CANADIAN FORCES
FLIGHT SAFETY INVESTIGATION REPORT (FSIR)

FINAL REPORT

FILE NUMBER: 1010-CH146475 (DFS 2-4)
DATE OF REPORT: 12 January 2006

AIRCRAFT TYPE: CH146 - Griffon
DATE/TIME: 171443Z September 2003
LOCATION: 5 Wing Goose Bay, Labrador, Newfoundland
CATEGORY: “B” Category Accident

SYNOPSIS

On 17 September 2003 the crew of Griffon 146475 was conducting Stokes litter hoist training within the boundaries of 5 Wing Goose Bay. This training involves transferring a simulated patient from the ground to the aircraft while the aircraft is in a 50 foot hover. At the time of the accident the crew onboard the helicopter consisted of two Pilots, and two Flight Engineers – one of which was under training. As well, there was a Search and Rescue Technician on the ground. During Stokes litter hoisting, the flight engineer operates the hoist, except for the final recovery of the litter into the aircraft. At this point, control of the hoist is transferred to the non-flying pilot. This allows the flight engineer to manage the litter with both hands while the non-flying pilot operates the hoist. In this accident, control of the hoist had just been transferred from the flight engineer to the non-flying pilot when the aircraft began to sink and yaw to the right. The flying pilot initiated actions for a suspected tail rotor failure that included rolling both throttles to idle. The aircraft landed in a flat attitude and suffered “B” category damage. All of the crewmembers on board the aircraft suffered injuries due to ground impact forces (1 major and 3 minor injuries).

TABLE OF CONTENTS

1. FACTUAL INFORMATION

1.1 History of the Flight

On 17 September 2003 the crew of Griffon CH146475 was scheduled to conduct a local flight which included ”Stokes” litter transfer training. “Stokes” litter training involves lowering and recovering a “Stokes” litter from a hovering helicopter. The crew consisted of two Pilots, one Search and Rescue Technician (SAR Tech) and two Flight Engineers (FEs) – one of which was under training. Pre-flight preparation was normal, however, departure was delayed approximately 40 minutes due to an unrelated snag. At approximately 1316(Z) the aircraft departed from 444 Combat Support (CS) Squadron ramp. The crew initially conducted local flying in order to burn fuel and reduce the weight of the aircraft in preparation for the “Stokes” litter hoisting. When the required weight was reached the crew returned to the “Webber Drop Zone”, a flat sandy area inside the boundaries of 5 Wing Goose Bay. They then conducted a confined area landing to drop off the SAR Tech and trainee FE. The first “Stokes” litter drop and recovery was conducted with the trainee FE on the ground. After this sequence was completed the aircraft landed to pick up the FE on the ground. The intent was to repeat the sequence with the trainee FE on board the aircraft.

The second recovery of the “Stokes” litter was conducted in an “out-of-ground-effect” (OGE) hover at about 50 feet above ground level (AGL). The SAR Tech was on the ground to stabilize the line attached to the litter. The litter was in the full up position when the FE requested “Pilot override out”. The “Pilot override out” is the request by the crewman for a pilot to use the hoist override switch, located on the right collective, to pay out hoist cable. This allows the FE to use both hands to recover the litter into the aircraft as the cable pays out. Within seconds of the crewman’s request, the flying pilot noted the aircraft sinking and yawing to the right. The attempt to control the sinking with collective did not appear to be effective and the flying pilot called “Power loss, power loss”, and simultaneously rolled off both engine throttles in response to the perception that a “Tail Rotor loss” had occurred. Without power to the rotor, the aircraft descended rapidly and the pilot moved the aircraft to the left and forward to avoid the SAR Tech on the ground. Despite full collective application as the ground approached, the aircraft impacted the ground causing severe damage and threw the two rear crewmembers to the floor of the cabin.

With the aircraft on the ground the flying pilot moved the throttles to off, then pulled the “T” handles for both engines to ensure fuel flow to the engines was stopped. The rotor brake was used to stop the rotor. A “mayday” was transmitted to the tower that was acknowledged and then the battery switch was turned off. The battery switch was later turned on momentarily to turn the generators and inverters off before the battery was again secured.

The pilots and the SAR Tech on the ground responded to the injured crewmembers.

At 1520Z, rescue and medical personnel from 5 Wing were transported to the accident scene by a second CH146. Shortly thereafter the ground emergency response team arrived and secured the crash scene. The Rescue CH146 transferred the severely injured crewmember to the Goose Bay hospital, while surface vehicles transferred the personnel with minor injuries.

1.2 Injuries to Personnel

	Crew	Passengers	Other
Fatalities	0	0	0
Critical injury	0	0	0
Major injury	1	0	0
Minor Injury	3	0	0

1.3 Damage to Aircraft

The aircraft, CH146475, sustained "B" category damage. There was extensive airframe damage. The roof segment was severed above the pilots' doors on both sides, the windscreens were shattered and the entire forward section of the fuselage buckled. The landing skid torque tubes were badly splayed outwards. The lower fuselage was not punctured and there was no fuel spill. The rear fuselage behind the cabin was also buckled with wrinkles and noticeable distortion under the aircraft. The tail boom "stinger" had struck the ground and the tail boom was partially separated from the fuselage (Photo 1 – 4).

