THE DUTCH SAFETY BOARD

HARD LANDING DURING AUTOROTATION TRAINING

The aim in the Netherlands is to reduce the risk of accidents and incidents as much as possible. If accidents or near-accidents nevertheless occur, a thorough investigation into the causes of the problem, irrespective of who is to blame for it, may help to prevent similar problems from occurring in the future. It is important to ensure that the investigation is carried out independently from the parties involved. This is why the Dutch Safety Board itself selects the issues it wishes to investigate, mindful of citizens' position of dependence with respect to public authorities and businesses. In some cases, the Dutch Safety Board is required by law to conduct an investigation.

GENERAL INFORMATION

Identification number:	2011061
Classification:	Accident
Date, time[1] of occurrence:	31 July 2011, 11.27 hours
Location of occurrence:	Lelystad Airport (EHLE)
Aircraft registration:	PH-WTW
Aircraft model:	Guimbal Cabri G2
Type of aircraft:	Helicopter
Type of flight:	Training flight
Phase of operation:	Landing
Damage to aircraft:	Severe
Cockpit crew:	Two
Passengers:	None
Injuries:	None
Other damage:	None
Lighting conditions:	Daylight

SUMMARY

During the execution of the final part of an autorotation[2] landing at Lelystad Airport, the main rotor blades struck the tail boom, causing a broken boom, a bent tail rotor driveshaft and a disintegrated tail rotor. Both crewmembers suffered no injuries.

[1] All times in this report are local times, unless otherwise specified.

[2] Autorotation is the state of flight where the main rotor system of a helicopter is being turned by the action of air moving up through the rotor rather than engine power driving the rotor.

FACTUAL INFORMATION

The flight

On the day of the accident two instruction flights were planned with the PH-WTW. Two persons were on board, an instructor and a pilot. The flights were executed according to the Flight Training Organisation (FTO) training manual. The pilot was trained to get a Guimbal Cabri G2 type rating on his pilot licence. The first flight lasted about thirty minutes and consisted of normal landings and one autorotation landing. After refuelling the PH-WTW took off for the second series of training exercises. After flying three circuits, the pilot performed an autorotation landing which was uneventful. After climbing to 1000 feet the next challenge was another autorotation landing in area III (see figure 1).

