AVIATION INVESTIGATION REPORT
A02O0105

LOSS OF CONTROL AND COLLISION WITH TERRAIN

SILVERLINE HELICOPTERS INC.
SCHWEIZER 269C (300C) C-GGUV
SU34 HARE FIELD, ONTARIO
18 APRIL 2002

Aviation Investigation Report

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Summary

The Schweizer 269C (300C) helicopter, registration C-GGUV, serial number S1806, was being flown by an instructor and a student pilot at Hare Field, approximately 15 nautical miles northwest of the Toronto/Buttonville Municipal airport in Ontario. They were on a training flight to practice autorotations with power-on recoveries in preparation for a flight test that was scheduled for the following week. After flying three uneventful straight-in autorotations, the student pilot entered a 360° autorotation from a height of approximately 800 feet over the airfield. By half-way around the 360° turn, the airspeed was abnormally low, the rate of turn was slow, and the rate of descent was abnormally high.

The instructor took control at a height of about 200 feet and attempted to recover the autorotation. At that moment the airspeed was approximately 25 knots indicated and rotor speed was about 400 rpm. He lowered the nose to regain airspeed, then raised the nose as the helicopter approached the ground, but he did not consciously attempt to add power or bring in collective. The helicopter landed hard, striking on relatively soft turf in a slightly nose-up attitude. The heels of the skids struck first, causing them to spread. The helicopter then rolled forward and to the left, coming to rest inverted. It suffered substantial damage. The pilots received only minor injuries. There was no post-crash fire.

Ce rapport est également disponible en français.

Other Factual Information

Silverline Helicopters Inc. is the operator of Hare Field, the location of the accident. Field elevation is 850 feet above mean sea level (msl). There are two unlicenced turf runways, 06/24 and 03/21 and a licenced heliport[1]. The circuit altitude for helicopters is 1500 to 1600 feet msl, a height of 650 to 750 feet above ground level (agl)[2], an altitude adopted in consideration of neighbouring property owners and local terrain. There are no written standard operating procedures (SOPs) covering airfield procedures.

Silverline Helicopters Inc. is a flight training unit operating under Part IV of the *Canadian Aviation Regulations* (CARs). The syllabus for the flight training program is set out in the Company Flight Training Operational Directives as required by the CARs[3]. The CARs require flight training to be carried out "in accordance with the applicable flight instructor guide and flight training manual or equivalent document . . . ."[4]. The flight training manual[5] is not presently available through Transport Canada (TC), but it will be available on the TC web site in the near future. The flight training manual is available from commercial sources and is used by Silverline Helicopters. The company does not have additional written SOPs for training syllabus exercises.

The helicopter involved in the accident had been acquired new by Silverline in 2000. At the time of the accident, it had approximately 200 hours total time and records indicate that it had been maintained in accordance with regulations. There was no indication of any pre-existing mechanical failure or other condition of the helicopter that would have contributed to this accident.

The instructor pilot on the accident flight had a commercial pilot - helicopter licence for just over two years and had approximately 800 hours of helicopter experience. He had a class IV instructor rating for one year and had recently started instructing at Silverline. The student pilot was to be the first student to be recommended by him for a flight test.

The student pilot had a student pilot permit - helicopter and approximately 80 hours of helicopter flight time, all acquired during training at Silverline in the previous six months. The student had started his instruction with a different instructor, and 360° autorotations had been taught by the previous instructor. These had all been entered at 1000 feet agl or higher.

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1 Listed in the *Canada Flight Supplement* aerodrome/facility directory as CHL2, Holland Landing (Silverline Helicopters) ON (Heli).

2 Throughout this report, "altitude" is measured from mean sea level (msl) and "height" is measured above ground level (agl).

3 *Canadian Aviation Regulations*, Part IV - Personnel Licensing and Training, Section 405.12 - Flight Training Program Approval.

4 *Canadian Aviation Regulations*, Part IV - Personnel Licensing and Training, Section 405.14 - Flight Training Program Requirements.