1.4 Collateral Damage

The aircraft crashed in the "Webber Drop Zone", a flat sandy area within the boundaries of 5 Wing. Environmental clean up efforts were greatly simplified since there was no fuel or liquids spilled in the accident. No claim against the Crown is expected.

1.5 Personnel Information

	Aircraft Captain	Co-Pilot	1st FE	2nd FE	SAR Tech
Rank	Capt	Capt	MCpl	Cpl	Sgt
Category/ Expiry	Cat I 28 Aug 04	Cat III 17 Jun 04	SAR 04 Jun 04	Restricted 29 July 04	Team Leader 26 Mar 04
IRT Category/ Expiry	Cat I/R 01 Apr 04	Cat I/R1 18 Mar 04	N/A	N/A	N/A
Medical Expiry	Aug 04 (non-signé)	Jul 04	Nov 03	Feb 04	Nov 03
Total flying time	1740	435	1200	480	1755
Flying hours on type	1450	201	1200	480	549
Flying hours last 30 days	28	25	13	45	28
Flying hours last 24 hours	4	3	3	6	1
Flying hours on day of Occurrence	1	1	1	1	1

The aircraft captain was the flying pilot at the time of occurrence. He was assigned to 444 (CS) Sqn on temporary duty (TD) from 417 (CS) Sqn. He was a qualified and current CH146 SAR Standards Officer, able to conduct all check rides. He had completed a 45 day check flight, a 30 day instrument check flight and an annual night proficiency check flight with 439 (CS) Sqn in Bagotville prior to assuming his TD, on 28 Aug 03. He also flew a successful unit check out with the 444 (CS) Sqn Standards Officer on 02 Sept 2003 following which he was authorized to fly as a Category 1 SAR CH146 aircraft captain. At the end of his TD he was posted to 413 SAR Sqn to become a CH149 Cormorant pilot. The pilot had completed a Type 1 aircrew medical but it was unsigned with multiple outstanding issues.

The co-pilot was seated in the left-hand seat at the time of occurrence and was assuming non-flying pilot duties. He had completed CH146 Basic First Officer (BFO) phase on 26 Feb 2003. He was awarded a Category III CH146 pilot category in Jun 2003 and was in the process of completing his SAR on-job-training package.

The first FE (MCpl) had been a member of 444 (CS) Sqn since Feb 2000. He was a qualified and current SAR FE, Instructor FE and Standards FE.

The second FE (Cpl) was recently posted in from 400 Tactical Helicopter Sqn (THS) in July 2003. He held a current restricted flying Category and was undergoing his on-job-training for upgrade to SAR operational status.

The SAR Tech was up-to-date for all over land SAR currency requirements. He held a valid CH146 Team Leader and Standards Category.

1.6 Aircraft Information

A review of aircraft records for CH146475 revealed no maintenance abnormalities. The aircraft was serviceable at the time of the occurrence.

The position of the Rotor RPM Governor was examined at the accident scene. It was found in the full "beep down" position. Both pilots' seats were examined and it was evident that the seat energy attenuation mechanism had functioned. The seats were extracted for further laboratory analysis. The inertia reels for the pilot harnesses were tested on scene and both functioned properly.

1.7 Meteorological Information

The following are the forecast and actual weather reports for the time frame of the accident. CYYR is Goose Bay.

CYYR 171426Z 171515 19010KT P6SM SCT060 BKN110 TEMPO 1520
P6SM –SHRA BKN040 PROB30 1520 5SM TSRA BR OVC030CB
FM2000Z 24010G20KT P6SM BKN040 PROB40 0312 P6SM –SHRA
BECMG 2301 27012KT BECMG 1214 29015G25KT
RMK NXT FCST BY 18Z

CYYR 171400Z 19008KT 15SM FEW036 FEW110 FEW160 BKN230 24/16
A2981 RMK CS1AC1AC1C/BLUE/ SLP096 SKY36=
CYYR 171444Z 26005KT 15SM SCT044 BKN090 BKN240 24/16 RMK
SC3AC1CI0 /BLUE/ SKY58=

Weather summary for Wednesday, September 17, 2003

Time: 1444Z / 1144 LCL
Temperature: 24
Dew Point: 16
Mslp: 1009.2
Winds: 26005KT – no gusts
Visibility: 15SM
Freezing Level: 12500 feet
Sky Condition Partly/Mostly Cloudy – SCT044 BKN090 BKN240

Generally fair weather over Goose Bay. VFR Conditions.

1.8 Aid to Navigation

The entire mission was flown within a few miles of the Goose Bay aerodrome. The mission was conducted under VFR and all of the navigation aids in Goose Bay functioned normally.

