excessive amounts of fuel for the power setting and contributed to the fire witnessed coming from the left-engine exhaust as reported during the Jan. 5, 2002, occurrence on this aircraft."

Following the findings, the third-party maintenance organization said, "As a preventative measure, we have briefed our maintenance personnel to trim or adjust to mid-band position when trimming or adjusting to a given band."

Nondestructive Examination Fails to Reveal Landing-gear Crack

On May 10, 2001, a McDonnell Douglas MD-83 was being operated as a charter flight from Palma de Mallorca, Spain, to Liverpool (England) Airport. The first officer was the pilot flying, and at Liverpool Airport, she was conducting an autopilot landing in the "AUTOLAND" mode. The aircraft touched down on or near the runway centerline in a roll attitude of 2.6 degrees right-wing-down.

"Immediately upon touchdown, the right-main-[landing]-gear discrete parameter [of the flight data recorder] indicated that the gear had come out of the downlock position and aural warnings of 'LANDING GEAR' were recorded on the CVR [cockpit voice recorder]," said the report by the U.K. Air Accidents Investigation Branch (AAIB). The MD-83 eventually came to rest close to the centerline with a roll attitude of 12.1 degrees right-wing-down, with the right wing tip touching the ground.

The captain commanded an emergency evacuation of the crew and passengers. There were no injuries to the six crewmembers and 45 passengers.

"The right MLG [main landing gear] had fractured, with consequent damage to MLG components, MLG door and right inboard flap," said the report. The fracture was located on the cylinder that encloses the piston-axle assembly. Sections of the fracture face were sent for metallurgical examination in the United Kingdom under AAIB supervision and to Boeing Commercial Airplanes (BCA), which had acquired the original manufacturer and was now responsible for support of McDonnell Douglas aircraft.

"Both subsequent reports agreed on the presence of a fatigue crack measuring 1.0 millimeter [0.04 inch] deep and 3.2 millimeters [0.13 inch] wide at the [MLG] cylinder surface," said the report. "There were multiple initiation sites within this major crack and, additionally, smaller fatigue cracks were identified [on] either side of the major crack over a chord length of about 40 millimeters [1.57 inches]."

During manufacturing, the MLG cylinders were shot-peened, which has a beneficial effect on fatigue life, and then were blasted with aluminum oxide grit to prepare the surface for cadmium plating, the report said.

The report said, "In order to comply with internationally accepted [U.S. Federal Aviation Regulations] relating to crashworthiness, a section of the cylinder was designed to be 'fusible,' so that the leg would fail first at this location, assuming that the overload was to occur in an aft-and-upward direction. This should result in a 'clean' detachment of the leg, in a heavy-landing or overrun situation, without rupturing the integral wing fuel tanks. …

"Although this was effectively a 'weak point' on the leg, it was considered by DAC [Douglas Aircraft Corp., a component of McDonnell Douglas] that it met the normal stress requirements, albeit marginally."

There had been two previous similar failures of the MLG cylinder on MD-80 series aircraft. One occurred at Manchester (England) International Airport on April 27, 1995. The second occurred during a landing in Jinan Airport, China, on April 27, 1997.

"Conclusions concerning the events which initiated the fatigue crack were reached during the [1995-accident] investigation," said the report. "'Gear walking' was considered the most likely abnormal event which could have generated the loads necessary to propagate the fatigue through the compressive layer [induced by shot-peening], if it was assumed that the cylinder design actually resulted in routine operating stress levels consistent with those used to calculate the fatigue life (as asserted by the manufacturer)." ["Gear walking" is a mode of MLG self-sustaining vibration caused by interaction between the anti-skid-system modulation frequency and the natural flexing of the MLG leg.]

The failed MLG cylinder involved in the 2001 accident had been received by the operator in new condition on another aircraft. The cylinders were inspected on Jan. 15, 1996, at 10,310 cycles since new (CSN), and no cracks were found. On May 6, 1998, both MLGs were removed from the original aircraft and sent for overhaul, during which the cylinders underwent nondestructive examination (NDE) and were concurrently inspected, at 14,589 CSN. Both MLGs were installed on the accident aircraft on July 15, 1998. The third inspection took place at 15,769 CSN, and a fourth at 16,901 CSN. None of those inspections detected any signs of cracks.