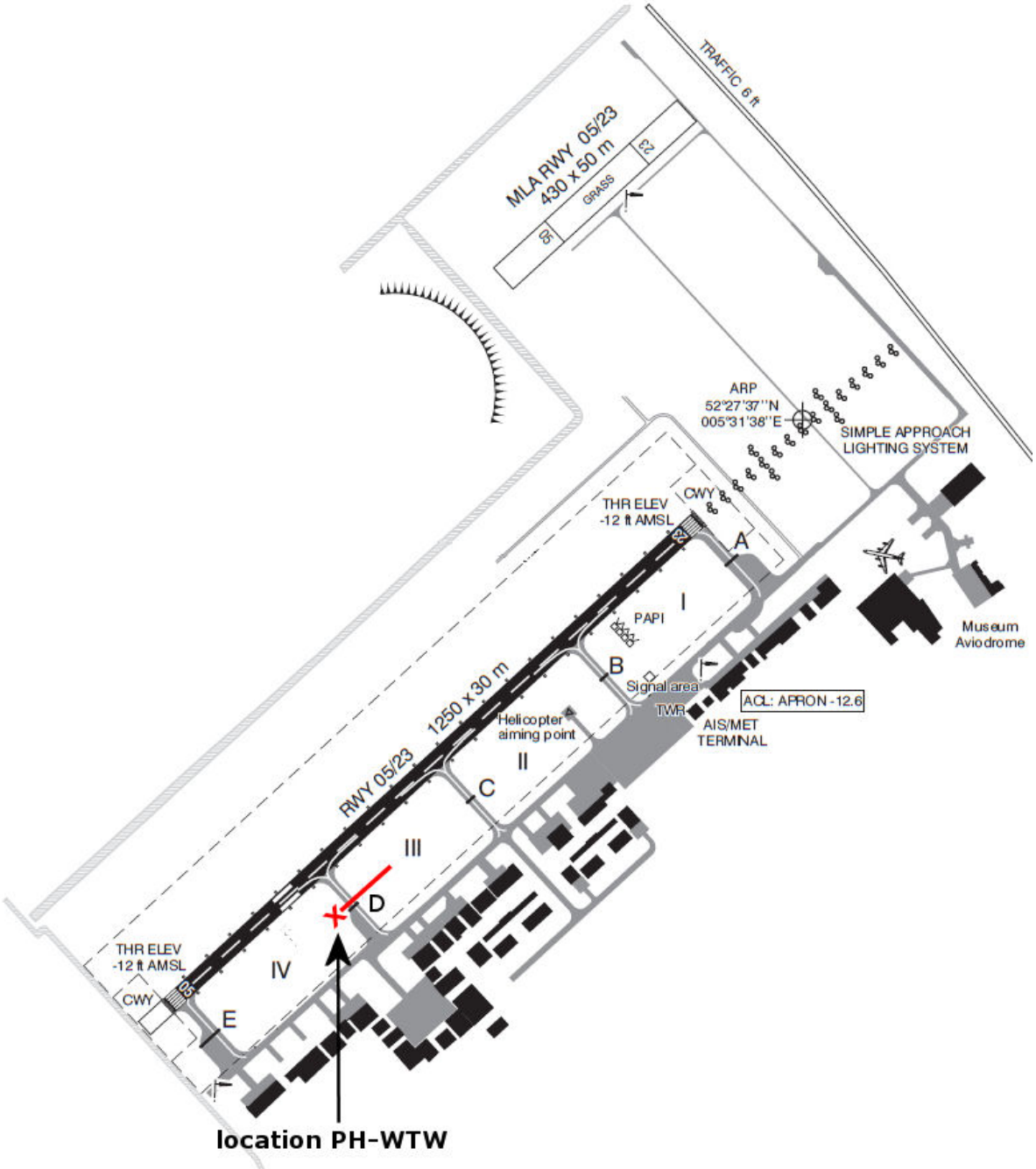

Figure 1: Lelystad Airport (source: AIP Netherlands)

The instructor set the throttle to idle, the pilot lowered the collective[3] and decreased the airspeed to the speed used for autorotation. During descent, shortly before landing, the instructor realised that the intended landing spot would be over flown and announced that it was better to perform a power recovery.[4] At a height of about 10 feet over taxiway D, throttle was increased while the pilot started the flare by pulling the collective. Next the helicopter hit the ground and the crewmembers heard a loud bang from behind and observed pieces of debris flying around. The helicopter bounced back into the air and came to a standstill a few meters away from the initial impact point. The main rotor was still turning and the pilot used the rotor brake switch to slow down the rotor, but there was no response. The engine was still running and the main rotor stopped turning some time after switching off the engine. Both occupants left the helicopter without injuries. The helicopter's tail boom was found broken and the tail rotor had disintegrated.

Figure 2: PH-WTW after the accident

The crew

The crew of the PH-WTW consisted of an instructor of 65 years of age and a pilot of 48. The instructor possessed a valid pilot licence to operate the flight. His Commercial Pilot Licence (CPL(H)) was valid until 9 June 2014 and his medical certificate, class 1, until 11 December 2011.

Number of hours total	8364
Number of hours on type	151
On type last three months	39

Table 1: flying experience instructor

The pilot possessed a Commercial Pilot Licence (CPL(H)) which was valid until 19 June 2016. His medical certificate, class 1, was valid until 19 October 2011.

Number of hours total	1292
Number of hours on type	9
Number of hours last three months	34

Table 2: flying experience pilot

[3] The collective controls the movement in the vertical plane.
[4] Power recovery is a manoeuvre where engine power is used to maintain rotor speed.

The helicopter
The helicopter is single engine (piston) powered, and has two seats. It is equipped with a fully-articulated[5], three-bladed rotor system and a Fenestron[6] type tail rotor.

The weather
The weather information was received from the Royal Netherlands Meteorological Institute (KNMI). At the accident location visual meteorological conditions prevailed. Visibility was more than 10 kilometres and there was no precipitation. It was partly cloudy with some cumulus clouds around 3000 feet. The wind was westerly with a speed of 4 knots.

INVESTIGATION AND ANALYSIS

Technical investigation
The technical investigation was performed with assistance of an expert of the helicopter manufacturer. The landing site was explored and the witness marks in the ground were measured and investigated to reconstruct the landing. The marks in the grass indicated that the first ground contact was hard with the helicopter slightly nose down and slightly banked to the left. After bouncing up, the second ground contact a few meters further was smooth.

Engine
The fuel filter, air filter and spark plugs were checked and found in good condition. The fuel in the fuel filter was of the approved type (AVGAS). The electronic fuel quantity gauge displayed 61 liters. The parameter status page on the electronic display showed a fault in the oil pressure parameter. The engine was run without rotor engagement and was subjected to some limited acceleration tests. No engine problems were found. The helicopter is equipped with an automatic carburetor heat system to prevent carburetor icing. After the accident the switch in the cockpit was found in the correct (AUTO) position. The automatic system was checked and found serviceable.

Main rotor and tail rotor
The main and tail rotor controls were checked. No indications for a pre accident malfunction were found. The tail boom was cut off by two of the three rotor blades. The first blade that hit the boom penetrated 20 mm into the boom skin, clearing the tail rotor driveshaft. The absence of any mark on the blade's paint aft of the steel leading edge proved that the tip pitch was close to zero at impact. The next blade penetrated 40 mm into the boom and hit the tail rotor driveshaft (see figure 2). The blade tip shows dents in the stainless steel cap which match with the tail rotor driveshaft damage. Since the structure and paint of the blade tip was intact, it confirmed the strong down-bending during the impact of the blade.

