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Unapproved Modification of Cyclic Trim Switch Cited in Offshore Landing Accident

Pilot lost control of helicopter while approaching to land on a ship after experiencing hard-over lateral-trim runaway during fish-spotting operation.

FSF Editorial Staff

On the morning of June 20, 1997, a Hughes 500 Model 369HS helicopter struck an antenna and descended into the ocean about 2,000 miles (3,200 kilometers) southeast of Guam during an attempted landing on a Korean-owned fishing vessel. The helicopter, operated by Hansen Helicopters of Guam, was destroyed. The pilot sustained serious injuries, and the observer aboard the helicopter was killed.

The U.S. National Transportation Safety Board (NTSB) determined that the probable causes of the accident were an unapproved field modification of the cyclic-control trim switch, a cyclic-trim runaway and the pilot's failure to maintain control of the helicopter during the landing attempt.

The NTSB accident report said that the pilot in the landing-approach accident had a commercial airman certificate issued by the U.S. Federal Aviation Administration (FAA) and 3,132 hours of flight time in rotorcraft. His experience included 248 hours in Hughes 369HS helicopters, with 118 hours flown during the 90 days preceding the accident.

"The pilot of the accident helicopter reportedly is a high-time Bell 47 pilot with low time in the HU-369 model," said the report.

The pilot had completed a biennial flight review required by U.S. Federal Aviation Regulations six months before the accident in a Bell 47G2A helicopter. The pilot was 49 years old and had a second-class medical certificate issued by the FAA on Jan. 10, 1997.

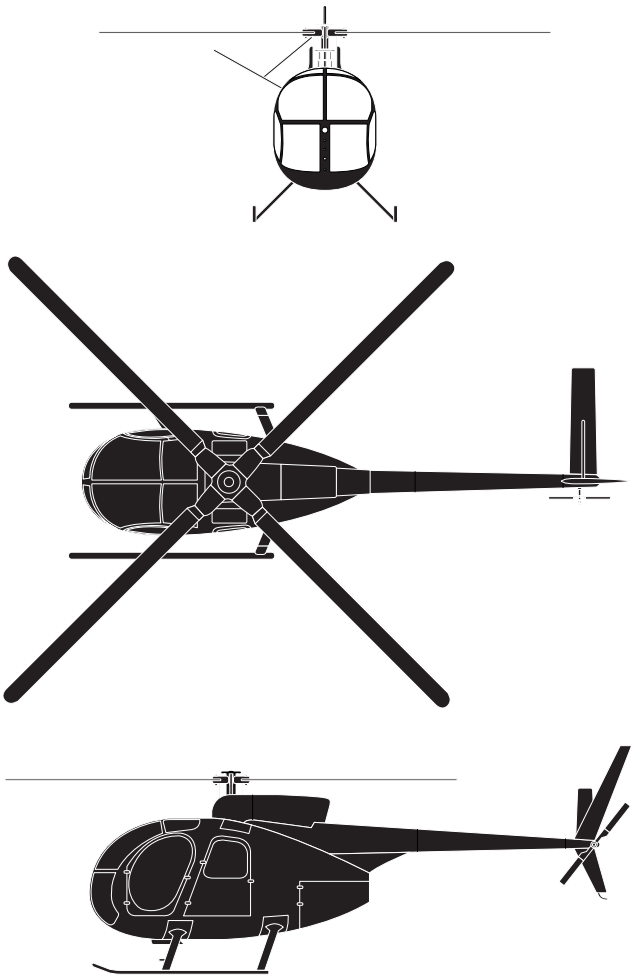
The report said that there was no record that the pilot had received factory training in the Hughes 369HS. According to Boeing Helicopter's chief pilot for test flight, procedures for cyclic-trim failure are reviewed routinely with students who attend factory training courses.

The helicopter had a total of 3,908.8 hours of service since its manufacture, and had been flown 118 hours since its last maintenance inspection, four months before the accident.

The accident occurred about 1030 hours local time near Tarawa, Kiribati. Weather conditions included scattered clouds at 2,500 feet (758 meters) and 20 miles (32 kilometers) visibility. Temperature was 85 degrees Fahrenheit (30 degrees Celsius). Winds were from 220 degrees at 15 knots (28 kilometers per hour). The surface of the water was described by witnesses as calm and smooth.

The float-equipped helicopter was maneuvering during a fish-spotting flight for the fishing vessel *Granada* when, according to the pilot, the electric-trim switch on the cyclic-control stick malfunctioned, forcing the control stick into a full-left position. The helicopter was maneuvering 10 miles from the ship when the malfunction occurred.

In his report to the NTSB, the pilot said, "Attempts to return [the] cyclic to neutral position with trim failed. I flew around trying to get the trim motor to re-engage, [but] this also did not work.



