

AVIATION OCCURRENCE REPORT

LOSS OF CYCLIC CONTROL - COLLISION WITH TERRAIN

COULSON AIRCRANE LTD.
SIKORSKY S-61N (HELICOPTER) C-GBRF
STAVE LAKE, BRITISH COLUMBIA
19 APRIL 1997

REPORT NUMBER A97P0094

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.

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Summary

At 1415 Pacific daylight time (PDT) the two pilots of a Sikorsky S-61N helicopter, serial number 61748, took off from the Stave Lake airstrip, British Columbia, to return to heli-logging operations in an area about two nautical miles (nm) from the airstrip. Following four uneventful lifting cycles, while manoeuvring over the logging area, the aircraft started an uncommanded, nose-down attitude change that the pilot was unable to counteract with rearward cyclic control. Seconds later, cyclic control returned. The pilot, flying from the left seat, attempted another approach from a different direction with the same result. The pilot and co-pilot then assessed that they had significant flight control problems and decided to return to the airstrip to carry out a running landing. The pilot established a slow and shallow final approach path profile to land at the airstrip. The helicopter then approached the intended landing site with a slight nose-up attitude, at a ground speed of 10 to 15 knots, and about 10 feet above the ground. When the pilot began to level the helicopter, the nose continued to pitch down quickly. The pilot applied collective pitch and rearward cyclic, but the helicopter descended nose-down into the trees at the end of the airstrip and rolled over, coming to rest on its left side. The pilot was

¹ All times are PDT (coordinated universal time minus seven hours) unless otherwise noted.

seriously injured, and the co-pilot was fatally injured. There was no fire and the helicopter was substantially damaged.

Other Factual Information

Earlier that day, the pilots had taken off from the service pad, and resumed heli-logging operations. After 6.5 hours of heli-logging without incident or difficulty, they returned to the service pad at 1345 for midday maintenance, refuelling, and crew relief.

When the first upset occurred, the pilot assessed that it had been caused by a wind shift. Seconds later, when the helicopter gained airspeed, cyclic control seemed to return to normal, and he flew away to attempt an approach from a different direction. On the second attempt, the upset and loss of control were more pronounced. Cyclic control again returned when the helicopter descended and increased airspeed; this time, however, the pilots heard a distinct, loud “bang” behind them when the helicopter recovered to about the nose-level attitude.

The short, one-minute flight back to the airstrip was uneventful until the pilot again tried to hover to release the 200-foot long-line; the nose dropped once more without cyclic input. As in the previous episodes, cyclic control appeared to return when airspeed increased, and when the nose was returning to the nearly-level attitude, the pilots heard the loud “bang” again. The pilot aborted this approach and flew away to set up another approach from the opposite direction. On this approach, the pilot jettisoned the long-line, and carried on flying to make a left-hand circuit back to the service area, with the intention of carrying out a slow, running-landing at the end of the airstrip. During the next few minutes of flight, the “banging” increased in frequency and was without apparent association with any flight control input. The pilot deliberately established a slow and shallow final approach path profile for the attempted landing, in an effort to avoid the known, uncontrollable flight regime.

The operating environment was unremarkable in comparison to previous heli-logging operations and sites. The weather conditions during the period leading up to the accident were reported by witnesses at the site as being good, with light winds and occasional light rain showers; such conditions are consistent with the visual meteorological conditions (VMC) requirement of this operation. The operating terrain, environment, and weather are therefore not considered as contributory factors in this accident. The pilot at the time of the accident was also the pilot-in-command and had been employed by Coulson Aircrane for five weeks, having recently worked for other Canadian operators of heavy helicopters, such as the S-61. He had accumulated a total of about 8000 hours flying, of which 7500 hours were in helicopters, and 2500 hours in the S-61. He held a valid Canadian airline transport helicopter pilot licence (ATPL(H)) and medical certificate, and endorsements for other medium and light helicopters. He had also held a Canadian Group 4 instrument rating, but it had expired in February 1996. An instrument rating is not required for heli-logging in the S-61. His flying experience included instrument flying rules (IFR) offshore operations, as well as about 2500 hours in heli-logging operations. His most recent pilot proficiency check (PPC) was in March 1997, and was carried out, as on previous occasions, with a high degree of competence.

