

Transportation Safety Board
of Canada



Bureau de la sécurité des transports
du Canada

AVIATION INVESTIGATION REPORT

A00P0182



INPUT FREEWHEEL UNIT MALFUNCTION

HELIJET INTERNATIONAL INC.

SIKORSKY S-61N/SP (HELICOPTER) C-GHJU

VANCOUVER HARBOUR HELIPORT, BRITISH COLUMBIA

14 SEPTEMBER 2000

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Aviation Investigation Report

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Summary

At 1520 Pacific daylight time, the Helijet Sikorsky S-61N/SP helicopter, serial number 61711, lifted into the hover at the Vancouver Harbour helipad for a 35-minute, visual flight rules flight to Victoria. Three crew members and 15 passengers were on board. The pilot applied take-off power, and, as the helicopter began to climb vertically through about 30 feet above the deck, there was a sudden and immediate loss of power from the No. 2 engine, accompanied by an indication of a significant engine torque split—No. 1 engine high and No. 2 engine low. Because the helicopter had not yet begun to move forward, the pilot rejected the take-off, turned the helicopter left, and landed with one engine inoperative on the northern edge of the helipad. No damage or injury occurred.

Ce rapport est également disponible en français.

Other Factual Information

After the helicopter landed and was stabilized, the crew secured the No. 2 engine, which had shut itself down. The pilot then assessed that the passengers could not easily disembark the helicopter in the position it had landed, and he began to taxi forward to better situate the airstair door. After a short distance, however, the tail wheel ran off the edge of the deck, allowing the rear of the fuselage to fall and strike the deck edge. The aft section of the hull was damaged.

The pilot could not pull the tail wheel back onto the helipad because it was caught in the deck-edge net. He instructed the first officer and the cabin attendant to deplane the passengers while he kept the main rotor running, since the airstair door alignment was now suitable. After the passengers had moved into the nearby terminal building, the first officer cut the netting cable and freed the tail wheel. The pilot then taxied to the eastern side of the helipad and shut the helicopter down.

Records reveal that both pilots were trained and qualified for the flight in accordance with existing Transport Canada regulations. Records also reveal that the helicopter was maintained in accordance with existing Transport Canada regulations.

The No. 2 engine was removed, disassembled, and examined. The associated fuel control unit and flow divider were removed, rigorously bench-tested, disassembled, and examined at an approved overhaul facility. The engine overspeed protection mechanism in the fuel control unit was tested several times. The fuel control unit functioned normally, and no defect was found in its operation or construction. In summary, no sign of defect, abnormality, or malfunction was found with the engine or its components that would have caused or contributed to the incident.

The main-rotor gearbox was removed, disassembled, and examined. With the exception of the No. 2 (right) input freewheel unit (IFWU), no defect was found. The No. 2 IFWU was disassembled and examined (see Appendix A). The IFWU gear housing was found to have been worn well beyond tolerance; the wear was eccentric, and the wear depth was greater than normally seen in a component with similar in-service life.

The IFWU is essentially a clutch mechanism that provides a means to engage or disengage the engines from the main-rotor transmission system. The IFWU comprises three notable elements: a gear housing, a cam shaft, and 12 rollers. In the event that an IFWU slips, the associated engine is instantly off-loaded and, as a result, frequently reaches an overspeed condition and automatically shuts down. An IFWU has a normal service life of 1250 hours. Both IFWUs were installed in the main-rotor gearbox in January 1999, eight months before the incident, and had accumulated 464 hours of service up to the time of the incident.

The maximum permitted internal dimension of an S-61 IFWU gear housing at overhaul is 3.7535 inches. In places, the internal dimension of the No. 2 IFWU housing was 3.7595 inches: the wear was 0.0059 inch greater than the rejection limit. Furthermore, the wear was eccentric and 0.0045 inch out of round. In comparison, the No. 1 (left) IFWU gear housing showed less than 0.001 inch of uniform wear.

Wear in the IFWU is normally caused by the unit overrunning, that is, by the main-rotor gearbox input turning faster than the driving input speed from its associated engine. This situation always occurs during main-rotor engagement when one engine is operating at lower revolutions per minute (rpm) than the other. The degree and severity of the wear can be influenced by the variables of operations and pilot technique.