The MLG failure occurred when the cylinder had accumulated 20,145 CSN.

The report identified the following causal factors:

- "The right [MLG] cylinder failed immediately upon touchdown due to the application of spin-up drag loads on a section of the cylinder containing a major fatigue crack 3.2 millimeters long and 1.0 millimeters deep and several other associated smaller cracks;
- "The origins of these fatigue cracks could not be identified, but other embryonic cracks were found which were associated with surface irregularities arising from a grit-blasting process during manufacture. Abnormal loading, possibly due to an occurrence of a mode of fore-and-aft vibration known as 'gear walking,' is thought to have been responsible,

at some time in the aircraft's history, for propagating the cracks to a depth at which continued growth was possible under normal loading. Alternatively, some abnormal loading may have relaxed the beneficial compressive surface stresses induced by shot-peening at the critical section and allowed propagation from the same surface defects; [and,]

- "Inspection and other mandatory preventive measures taken following two similar accidents did not prevent the occurrence of this third accident. This was probably due to the small size of cracks which are required to be detected before reaching a critical dimension."

BCA issued, on March 31, 2003, ASB 32-A344, requiring "a repetitive-inspection regime on MLG cylinders which have, at any time, been operated on aircraft not equipped with brake-line restrictors [which are designed to suppress gear walking]. Compliance dates and repeat intervals are variable according to the number of cycles the cylinders have operated since [installation] of the restrictor."

The report said, "Early detection of cracks before they reach critical dimensions is vital in preventing MD-80 series MLG failures. The proposed new procedure should assist this, and the requirement for repetition of inspections, which does not assume that cylinders are crack-free after a few negative results, should increase the probability of detection."

Emergency Airworthiness Directive Issued for MD900

The U.S. Federal Aviation Administration (FAA) issued an Emergency Airworthiness Directive (EAD), dated July 2, 2003, for the MD Helicopters Model MD900.

FAA said that the EAD (2003-14-51) was "prompted by two instances of failure of a main-rotor-blade retention bolt and subsequent new information as a result of the investigation. The failure of these bolts creates an unsafe condition that, if not corrected, could result in loss of a main-rotor blade and subsequent loss of control of the helicopter."

Earlier, pending the completion of its investigations, FAA had issued on June 20, 2003, an EAD requiring interim actions, including inspections of the bolt (part no. 900R3100001-103) and replacement of the bolt if necessary. After issuing that EAD, investigations found that the bolt failures were caused by fatigue. In addition, MD Helicopters issued Service Bulletin SB900-092R1, describing procedures for disassembling and inspecting the bolts.

FAA "determined that the pilot check and torque inspection could be limited to bolts with 400 or more hours time-in-service (TIS)," the EAD said. "FAA also determined that disassembly and a more detailed inspection of the condition of each bolt is necessary."

Saying that "an unsafe condition is likely to exist or develop on other helicopters of the same type design," the July 2 EAD required the following:

- "Before further flight, remove, inspect and reinstall each bolt, unless accomplished previously. If segments do not move freely or a crack is found, replace the bolt with an airworthy bolt before further flight;

- "Thereafter, until the terminating action is accomplished, before each start of the engines for each bolt with 400 or more hours TIS, do a visual check. A pilot may perform the visual check;

- "If a bolt has shifted upward or if there is no gap between the thrust washer and retainer (the gap indicates that the o ring is intact), before further flight, inspect the bolt;

- "At specified intervals, until you accomplish the terminating action, for bolts with 400 or more hours TIS, do a cam-lever-force inspection on each bolt, without removing the bolt;

- "Within 30 days, for bolts with more than 400 hours TIS, disassemble, inspect and reinstall each airworthy bolt. If a crack, fretting or corrosion is found, replace the bolt with an airworthy bolt before further flight; [and,]

- "Before accumulating 400 hours TIS, for each bolt with less than 400 hours TIS, disassemble, inspect and reinstall each airworthy bolt. If a crack, fretting or corrosion is found, replace the bolt with an airworthy bolt before further flight."