5 Transport Canada, *Helicopter Flight Training Manual*, January 1993 (TP 9982E).

In the flight training manual, the 360° autorotation is part of exercise 18, autorotations (range variations). It indicates that turns of 90°, 180°, or 360° may be used to reach a selected touchdown spot and that rates of descent in tight-turning autorotations can reach more than 2500 feet per minute (fpm) in some types of helicopters. Speed reduction is an alternative method of reducing range. A chart shows a typical rate of descent of 2500-3000 fpm at 25 KIAS compared with a minimum of about 1600 fpm at about 55 KIAS. The flight training manual contains no guidance as to the height required to safely accomplish or practice these types of autorotation. It advises to abide by the height-velocity chart (which is presented in an earlier exercise on transitions) of the helicopter being flown and to regain the minimum rate of descent airspeed by 200 feet agl in order to establish a normal autorotational touchdown profile. It provides a rule of thumb that 100 feet of altitude is required for every 10 knots of airspeed to be regained.

The Transport Canada *Flight Instructor Guide – Helicopter*[6], suggests an entry altitude of 1500 feet agl to demonstrate the effect of speed variations to reduce or extend range in autorotations. There is no specific guidance as to minimum height for carrying out autorotations. It advises that airspeed should be increased to the minimum rate-of-descent speed before entering the shaded area of the height-velocity chart.

The standards for helicopter flight tests for private and commercial licences[7] require the candidate to carry out two types of autorotations, one of which will include a 180° turn. It calls for entry at a safe height but not lower than 500 feet agl. There is no specific mention of a 360° autorotation.

The *Designated Flight Test Examiner Manual*[8] states that an engine failure should be simulated "from a minimum of 1500 feet above ground, but can be lower". It also indicates that autorotations usually consist of one straight-in and one 180° initiated at a safe height but in no instance less than 500 feet agl.

The aircraft flight manual[9] emergency procedures for autorotation call for a glide speed of 52 KIAS until initiating the flare at 50 feet agl. The normal procedures for practice autorotation contain a warning to avoid airspeed and altitude combinations that are inside the height-velocity curve **during power recovery**. The height-velocity chart (Appendix A) states that operation is to be avoided in the shaded area, which is below 55 KIAS at 150 feet agl, and 50 KIAS at 200 feet agl, decreasing linearly to zero airspeed at 450 feet.

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6 Transport Canada, *Flight Instructor Guide - Helicopter*, 1995 (TP 4818E)

7 Transport Canada, *Flight Test Standards - Private and Commercial Licence – Helicopter*, sixth edition, March 1998 (TP 3077E).

8 Transport Canada, *Designated Flight Test Examiner Manual*, first edition, January 1998 (TP 2654E).

9 Schweizer Aircraft Corp., *Model 269C Helicopter - Pilot's Flight Manual,* dated 21 September 1988

The occurrence flight was intended to be a brushup of the student's autorotations but was not a pre-test flight. There were no new exercises that would require a formal briefing. Consequently the briefing was abbreviated, covering only what was to be done, not how. Such a briefing is not considered abnormal under the circumstances.

Weather at the time of the flight was good visual meteorological conditions (VMC). The surface wind was southwesterly at 5 to 10 knots with gusts in the vicinity reported as high as 20 knots. Winds at circuit height were a bit stronger.

After taking off at about 1245 eastern daylight time (EDT)[10], the student performed three straight ahead autorotations from just above circuit altitude of 1500 feet msl before commencing the 360° autorotation. The student allowed the altitude to climb to 1600 or 1700 feet before entering the 360° autorotation.

Initial entry into the autorotation was normal. By the 180° point, the autorotation was not progressing ideally, but the instructor decided not to intervene because intervention by an examiner would constitute failure on a flight test. The student believed that the instructor would take control when and where required to accomplish the learning objective and continued the exercise.

When he took control, the instructor doubted that a power recovery was feasible from that flight condition. Therefore he continued with the autorotation, intending a power recovery in the flare. He aggressively lowered the nose to a steep nose-down attitude, then almost immediately raised the nose using cyclic in order to land flat. He did not introduce power or raise the collective.

Personnel on the airfield responded to assist in the rescue. The instructor and student were both taken to hospital, treated and released. The student, who was not wearing a helmet, was treated for minor facial cuts. The instructor was wearing a helmet which was undamaged except for some superficial scratches.

Analysis

The environmental conditions at the time of the accident were favourable for safe completion of the flight. Both pilots were familiar with the exercises to be performed during the flight. However, two main elements combined to create a significant risk: expectancy on the part of both the instructor and the student pilot, and ambiguous guidance in the reference material.

Although no new exercises were to be introduced during the occurrence flight, the instructor and student had not flown 360° autorotations together. The instructor was unaware that the student had been taught 360° autorotations using a minimum entry altitude of 1000 feet agl. A thorough briefing would have uncovered this fact and the instructor could have discussed the differences and additional challenges of starting a 360° autorotation from a circuit altitude of 650 to 750 feet agl.