The pilot-not-flying was acting as the co-pilot during the accident flight, and had been employed by Coulson Aircrane for three years, having also worked for other Canadian operators of both light and heavy helicopters; he had accumulated a total of about 11 400 hours flying, of which all but 150 hours were in helicopters, with 4000 hours in the S-61. He held a valid ATPL(H) and medical certificate, and was endorsed for other light,

medium, and heavy helicopters. He had also held a Canadian Group 4 instrument rating, but it had expired in February 1993. Although he was the co-pilot during this mission, he was an experienced logging captain in the S-61, and was the lead pilot for the Stave Lake logging operations. His overall flying experience included international, offshore IFR operations, and he had been involved in heli-logging operations for about five years. His most recent PPC was in February 1997, and was carried out with a high degree of competence. He had demonstrated strong inter-personal skills, and had a detailed working knowledge of the S-61 and its systems, and an effective sense of problem-solving.

The helicopter's weight and centre of gravity (CG) at the time of the accident were estimated to have been within acceptable limits. The weight of the helicopter was approximately 13 200 pounds, and the CG approximately 261 inches from the datum. The maximum certificated weight of the S-61N helicopter is 20 500 pounds, and the permissible CG range for the estimated weight at the time of the accident was 254.0 to 280.0 inches from the datum.

In general, the "vertical reference" flying technique used in heli-logging involves rapid and extreme flight control inputs, with the helicopter constantly experiencing attitudes and rates of attitude-change greater than during conventional route flying. Furthermore, the demands on the engine/transmission system can cycle from low to high power several times during the load pick-up and drop-off, imposing high stress and cycle counts on critical components.

On helicopters used in vertical reference flying, such as the S-61, cockpit dimensions and fuselage width require the pilot-flying to lean markedly to one side to be able to clearly see the long-line and load suspended below the helicopter. Because such a body position is physically impossible to achieve by a pilot wearing the shoulder harness of the seat restraints, it is a wide-spread practice for the pilot manoeuvring the helicopter to use the seat belt portion only. In helicopters dedicated to vertical-reference flying, it is common for the shoulder straps to be semi-permanently stowed behind the seat back to prevent them from interfering with the pilot's movements.

The pilot-in-command, seated on the left side, had remained secured in his seat during the impact and rollover, and sustained serious injuries from the disruption and break-up of the cockpit around him. He had not used the shoulder harness of his seat restraint; the shoulder straps had been re-routed behind the seat-back pad, making them difficult to retrieve in flight. It was not determined if his injuries would have been lessened had he worn the shoulder straps. Although the impact forces in this accident were survivable, the co-pilot perished as a result of being crushed by the helicopter as it rolled over. He was found out of his seat, a short distance away from the cockpit. Both pilots' seat restraints were examined by the TSB Engineering Branch to determine if the co-pilot's had failed or had released prematurely. The shoulder harness portion of his seat restraint was found free and available; however, it could not be determined if the co-pilot was using the shoulder straps at the time of the accident. Medical information revealed that the co-pilot had been wearing the seat belt portion. The laboratory examination (LP 120/97) revealed that the seat belt had not failed, and that it was functioning correctly; it was not possible to determine when the seat belt had undone. Both pilots were wearing flight helmets.

In heli-logging operations using the S-61 helicopter, it is a standard practice for the pilot-flying to occupy the left-hand seat, and for the pilot-not-flying to be in the right seat; the pilots in this accident were seated in this fashion. The pilot-flying manoeuvres the helicopter for all phases of flight, while the pilot-not-flying manipulates the engine speed select levers to maintain acceptable main rotor rpm, monitors the engines and ancillary systems, and records the loads picked up during the cycle. This division of work-load allows the pilot-flying to concentrate solely on manoeuvring the helicopter. At the end of a period of flying, usually about an hour, the flight crew will return to the service site to refuel and to exchange places before continuing for another cycle. This flying/non-flying cycle ensures a balanced work-load among the pilots, and reduces fatigue. An examination of the work and duty cycles of both pilots involved in this accident revealed that they had begun the logging operation only the day before the accident, and that they had followed the rest and work periods required by regulation. Based on the recent personal histories of the flight crew, pilot proficiency is not considered a contributing factor in this accident.