The terminating action referred to in the requirements consists of performing the required disassembly and inspection of each bolt, in accordance with the MD Helicopters service bulletin.

Loose Intake Components Remain After Inspection

The commercial pilot was flying the Schweizer 300C at 2,000 feet en route to Russellville, Alabama, U.S., when the sound of the engine changed and the helicopter began to descend.

"The engine and rotor tachometer needles fell below normal operating range, and the pilot's attempts to restore power were unsuccessful," said the report by the U.S. National Transportation Safety Board (NTSB).

"The pilot [initiated] an autorotation and sought a suitable landing area. During flare, the pilot was unable to see the terrain in the darkness, and the helicopter hit the ground hard."

The pilot received serious injuries in the Aug. 16, 2002, accident. The helicopter was substantially damaged. The skids were spread and broken, the cockpit glass was shattered, the main-rotor blades were buckled, and there was damage to the left pilot seat, fuselage and engine.

The report said, "Examination of the engine revealed [that] two lower screws of the no. 3 valve cover were missing. The attachment bolts of the intake pipes of both the no. 1 and no. 3 cylinder assemblies were found loose. The no. 3 intake pipe was found rotated approximately 180 degrees from the normally installed position.

"The gaskets normally installed under the intake pipe flanges of the no. 1 [intake pipe] and no. 3 intake pipe were missing. The no. 1 [spark plug], no. 2 [spark plug] and no. 4 spark plug were wet with fuel, and the no. 3 spark plug was dry and displayed tan-colored combustion deposits."

Maintenance records showed that the engine had been operated 38.2 hours since a 100-hour inspection on July 2, 2002, and there was no record of any maintenance performed since the inspection, the report said.

NTSB determined the probable cause of the accident to be "the failure of maintenance personnel to perform an adequate inspection of loose intake components, which resulted in a total loss of engine power and subsequent emergency descent, forced landing and collision with terrain in dark-night conditions."♦

NEWS & TIPS

Software Designed For Maintenance Management

Maintenix is a comprehensive maintenance-management system featuring eight interconnected modules, which include configuration and records management; diagnostics and prognostics; control; planning and scheduling; execution; maintenance-program management; material management; and fleet monitoring.

The software is said to enable reduced maintenance costs, increased aircraft availability, optimized supply-chain management and ensured regulatory compliance. Among other functions, it is designed to facilitate engineering changes resulting from airworthiness directives (ADs) and service bulletins

(SBs) by record keeping that immediately identifies the components to which the change applies. Engineering changes become maintenance tasks within Maintenix and appear on the "maintenance due" list for the relevant equipment.

For more information: Mxi Technologies, 1430 Blair Place, Suite 800, Ottawa, Ontario K1J 9N2 Canada. Telephone: +1 (613) 747-4698.

Heat Gun Approved for Use Near Fuel Vapors

The Malcom MCH-100 Portable Battery Powered Heat Gun Kit, designed for installing heat-shrinkable tubing, soldering and welding plastic parts, meets the U.S. military standard for use where JP-5 jet fuel vapors are present.

Portable Heat Gun Kit

The unit, which includes interchangeable heating elements ranging from 200 watts to 400 watts, is offered with a variety of nozzles for different applications. Power for the unit's built-in motor and fan, which provide airflow, is supplied by a 48-volt rechargeable battery pack.

For more information: Malcom Hot Air Systems, 1676 East Main Road, Portsmouth, RI 02871 U.S. Telephone: (888) 807-4030 (U.S.) or (401) 683-3199.

Eddy-current Instrument Fits in Hand

The Phasec 2d dual-frequency eddy-current instrument weighs 2.1 pounds (0.94 kilogram) and includes a liquid crystal display (LCD) backlit screen with 480 by 320 pixel resolution. The unit is designed to perform surface and subsurface crack detection and corrosion detection, conductivity measurement and coating-thickness measurement, rotary inspections and fastener inspections.