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[10] All times are EDT (Coordinated Universal Time minus four hours).

A thorough briefing would also have given the instructor the opportunity to articulate his expectations to the student before the flight. There was no discussion regarding recognition and correction of errors, and the student, therefore, relied on the instructor to take control at an appropriate time, an expectation that was consistent with the practice throughout his training.

Contributing to the differences in expectation as to entry altitude is lack of guidance in the reference material:

- The *Flight Training Manual – Helicopter* contains no guidance as to safe entry altitude for autorotations. It presents rate of descent, but not height loss information for 180° and 360° autorotations;

- The *Flight Instructor Guide* has guidance as to altitude for demonstrating the effect of speed on range, but no guidance as to safe height required for 360° autorotations;

- The standards for helicopter flight tests call for entry at a safe height but not lower than 500 feet agl, and only mention 180° autorotations, not 360° autorotations;

- The *Designated Flight Test Examiner Manual* calls for "a minimum of 1500 feet above ground, but can be lower" for a simulated engine failure. It also identifies a minimum of 500 feet agl for a 180° autorotation.

The situation for the student was set up by starting the 360° autorotation at a lower altitude than he had previously experienced. This gave him less time than he expected to carry out the manoeuvre. From the lower altitude, a rate of turn that previously produced acceptable results would be too slow. Turning downwind, he did not immediately realize that his airspeed was slow. The tailwind in excess of 10 knots likely contributed to an illusion of a higher speed. The student lacked the experience to recognize the development of the unsafe condition. It was only after prompting from the instructor that he realized that he was failing to deal adequately with the situation. Even then, he expected the instructor to take control, if necessary, essentially relying on the instructor's judgment, not his own, to determine when the situation became dangerous. He never contemplated aborting the manoeuvre and setting up for another attempt.

The instructor's expectation was that the student would handle the 360° autorotation proficiently and with minor errors. Since the flight was a review, he expected the student to recognise and correct errors. This expectancy led him to allow the unsafe situation to develop without adequate corrective action being taken. When he took control at 200 feet agl and 25 KIAS, the helicopter was already 250 feet lower than would be advised by the flight training manual and the flight instructor guide for the speed they were at in order to establish the conditions necessary for a proper autorotative flare. He had the choice of aborting the autorotation by applying power and flying away, or attempting to recover the autorotation from a point well inside the shaded area of the height-velocity chart and carrying out the flare and power recovery. At the time, he did not think that a power recovery was feasible from that position, so he elected to attempt to recover the autorotation.

To the instructor, there was ambiguity between guidance to avoid operation within the shaded area of the height-velocity chart versus the widespread practice of operating helicopters in that regime when carrying out operations such as slinging, logging, and hydro patrols. He was uncertain as to the risk associated with operations within the shaded area of the height-velocity chart. The Schweizer 269C helicopter was certified under part 6 of the U.S. *Civil Air Regulations* (CAR Part 6)[11], which require that a limiting height-speed envelope be established and included in the rotorcraft flight manual. The envelope is defined, for single-engine helicopters, as those combinations of height and speed (including zero) from which it is not possible to make a safe full autorotation landing following power failure[12]. This remains a requirement in *Federal Aviation Regulations* Part 27 (FAR 27)[13], the successor to CAR Part 6 and currently applicable to new designs. The FAA *Basic Helicopter Handbook*[14] reflects the CAR Part 6 and FAR 27 definitions, stating that a helicopter pilot must be familiar with the height-velocity chart for his helicopter:

> From it, he is able to determine at what altitudes and airspeeds he can safely make an autorotative landing in case of an engine failure; or, to restate it another way, he is able to determine those altitude-airspeed combinations from which it would be nearly impossible to successfully complete an autorotation landing.

Documents that are applicable to flight training in Canada are ambiguous as to the relevance and applicability of the height-velocity diagram:

- The *Helicopter Flight Training Manual* presents the height-velocity chart in the section on transitions. It does not explain how it is developed or define what the shaded area means. With respect to autorotations, it advises, without explanation, "to abide by the height-velocity chart when performing autorotations". The section on sling load operations does not acknowledge that hovering with a sling load is in the shaded area, nor does it mention that in the paragraph on safety precautions.