McDonnell Douglas 500

The McDonnell Douglas (formerly Hughes) 500 was introduced in 1968. The aircraft is a civil version of the U.S. Army's OH-6A light-utility and observation helicopter. The MD 500 has a fully articulated, four-blade main rotor, a two-blade tail rotor and a 317 shaft horsepower (237 kilowatt) Allison 250-C18A turboshaft engine. The engine is derated to 278 shaft horsepower (207 kilowatts) for takeoff and has a maximum-continuous-power rating of 243 shaft horsepower (181 kilowatts).

Tubular landing skids were standard equipment; floats and snow skis were options. The helicopter has a forward bench seat for the pilot and two passengers, and a rear bench seat for two or four passengers.

Standard empty weight is 1,096 pounds (493 kilograms). Maximum normal takeoff weight is 2,571 pounds (1,157 kilograms). Maximum cruising speed at sea level is 125 knots (232 kilometers per hour). Range at 4,000 feet (1,212 meters) is 327 nautical miles (606 kilometers). Service ceiling is 14,487 feet (4,390 meters). Hovering ceiling in ground effect is 8,250 feet (2,500 meters).♦

Source: *Jane's All the World's Aircraft*

"I contacted [the] boat and told them of a problem. I had the boat stop moving and turn into the wind.

"As I approached the boat and came to the landing deck, I lost control of the helicopter because I could not hold the cyclic with one hand," said the pilot. "The helicopter rolled to the left and [descended] upside-down into the water." The helicopter remained afloat after impact and was recovered by the ship.

A maintenance technician aboard the fishing vessel witnessed the accident. He told NTSB investigators that the helicopter's approach to the ship appeared normal. When the helicopter was approximately four feet (1.2 meters) above the landing deck, however, he heard an "abrupt power increase … followed by the helicopter rearing backwards, turning 270 degrees to the left, and then going into the water."

The witness also reported that the pilot of the helicopter told him shortly after the accident that he had experienced trouble with the cyclic-trim switch on prior flights.

The report included a digest of a conversation between an NTSB investigator and a helicopter pilot based in Guam who was experienced in fish-spotting operations. "He stated that he thought that cyclic-trim-runaway failures are not 'uncommon' on MD 500 models. He said that he had personally experienced five trim failures and didn't feel that the runaway-trim failures were a 'problem.'

"He reported that a number of pilots in Guam felt that the pilot of the accident aircraft thought things were getting away from him as he came in to land the helicopter on the boat," said the report. "They felt he did a 'panic pull' and pulled a large amount of collective to 'get away from the ground.'"

The report said, however, that the pilot denied that he performed such a maneuver.

The cyclic trim switch was examined under NTSB supervision at the Boeing Helicopter factory in Mesa, Arizona, U.S.

"The examination and subsequent disassembly revealed that the switch had been disassembled and then reassembled in the field at an undetermined point in time," said the NTSB report. "A series of tool marks, a cracked insulator and loose terminals were found during the examination." The NTSB also said that nonstandard parts were found inside the switch assembly.

The manufacturer of the cyclic trim switches used in some Hughes 500/369 helicopters, Guardian Electric Manufacturing Co. of Woodstock, Illinois, U.S., believed the prior disassembly and reassembly of the switch had been done to perform field maintenance, although the switch is not a repairable item.

The Guardian Electric trim switches installed in Hughes 500/369 series helicopters were the subject of a Mandatory Service

Information Notice issued in March 1994 by McDonnell Douglas Helicopter Systems (MDHS).

[MDHS was created after the acquisition of Hughes Helicopters in 1984 by McDonnell Douglas and was subsequently acquired by The Boeing Co. in 1997. At press time, Boeing was seeking to sell the light helicopter line.]

The mandatory service notice issued by MDHS required operators to replace existing trim switches (part number A218-100646-03) with an upgraded version designated as "Revision D." The notice explained that MDHS had received reports that some trim switches were sticking during operation.

The notice said, "This condition could cause an uncommanded directional travel in the cyclic-control system which can be overcome by the pilot. The forces will increase by approximately 30 pounds (13.5 kilograms) in this direction, thereby creating an increase in pilot work load. … Therefore, MDHS is requiring operators to replace those affected switches with switches that have been upgraded to a Rev. 'D' configuration."

The replacement trim switch is identified by the letter "D" stamped on the bottom of the switch's metal mounting bracket. Guardian Electric said that there was no identification mark on the mounting bracket of the trim switch in the accident helicopter and that no identification mark indicates the switch was manufactured before the MDHS mandatory service notice was issued.

"[The] 'field maintenance theory' is … supported by the age of the switch," said Guardian. "There were no markings of any kind on the switch to indicate the manufacturer, date code, etc."

During the examination of the switch by the NTSB, Boeing Helicopter and Guardian Electric personnel noted that the stainless-steel ball inside the switch had worn grooves into the contact disk. Investigators discovered that the surface of the contact disk was made entirely of silver and had no protective liner (Figure 1).

"Guardian has never produced a version of this switch which had a ball on the plunger unless there was a copper-beryllium liner in the contact to prevent wear," said the switch manufacturer. "Coupled with the evidence of tampering and damage on the contact retainer assembly, [this] clearly indicates this switch had some sort of modification or parts 'swap-out' done to it in the field."