Almost one month earlier, on 21 March 1997, the same pilots experienced an almost identical episode of uncommanded nose-down attitude change with the same aircraft, accompanied by the loud “bang,” in the same phase of flight. On this occasion, the pilots were able to bring the helicopter back to the service area and land without further incident. Following an extensive inspection, site maintenance personnel found no particular discrepancy with the helicopter or its systems. One of the aircraft engineers on site sprayed the “boot strap” springs at the base of the primary hydraulic servos with WD-40, a light lubricant/cleaner, as part of his trouble-shooting process to eradicate a possible cause of the problem. It could not be determined, however, whether that action was effective, but the aircraft continued to fly after that servicing, without any recurrence of the symptoms, for a total of about 120 hours, until the problem returned on the day of the accident. During this interval, the helicopter had been engaged in several types of flying operations, such as heli-logging and ferry flights, and no instances of abnormal performance of the helicopter or any of its systems were reported by the flight or maintenance crews that flew and attended the helicopter. The accident investigation has not revealed a chain-of-events in the first incident that would lead to identifying the causes or contributing factors relating to the loss of control in the accident flight.

The helicopter was manufactured in 1975 and had accumulated about 13 725 hours of flight time, of which about 5 000 hours were in the heli-logging environment with Coulson Aircrane. The maintenance records of the helicopter were examined and no deficiency or discrepancy was found. Records show that the aircraft had been maintained under a progressive maintenance schedule in accordance with existing directives and regulations. The helicopter was not equipped with either a cockpit voice recorder or flight data recorder (CVR/FDR); nor was either required by regulation.

Recent maintenance to the helicopter involved the scheduled removal and replacement of several components; each of these components was examined during the investigation and no defect was found.

Following a preliminary examination of the wreckage at the site, the airframe, engines, and ancillary systems were transported to secure facilities and examined in greater detail. Because of the level of interest that the international helicopter industry had in the proceedings of this investigation, the TSB enlisted technical expertise from the North American helicopter industry.

The entire helicopter was critically examined. Particular attention focused on the helicopter flight controls and hydraulic systems, the auto-pilot, the drive train, and the main rotor gearbox and head. Systematic examination revealed that all component breakage and damage were attributable to the impact forces of the accident. With few exceptions, no abnormalities were identified; those exceptions are described briefly in the following paragraphs. In summary, no evidence was found of any pre-existing condition, deficiency, or component or system malfunction that could have caused, or contributed to, the accident.

Examination of the hydraulic flight control systems and pumps revealed that slight buffing was found on a flange inside the locking collar connecting the two piston halves in the fore-aft primary hydraulic servo; since these parts of the servo experience no relative motion after assembly, the buffing was assessed as an assembly-related mark. It was determined that the buffing had no impact on the function of the servo. In the auxiliary hydraulic pump (serial number JO-622) a "Dublel" ring and seal unit was found to have been installed incorrectly at the last overhaul; tests showed that the inverted seal had not affected the output of the pump, but it is likely that after further hours in service, the seal would have begun to leak, requiring the removal and replacement of the pump.

During the examination of the primary hydraulic system, it was found that one of the wires leading to the cannon plug on the Primary Pressure Switch (3-way valve) had pulled out from its terminal post. The TSB Engineering Branch examined the wire and concluded that it had "...failed in a progressive manner under cyclic loading....," likely as a result of vibration. The examination could not accurately establish when the wire broke (refer to TSB Engineering Branch report LP 107/97). The effect of this fracture on the in-flight operation of the hydraulic systems would have been twofold: with the wire in the broken state, the auxiliary hydraulic system could not have been selected OFF by either pilot; if the wire broke after the auxiliary hydraulic system had been selected OFF, the hydraulic system would have been automatically restored to ON. The wire did not have an effect on the operation of the primary hydraulic system itself. Both pressure switches were examined and tested for specification conformance and functionality; both units were unremarkable. The surviving pilot did not recall any unusual indications or abnormal operation of either hydraulic system before or during the accident flight.