A flexible coupling connects an engine driven pulley to the tail rotor driveshaft. One side of the flexible coupling is connected to the pulley by external splines while the other side of the flexible coupling is welded to the tail rotor driveshaft. After the tail rotor driveshaft was hit and bent by the main rotor blades, the front part of the shaft moved backwards (see figure 3). Because the splines allow axial movement (see figure 4) and the rear part of the shaft is attached to the tail rotor gear box, the flexible coupling was pulled out of the pulley. When the tail rotor shaft with the coupling moved further backwards, the coupling became stuck at a cross bar of the airframe. Due to high forces the flexible coupling got bent and finally broke off near the weld (see figure 4). The coupling was catapulted into the airframe cowling (see figure 5).

The rear end of the tail rotor drive shaft is connected rigidly to the tail rotor gearbox with no sliding coupling. The tail rotor had disintegrated as a result of a pulling force of the drive shaft on the tail

[5] In a fully-articulated rotor system, the blades are attached to the rotor hub by hinges or elastomeric and are allowed to move independently of each other.
[6] A Fenestron (or fantail, sometimes called "fan-in-fin") is a shrouded tail rotor.

rotor gearbox in combination with high inertial forces on the tail blades created by the sudden jamming of the drive shaft. There are no indications that the tail struck the ground in flight. The observed damage on the tail skid had occurred when the tail fell on the ground after the tail boom was cut.

According to the helicopter manufacturer the rotor blades can only hit the tail boom at very low rotor speed (or rotor RPM) and a high vertical deceleration.

Figure 3: damaged tail and -tail rotor driveshaft

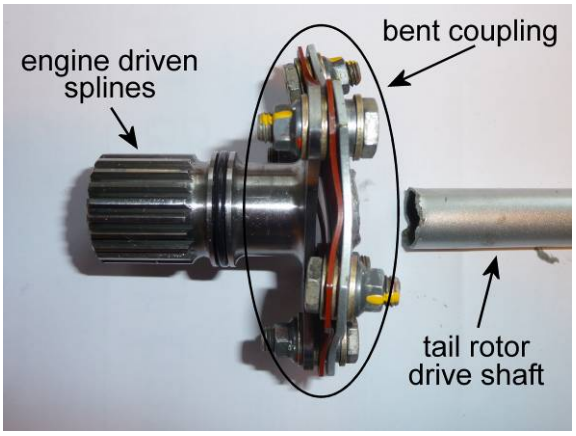

Figure 4: flexible coupling

Figure 5: coupling stuck in airframe cowling

Figure 6: engine driven pully with bent coupling

Sequence of events

Under supervision of the instructor, the pilot was performing the third autorotation practice of the day. The aim was to land in area III, between taxiways C and D, parallel to runway 23. During the final phase of the descent the instructor realised that the intended landing spot would be over flown. Since the concrete taxiway is substantially higher than the landing areas, there is a risk of a roll over of the helicopter when the edge of the taxiway is hit with forward speed. Because of the risk of landing close to the taxiway the instructor announced that it was better to perform a power recovery. The pilot flying replied *"OK".* However, there was no clear communication by the instructor regarding the transfer of the pilot flying tasks by a clear command like "my controls." Consequently, both pilots were flying the aircraft. By doing so it was unclear for both crewmembers if counteracting forces on the controls were a result of the aerodynamic loads on the aircraft or from inputs made by the other crewmember. Both crewmembers stated that the instructor opened the throttle (which is standard procedure during autorotation training) after his remark about the power recovery. It could not be verified when and how far the throttle was opened. However, the damage assessment indicated that the helicopter touched with low rotor RPM. The helicopter is equipped with an audible low rotor RPM warning. Both crewmembers stated that they did not hear the low rotor RPM warning. The low rotor RPM warning horn was tested after the accident and was found to be in serviceable condition. Due to the extent of the damage it was not possible to check

the RPM at which the warning horn is triggered. No visible damage was found on the rotor head and transmission. It cannot be excluded that this warning system had failed, however it is not uncommon that crewmembers do not remember audible warnings that sounded during fast-changing, high-workload and stress situations.

The helicopter had over flown area III and was at a height of about 10 feet over taxiway D heading for area IV. The helicopter overflew taxiway D and came hard in contact with the ground (grass) of area IV in a slightly nose down and low forward sliding motion. Considering the phase of flight and attitude of the helicopter, cyclic[7] pitch was neutral-to-rear. Due to the impact, the arm's inertia of the crewmembers lowered the collective instantaneously. The combination of low rotor RPM, impact inertia, abrupt lowering of the collective pitch and neutral-to-rear cyclic pitch, caused the blades to cut off the tail boom. The helicopter finally bounced back in the air once and came to a standstill thereafter.

CONCLUSIONS

The accident was a result of non optimal coordination between the instructor and the pilot.

- The helicopter made a hard landing with low rotor speed.
- The combination of low rotor RPM, high load factor, abrupt lowering of the collective pitch and neutral-to-rear cyclic pitch, resulted in the separation of the tail by the main rotor blades.
- No indications of a pre accident technical malfunction of the power- and rotor system were found.

This report has been published in Dutch and English language. If there are differences in interpretation the Dutch text prevails.

[7] The cyclic controls the movement in the horizontal plane.