- The *Flight Instructor Guide – Helicopter* cites the height-velocity chart as a reference in exercise 13, autorotation 2, but provides no further explanation. In exercise 18, autorotation 3, pertaining to range variation, it advises to acquire the minimum rate of descent speed "before entering the shaded area of the height-velocity chart".

- Neither the flight training manual nor the flight instructor guide address recognition of or recovery from the "avoid" areas of the height-velocity chart during practice autorotations, including the use of power.

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11 Title 14 - Civil Aviation, Chapter 1 - Civil Aeronautics Board, Subchapter A - *Civil Air Regulations*, Part 6 - Rotorcraft Airworthiness; Normal Category, as amended to 20 December 1956.

12 CAR Part 6, section 6.715, Limiting height-speed envelope.

13 *Federal Aviation Regulations* Part 27, Airworthiness Standards, Normal Category Rotorcraft, section 27.79, Limiting height-speed envelope.

14 Federal Aviation Agency Advisory Circular AC 61-13, *Basic Helicopter Handbook*, dated 1965. The most recent version of this handbook, FAA-H-8083-21, *Rotorcraft Flying Handbook*, dated 2000, contains similar language but notes that the height-velocity diagram does not apply to autorotations. It states that autorotations at very low airspeed are more critical because they require a greater amount of rotor energy to stop the high rate of descent; however it provides no specific guidance as to what altitude-airspeed combinations are unsafe.

- The height-velocity chart in the performance section of the aircraft flight manual indicates to "avoid operation in cross-hatched areas". The procedure for practice autorotations in the flight manual has a warning **during power recovery** to avoid the shaded areas of the height-velocity chart and that high rates of descent may develop that are not controllable. It is silent as to autorotative flight in or through the shaded area. This could be interpreted wrongly as advice against attempting a power recovery from within the shaded area of the chart. The addition of power and up-collective even within the shaded area would certainly have added to the total energy of the helicopter, reduced the rate of descent, given more time for the instructor to act, and reduced the severity of the touchdown if not completely averting it.

The instructor's doubt that adding power would allow him to fly away, together with his tacit acceptance that flight within the shaded area of the height-velocity chart was a normal and acceptable facet of helicopter operations, led him to continue with the autorotation with the expectation of success despite the critical nature of the situation. This effectively blocked reassessment of the situation or reconsideration of the better option of applying power and up-collective to abandon the autorotation. Had the instructor and student planned for such a contingency during the preflight briefing, the instructor would have been better prepared to make an appropriate decision.

Findings as to Causes and Contributing Factors

1. The flight was conducted following a briefing that lacked a detailed discussion of procedures or planning for contingencies. Therefore, the student and the instructor had different expectations, which allowed a dangerous situation to develop and continue beyond the point of safe recovery before corrective action was taken.

2. The 360° autorotation was initiated at a height lower than the student had previously experienced and too low to provide an adequate margin for error or to achieve learning objectives.

3. The student allowed the airspeed to decay and failed to recognize the danger inherent in the situation. He relied on the instructor to identify and respond to the situation if it became unsafe and as a result, failed to take corrective action to avoid the unsafe situation.

4. The instructor allowed the helicopter's speed and height to reach a state from which, according to the height-velocity chart, a safe autorotative landing was unlikely.

5. The instructor intervened after a safe recovery was not assured and made an inappropriate decision to continue the autorotation, doubting that power recovery was feasible. As a result, he was unable to arrest the rate of descent before the helicopter struck the terrain.

Findings as to Risk

1. The Transport Canada guidance material, including the *Helicopter Flight Training Manual*, *Flight Instructor Guide – Helicopter*, flight test standards, and *Designated Flight Test Examiner Manual*, contains ambiguous and conflicting guidance as to what constitutes a safe entry height for the various autorotative landings, increasing the likelihood of autorotations being initiated from heights that offer inadequate defence against errors in execution.

2. Transport Canada reference material is ambiguous and incomplete in its treatment of the height-velocity chart. The *Helicopter Flight Training Manual* does not explain the significance of the height-velocity chart nor identify it as a risk that needs to be managed. The *Flight Instructor Guide – Helicopter* refers to the height-velocity chart without an explanation of why.

3. Transport Canada reference material contains no discussion as to appropriate means for pilots to avoid or recover from dangerous situations during autorotation training exercises.

Other Findings

1. The company had no written standard operating procedures (SOPs) on autorotation initiation altitudes.

2. The helicopter flight manual indicates that entry into the shaded area of the height-velocity chart is a particular problem when carrying out a power recovery.