The automatic flight control system (AFCS) and associated controls were examined at the TSB Engineering Branch laboratory. No pre-existing mechanical or electrical defect was found. The AFCS was not functioning at the time of the accident, since it had been purposely selected OFF by the pilot-in-command at the beginning of the series of the cyclic pitch control difficulties, and had not been re-engaged. No evidence of intermittent or uncommanded AFCS input was found, and the surviving pilot reported no incidence of autopilot involvement during the control upsets. The AFCS system is thus not considered to have been a factor in the loss of control.

The S-61N was powered by two General Electric (GE) CT58-140-1 gas-turbine engines. An examination of the engines, the engine mounts, the controls and accessories, the throttles, and the airframe high speed shafts,

² "Cyclic" in this context means repetitive motion; not to be confused with the cyclic control.

revealed no evidence of any malfunction, defect, or anomaly. Fuel samples taken from the helicopter after the accident were tested for contamination; none was found. The engine inspection revealed minor damage to both engines resulting from the impact, but no condition was found that would have prevented the normal operation of either engine. Coupled with the evidence from witnesses at the accident site and the surviving pilot, the engines are not considered to have contributed to the loss of control.

Analysis

The investigation into this accident included examination of environmental, technical, human, and operational factors, and an in-depth examination of the mechanical aspects of this helicopter, its component parts, and their service life and history. Extensive examination and testing to date have not found any anomaly or defect that is likely to have contributed to, or caused, the nose-down attitude change on the day of the accident.

Although it could not be determined in the case of the co-pilot, it is likely that neither pilot was wearing his shoulder harness. Accident investigation and research carried out by the TSB has consistently shown that the use of the shoulder harness portion of the seat restraint system is effective in reducing or preventing injury during moderate impact forces. While it is unknown if the use of the shoulder harness in this particular accident would have prevented or lessened the co-pilot's fatal injuries, the situation where the left pilot seat shoulder harness was essentially unavailable, is cause for concern. Given that vertical reference flying necessitates upper-body freedom of movement, the universal dismissal of the shoulder harness, in its present configuration, is almost inevitable. However, the practice of restricting the shoulder straps in some manner prevents the pilot from gaining immediate access to them in the event of an emergency. Furthermore, it is likely that the regular non-use of the shoulder harness will diminish the pilot's awareness of its safety advantages, and at the same time reinforce a less-than-ideal safety practice.

The following TSB Engineering Branch reports were completed:

- LP 71 /97 - Hydraulic Fluid Examination
- LP 105/97 - Trim Diode Adapter Examination
- LP 107/97 - "D"-pin Connection Failure Examination
- LP 120/97 - Seat Belt Examination

The following additional engineering examinations were completed:

- CT58-140-1 engines examination - GE Aircraft Engines
- Primary and Auxiliary hydraulic components examination - HASC
- X-ray examination of the hydraulic servos and manifolds - Bacon Donaldson
- Flight Controls examination - Sikorsky Aircraft Corporation

- Main rotor swash plate examination - Sikorsky Aircraft Corporation
- Main rotor head spindle bearings examination - ACRO Aerospace
- Main rotor head examination - HeliPro
- Hydraulic pumps (2) test and examination - Columbia Helicopters

Findings

1. The pilots were licenced and qualified in accordance with existing regulations.
2. Records indicate that the helicopter was certificated, equipped, and maintained in accordance with existing regulations and approved procedures.
3. No indication was found of any malfunction or pre-existing mechanical defect with the helicopter, its engines, or its systems, that could have contributed to the accident.
4. The helicopter's weight and centre of gravity were within certificated limits.
5. Neither weather conditions nor operating environment were factors in the accident.
6. The uncommanded nose-down attitude change and loss of rearward cyclic pitch control occurred for undetermined reasons.
7. The pilots were unable to prevent the helicopter from pitching nose-down.
8. Immediately before striking the trees, the helicopter reached a nose-down attitude at a height from which it was impossible for the pilots to recover.

Causes and Contributing Factors

The pilots experienced a loss of rearward cyclic pitch control, at a height from which they could not recover before striking the ground. The reason for this loss of control could not be determined.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 15 April 1999.