The issue of increasing premature removal rates for the IFWUs in the S-61 helicopter had been identified by Sikorsky Aircraft in early 1980. At that time, the manufacturer issued a customer service letter entitled "Input Freewheel Unit Serviceability (MGB)" (CSL-P-80-011, dated 21 February 1980 and revised 02 April 1980). The letter highlighted the probability of freewheel unit slippage being aggravated by the practice of rapid, harsh rotor engagements and predominant engine starts.¹ It also recommended that the following four operational techniques be adopted by S-61 operators:

- a. alternate rotor engagements between engines to reduce the frequency of overrunning and engagement impact cycles on the same IFWU, and to equalize the wear between the two IFWUs;
- b. moderate engine acceleration when matching torques for load-sharing by ensuring that pilots carry out all rotor engagements smoothly to prevent shock-loading the IFWUs;
- c. monitor the free power turbine for overshoot during flight since this is an indication of degraded performance of the IFWU; and,
- d. reduce the amount of IFWU freewheeling and rotor engagements during ground operations by sharing the load between the engines.

As a result of these revised procedures being adopted, the removal rate of IFWUs improved.

Helijet International, the operator of the S-61N involved in this incident, had not implemented the alternating starting procedures identified in the customer service letter. The TC-approved rotorcraft flight manual (RFM) does not include reference to the alternate starting procedure. Helijet's starting and engagement procedures were in accordance with the rotorcraft flight manual and included starting the No. 1 engine first, engaging the rotor, then starting the No. 2 engine, in that order. This practice always exposed the No. 2 IFWU to an overrun condition. As well, it was not uncommon at Helijet to shut down the No. 2 engine, stop the main rotor, then shut down the No. 1 engine. This practice also exposed the No. 2 IFWU to an overrun condition. In the recent past, the operator had used this helicopter to type-train several pilots. This training included single-engine flight operations carried out with the No. 2 engine retarded. For technical reasons, S-61 operators prefer to reduce power on the No. 2 engine during simulated single-engine training. This practice again exposed the No. 2 IFWU to an overrun condition.

Since the incident, Sikorsky Aircraft has submitted the improvements described in CSL-P-80-011 to the United States Federal Aviation Administration, for approval and incorporation into the RFM. This change will subsequently be incorporated into the TC-approved RFM.

¹ *Predominant engine starting* refers to the practice of always starting the same engine first, usually the No. 1 engine.

Analysis

A review of the flight crew's actions during this incident revealed no indication that their actions contributed to or exacerbated the chain of events that led to the freewheel unit slippage. A review of the company flight operations, however, revealed that some standard operating procedures probably contributed to the freewheel unit slippage.

Accelerated wear in the IFWU was likely caused by a combination of frequent overrunning of the same IFWU, frequent single-engine training, and rotor engagement techniques. It was not determined why the No. 2 IFWU gear housing had worn in an eccentric manner.

The manufacturer's customer service letter (CSL-P-80-011) highlighted the probability of freewheel unit slippage being aggravated by the practice of rapid, harsh rotor engagements and predominant engine starts. The Sikorsky recommendations of alternating rotor engagements between engines, moderating engine acceleration when matching torques, monitoring the free power turbine overshoot, and reducing the amount of IFWU freewheeling have noticeably reduced the frequency of IFWU slippages. Helijet was aware of these recommendations and, since the incident, began to alternate rotor engagements between engines and reduce the amount of IFWU freewheeling. Since then, little wear was seen on the IFWU gear housing. It is therefore likely that the operator's standard operating practices, at the time of the incident, contributed to the accelerated wear seen in the incident IFWU.

Findings as to Causes and Contributing Factors

1. The No. 2 input freewheel unit (IFWU) in the main-rotor gearbox was worn beyond limits and slipped under high power loading at take-off, precipitating the spontaneous overspeed and shut down of the No. 2 engine.
2. Accelerated wear in the IFWU was likely caused by a combination of frequent overrunning of the same IFWU, frequent single-engine training, and rotor engagement techniques.

Findings as to Risk

1. IFWUs in the S-61 helicopter are susceptible to high wear rates under certain operational conditions. As a result, IFWUs can fail, cause engine overspeed, and shut down.

Other Findings

1. The helicopter manufacturer recommended procedures to improve torque load-sharing and to counter high wear rates with IFWUs in S-61 helicopters. These procedures have not been fully incorporated into the Transport Canada-approved rotorcraft flight manual.

Safety Action Taken

As a result of this incident, Helijet implemented an improved starting and engagement procedure with its S-61N helicopter. This procedure involved starting both engines and then engaging the rotors with both engines together, which significantly reduces overrun. The operator reduced the maintenance inspection cycle for the IFWUs to 300 hours in service to see if the wear was affected by the new operating procedures. An inspection of the main-rotor gearbox was carried out on 31 January 2001, 300 hours in service since the original freewheel slippage event that is the subject of this investigation. That examination of the No. 2 IFWU revealed wear on the cam and the rollers but virtually none on the IFWU housing. Helijet replaced the IFWU and has scheduled another inspection of this IFWU after 450 hours of service.

