**SAS Accident Investigation Case Study 2**

Helicopter system malfunction on primary system on 1st flight after maintenance

The purpose of this exercise is to review the following information and to use it to complete the provided Accident Investigation Workshop Evaluation Worksheet

**Introduction**

‘Inadequate Maintenance’ - Improper use of connection hardware began a chain reaction that led to the crash of an AS350 on a sightseeing flight, the NTSB says.

A series of maintenance errors was responsible for the Dec. 7, 2011, crash of a Sundance Helicopters Eurocopter AS350 B2 in the mountains east of Las Vegas, the U.S. National Transportation Safety Board (NTSB) says.

The pilot and all four passengers on the “Twilight Tour” sightseeing flight were killed in the crash, and the helicopter was destroyed.

**General Findings**

The primary category of maintenance error is “failing to carry out necessary actions.

“Each servo is connected to the main rotor transmission case, the nonrotating swashplate and the servo control input rod. A bolt, washer and self-locking slotted nut connect the servo control input rod to the servo input lever; the nut also is secured with a split pin (also called a cotter pin), which prevents it from unthreading

Investigators found the fore/aft main rotor servo control input rod in the wreckage, disconnected from the input lever; its connection hardware was not found.”

The last maintenance on the accident helicopter — which included a 100-hour inspection and replacement of the tail rotor servo, the engine and the main rotor fore/aft servo — was completed the day before the crash.

The fore/aft servo was replaced with a new unit, and the mechanic said after the accident that he had no difficulties with the installation.

Eurocopter stated in a letter that said, because the nut had two locking devices — the self-locking feature and the split pin — it was designed to remain tight. Even if the split pin had not been in place “behind an airworthy self-locking nut,” the nut should not have loosened as long as it was properly torqued.

**Flight Conditions**

The flight began at 1621 local time, when the helicopter took off at dusk from Las Vegas McCarran International Airport in visual meteorological conditions with good visibility. The pilot planned to fly to Hoover Dam, about 30 nm (56 km) southeast and then to return to the airport.

Radar data from the U.S. Federal Aviation Administration (FAA) showed that the helicopter had been level at 3,500 ft, with a groundspeed of 120 kt, until about one minute before impact, and then climbed to 4,100 ft, turned 90 degrees left and slowed. The helicopter descended to 3,300 ft and tracked northeast for 20 seconds before entering a left turn and plunging toward the ground “at a rate of at least 2,500 ft per minute,” the NTSB said in its final report on the accident. Parts of the helicopter were destroyed by a post-impact fire. The wreckage was found in a ravine about 14 mi (23 km) east of Las Vegas.

**Probable Cause**

“Based on the evidence, “the NTSB concludes that the most likely explanation for the in-flight loss of control is that the fore/aft servo bolt disengaged in flight, which resulted in the separation of the control input rod to the fore/aft servo’s input lever, rendering the helicopter uncontrollable.”

The NTSB said the probable causes of the crash were

* Sundance Helicopters’ “inadequate maintenance of the helicopter, including
* The improper reuse of a degraded self-locking nut,
* The improper or lack of installation of a split pin and inadequate post-maintenance inspections,

Which resulted in the in-flight separation of the servo control input rod from the fore/aft servo and rendered the helicopter uncontrollable.”

**Contributing Factors**

Contributing factors were

* The mechanic’s and inspector’s fatigue and
* The “lack of clearly delineated” steps for the maintenance task and the inspection, the NTSB said.

**Maintenance Personnel**

The mechanic who installed the fore/aft servo received his airframe and powerplant (A&P) mechanic certificate in December 2008 and worked on maintaining general aviation airplanes and business jets before being hired by Sundance in June 2011. After his hiring, he received indoctrination training in record keeping, maintenance procedures and use of the Eurocopter manuals, as well as on-the-job training, but he had yet to attend any helicopter-specific training.

The mechanic who inspected the servo replacement had been named a quality control inspector about six months earlier. He also was one of three lead mechanics who directed maintenance tasks when management personnel were not present. He received an airframe and powerplant mechanic certificate in 2002, and had spent about two years in commercial aircraft maintenance and seven years in helicopter maintenance before he was hired by Sundance in 2010.

**Maintenance Human Factors**

Although maintenance personnel were under no time pressure to complete their work, the mechanic and the quality control inspector both met criteria for “susceptibility to the debilitating effects of fatigue,” the report said. “Because both the mechanic and the inspector had insufficient time to adjust to working an earlier shift than normal, they were experiencing fatigue. … In addition, the mechanic had an inadequate amount of sleep and the inspector had a long duty day, both of which also contributed to the development of their fatigue.”

Although the report said that fatigue alone could not explain the maintenance errors, it noted the NTSB’s “longstanding concerns about the effects of fatigue on maintenance personnel.”

In particular, the NTSB cited the extended duty time that contributed to the inspector’s fatigue, adding that it “continues to believe that establishing duty-time limitations is a key strategy to reducing the risk of fatigue-related errors in aviation maintenance.”

**Post Accident -Follow up**

Eurocopter, in its Standard Practices Manual, specifies that a locking nut may be reused only if it is “not excessively damaged,” is hard and cannot be tightened by hand.

Sundance inspected all of its AS350s after the accident and found all fore/aft servo connection hardware was properly connected and safetied. At the same time, the connection hardware was examined on the main rotor servos of all Sundance helicopters with at least 5,000 flight hours; the examinations showed that about half of the self-­locking nuts on the 13 helicopters that had been inspected by January 2012 had no locking capability, the NTSB said.

On two helicopters, self-locking nuts “could be easily and fully tightened or loosened on the accompanying bolts with finger pressure,” the NTSB said, adding, “This indicates that the nuts … were not suitable for reuse.”

After the accident, Sundance directed maintenance personnel to replace the self-locking nut and other connection hardware at the next scheduled inspection of all of its helicopters with more than 5,000 flight hours and then at 5,000-hour intervals.

The company also said that the nut must be replaced with a new nut any time an input rod is disconnected from a servo.

**Conclusions & Findings**

NTSB’s conclusion that, “at the time of the accident, Sundance Helicopters was not following Eurocopter and FAA self-locking nut reuse guidance, which led to the repeated improper reuse of degraded nuts on its helicopters,” the report said.

The NTSB included several safety recommendations to the FAA, including one that called for the establishment of duty-time regulations based in part on start time, workload, shift changes, circadian rhythms and adequate rest time.