"This switch is not a repairable item," said Guardian. "No repair manual or spare-parts program exists for this switch. The disassembly and reassembly using alternate 'mixed-design' parts created a mismatch of technologies which, coupled with the damaged contact retainer assembly [and] loose contact, caused the switch to function abnormally."

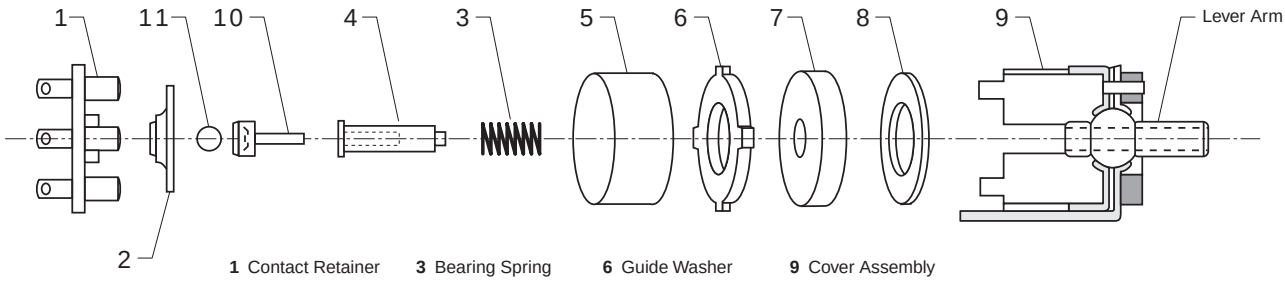
The Hughes 500 Model 369HS Owners Manual provides the following description of the mechanism: "The cyclic-trim switch has five positions; normally OFF in the center and momentary FORWARD, AFT, LEFT and RIGHT.

"When the trim switch is moved off center to any of the four trim directions, the electrical system energizes one of the trim motors to apply trim-spring force in the desired direction. By momentarily moving the switch, very small trim increments may be obtained. … Cyclic pitch-control-stick trim-spring tension can be overridden at any time."

The manual describes a runaway-trim condition as "an uncommanded longitudinal or lateral cyclic-trim actuation."

"The cyclic may move to a full-travel position or some intermediate position, resulting in cyclic forces up to the maximum," says the manual. "Uncommanded movement can occur after cyclic-trim-switch actuation or as the result of an electrical short.

Switch, Four Position P/N A218-100646-02



Source: U.S. National Transportation Safety Board

Figure 1

"Runaway cyclic-trim failures can produce cyclic-stick forces of approximately 30 pounds in the direction of the runaway. Although the forces required to move the cyclic will be higher than normal, the helicopter will respond normally to all cyclic inputs by the pilot."

The manual recommends the following actions in response to a lateral cyclic-trim runaway:

- "Utilize left hand and legs, as necessary, to apply pressure against the cyclic stick to relieve the right-hand loads and conserve strength for landing. Use collective friction to prevent unwanted collective movement and associated power change. Be prepared to respond to any emergency requiring the use of collective pitch"; [and]

- "Actuate the trim switch through all positions, several times if necessary, as this will generally re-establish trimming capability. When restored, trim to a near-neutral position and land as soon as practical, avoiding further trimming."

The manual also includes the following warning: "Control of the helicopter is the primary consideration of a pilot confronted with any type of trim-motor or switch malfunction. The pilot-in-command should land the helicopter immediately if the pilot's physical condition, strength or threshold of fatigue would compromise [his or her] ability to safely control the helicopter in continued flight." [Hansen Helicopters said that the pilot was six-feet tall and weighed 175 pounds.]

During the investigation of the accident, NTSB conducted a test flight "to replicate as closely as possible the conditions and force pounds necessary to control the helicopter with a cyclic-trim failure."

A McDonnell Douglas MD520N was used for the tests. NTSB noted that this model has a five-blade main-rotor system, which produces a heavier load and control force than the Model 369. The flight test showed that runaway-trim conditions were controllable, said the NTSB.

"Cyclic-trim failures were replaced in all four axes, in various flight configurations, and were successfully flown to touchdown in a confined … landing site," said the report.

In its report, the NTSB concluded that the probable causes of the accident were "the unapproved field modification of the cyclic-trim switch, including the use of nonstandard parts, which resulted in a hard-over lateral-trim failure, and the pilot's subsequent failure to maintain control of the helicopter during a landing approach."

The NTSB said that factors contributing to the accident were "the operator's failure to comply with a factory service bulletin which required replacement of the [cyclic-trim] switch with a new version, and the pilot's continued operation with a known [equipment] discrepancy."♦

Editorial note: This article is based on information included in the U.S. National Transportation Safety Board's factual report on the accident, NTSB identification LAX97LA218. The 66-page report contains diagrams, photographs and appendixes.

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