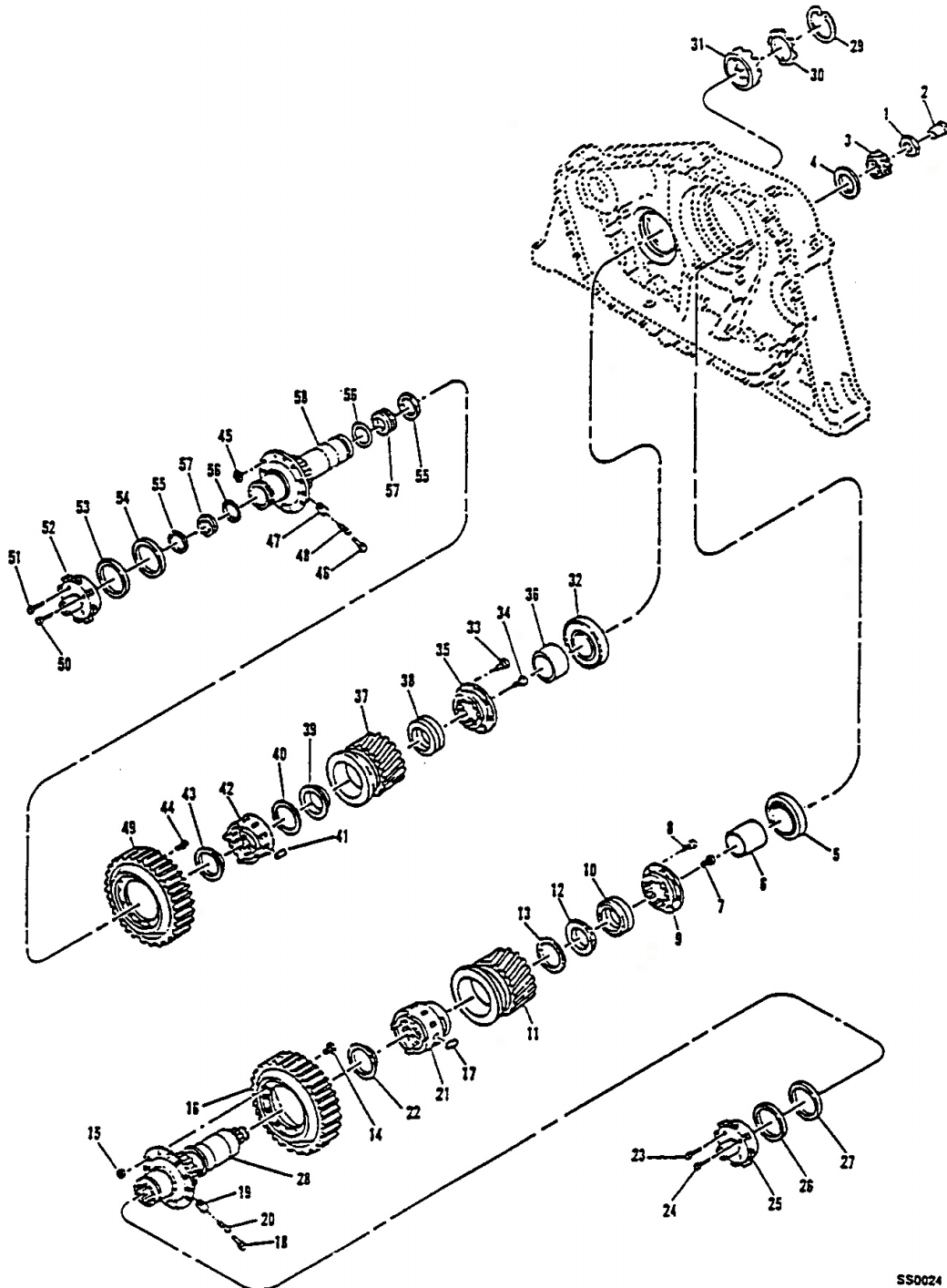
Since the incident, Sikorsky Aircraft has submitted the improvements described in CSL-P-80-011 to the US regulator, the Federal Aviation Administration, for approval and incorporation into the RFM.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 3 October 2001.

Appendix A - Input Freewheel Unit Assembly

Section II
Group Assembly Parts List

S-61N ILLUSTRATED PARTS CATALOG
SA4045-79



SS0024

FIGURE 149A. MAIN GEAR BOX INPUT FREE WHEEL UNIT QUICK CHANGE ASSEMBLY