The one-screen-page menu is said to make set-up easy. Operating frequencies are 10 hertz (Hz) to 10 megahertz (MHz) in normal mode and 10 Hz to two MHz in rotary mode. Lithium-ion batteries power the unit for six hours (when the backlight is used) or eight hours (when the backlight is not used) without recharging.

For more information: Agfa NDT, 50 Industrial Park Road, Lewistown, PA 17044 U.S. Telephone: +1 (717) 242-0327.

Eddy-current Instrument

Painting System Streamlines Preparation

The Paint Preparation System from 3M Aerospace eliminates traditional paint-mixing methods. The paint is mixed in a liner bag that is directly coupled to a filter, spray gun and adapter, which eliminates any need for separate mixing cups and filters. The spray gun can be used at any angle, and when painting is completed, the liner bag and filter are discarded. Only the spray gun and adapter need to be cleaned.

Because less solvent is needed for cleaning, the operator is exposed to smaller amounts of solvent vapors and volatile organic compounds, the manufacturer said.

The product is designed for painting engine cowlings, tail sections, spoilers, flaps, ailerons, elevators and rudders, and is also usable for spraying liquid adhesives in aircraft interiors. Adapters are available for many models of spray guns.

For more information: 3M Aerospace, 3M Center, Building 220-9W-14, St. Paul, MN 55144 U.S. Telephone: +1 (651) 736-7918.

Column Adjusts Height of Work Environment

Height adjustment of worktables, conveyors, loaders and unloaders, and other applications is facilitated by the Thomson Movoact, the manufacturer said. The product, a self-supported anodized-extruded aluminum column, consists of two parts with one part sliding into the other under control of a linear actuator that is integral with the product.

The height adjustment made possible by the product can position the work environment to the specific ergonomic requirements of different dimensions of articles or the physical requirements of different operators, the manufacturer said. The stroke, load and speed capacity of the linear actuator can be specified to meet the customer's needs.

For more information: Danaher Motion, 6095 Parkland Boulevard, Suite 310, Mayfield Heights, OH 44124 U.S. Telephone: + 1 (440) 995-3200.

Sensor System Detects Flaws in Moving Engine Blades

The LMI Technologies/Oryx System has been designed to inspect small concave stainless-steel and Inconel jet-engine blades while the blades are turning at high speeds. LMI Technologies said that the unit makes it possible to avoid time-consuming manual inspection of the distance from the turbine shaft to the tip of each blade within the rotary intake.

The laser twin sensor (LTS) from LMI Technologies projects a laser spot 30 micrometers (0.001 inch) in diameter, which is reflected through two imaging optics onto two position-sensitive detectors. The LTS is coupled with software and with signal-processing hardware from Oryx Systems, which includes a personal computer–based controller. The controller provides a report of the average readings for all the blades in each rotary intake, along with high and low readings, which indicates the blades that need to be replaced or repositioned.

For more information: LMI Technologies (USA), 21455 Melrose Avenue, Suite 22, Southfield, MI 48075 U.S. Telephone: +1 (248) 359-2409.

Crimping Tool Suited for Airframe Wiring

The micro-pneumatic crimping tool from Tyco Electronics, 5.75 inches (14.61 centimeters) long and weighing 1.5 pounds (0.68 kilogram), is said by the manufacturer to be well suited for the intricate crimping found in airframe wiring installation and repair. The tool is hand-actuated and operates on air pressure.

Micro-pneumatic Crimping Tool

The micro-pneumatic crimping tool can be outfitted with a double-action crimp head, a T-head crimper or a straight-action crimp head. The tool is designed for use on many types of terminals, splices and contacts, the manufacturer said.

For more information: Tyco Electronics, P.O. Box 3608, Harrisburg, PA 17105 U.S. Telephone: (800) 522-6752 (U.S.) or + 1 (717) 592-2409.♦

Want more information about Flight Safety Foundation?

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Visit our Internet site at <www.flightsafety.org>.