3. *Canadian Aviation Regulations* (CARs) refer to a flight training manual (FTM) but no FTM is available from Transport Canada.

4. The pilot not wearing a helmet received minor cuts to the face whereas the pilot wearing a helmet had no cuts.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 19 May 2003.

*Visit the Transportation Safety Board's Web site (**www.tsb.gc.ca**) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.*

Appendix A – Schweizer 269C Height-Velocity Diagram

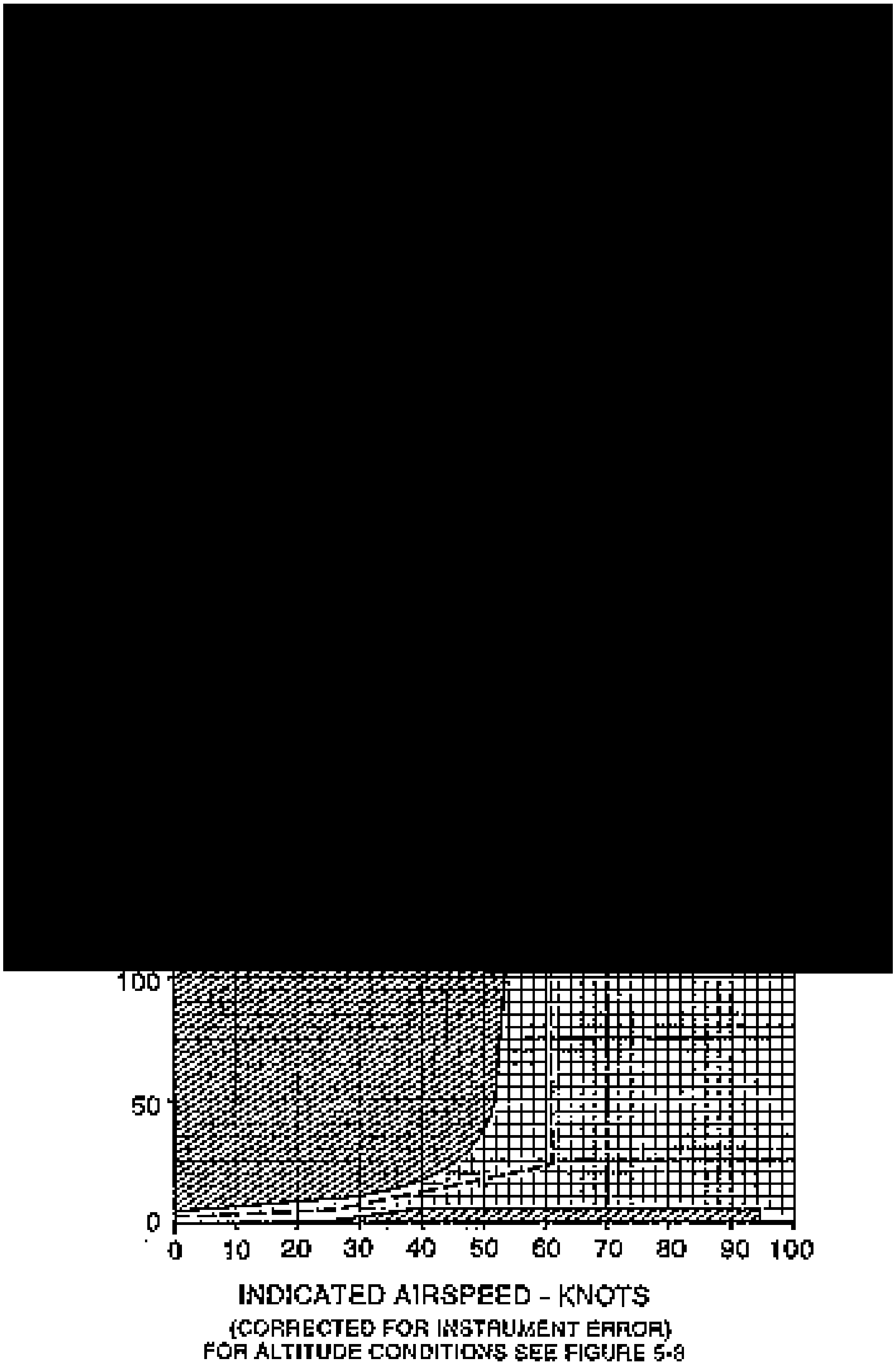

Figure 5-2. Height Velocity Diagram at Sea Level