1.9 Communications

The crew radioed a “Mayday” due to “double engine failure” after the aircraft was on the ground. Goose Bay Tower received and acknowledged the transmission. They then initiated the 5 Wing emergency response plan.

1.10 Aerodrome/Alighting Area Information

The terrain at the crash site is relatively level with thick moss covering sandy soil. There are 30-40 foot tall trees surrounding an open area where the crew was conducting the training scenario. The hoisting target platform was two wooden pallets in the middle of the area. The crewmembers on the ground use these wooden platforms to recover or launch the Stokes litter.

1.11 Flight Recorders

The CH146 carries a combined cockpit voice recorder (CVR) and flight data recorder (FDR), known as a CVFDR. The aircraft also has a Helicopter Usage Monitor System (HUMS) recorder that records various aircraft parameters and vibrations. Both the HUMS and the CVFDR were removed from the aircraft by a qualified technician and transported to 5 Wing Ops on the afternoon of 17 Sept 03. The investigation team arrived on the evening of 17 Sept 2003 via a CC144 Challenger and the CVFDR was transported on the return flight back to the National Research Centre (NRC) in Ottawa for downloading. The data portion of the CVFDR was successfully down loaded.

The Voice portion of the CVFDR data was downloaded in its entirety. It contained the final 30 minutes of the crews’ conversations captured on 4 separate channels, up to the point of ground impact:

Channel 1	Right Seat
Channel 2	Left Seat
Channel 3	Flight Engineer
Channel 4	Cockpit Area Microphone

Both sets of data were made available to the investigation team by early evening of 18 Sept 2003.

The CH146 Helicopter HUMS has a system of sensors and recording mechanisms to record vibration data with the view to pinpointing problems before they develop into major repairs. The system is also used to help reduce or eliminate vibrations by allowing fine balancing of dynamic components, particularly the rotor systems.

The HUMS data was available to the accident investigation team but initial analysis of the CVFDR data indicated that HUMS data analysis was not necessary.

1.12 Wreckage and Impact Information

The aircraft remained substantially intact with wreckage being limited to broken windscreen pieces. Some aircraft survival and crew equipment was spread out near the impact area during the post accident response. Examination of the ground scars showed the aircraft contacted the ground in a relatively level, slightly tail low attitude.

1.13 Medical

After completing the landing, both pilots identified themselves as fit to self-egress the aircraft and provided assistance to the two FEs still located on the aircraft cabin floor. The SAR Tech, on the ground at time of the incident, carried out first responder actions by helping to secure the aircraft, and providing initial medical care to the two FEs. The co-pilot used the SAR satellite telephone to co-ordinate a rescue flight. The Sqn Commanding Officer (CO) and two flight surgeons landed on scene within 15 minutes. Further medical intervention was performed immediately on the FE who appeared to suffer the more serious injuries. Shortly thereafter, ground resources arrived and the four on board aircrew were identified, triaged, and medically evacuated to Labrador Health Centre (LHC). The more seriously injured FE was triaged with major injuries and evacuated by air. The other FE was also triaged with major injuries, while both pilots were initially triaged with minor injuries. All three were transported by ground over rough terrain - one in a sitting position. All five aircrew members were interviewed and examined at the hospital. The SAR Tech was not processed for toxicology, as he was not in the aircraft at the time of incident. All members were discharged home from the emergency room except the more seriously injured FE. The four discharged crewmembers were reassessed at 5 Wing Medical Centre the next morning. All had developed minor medical concerns requiring documentation and follow-up. The FE who remained at the LHC was discharged from the hospital and sent home for continued outpatient care by 21 Sep 2003.

1.14 Fire, Explosives Devices, and Munitions

There was no post crash fire. Several cartridges are installed on CH146 aircraft (hoist guillotine, fire bottles, etc.) and all were made safe by qualified technicians on 18 Sep 2003 before in-depth aircraft examination commenced.

The aircraft carried survival equipment that included ammunition for the survival rifle and a number of survival flares. All of this equipment was recovered from the accident scene on 18 Sep 2003 by qualified technicians from the Ground Search Team.

1.15 Survival Aspects

One of the five crewmembers was on the ground at the time of the accident. This crewmember noted the aircraft's rapid descent, avoided the area under the aircraft and only approached the aircraft after the rotor had stopped.

The other four crewmembers were inside the aircraft during the evolution and all sustained injuries. One of the injuries was serious, but none was life threatening. The pilots were in their seats and strapped in appropriately. Both of the FEs were conducting a "Stokes litter" transfer training scenario with the right cargo door open. Each FE was standing in the cabin connected to a "monkey tail" harness. When the aircraft began descending, both rear crewmembers unsuccessfully attempted to get to the rear seats. One was only successful in attaining a sitting position on the aircraft floor, while the second only attained a partially prone position, and, the ground impact caused them to fall on each other. Both rear crewmembers suffered serious injuries.

Both of the pilot's seats energy attenuation stroking mechanisms functioned during the impact sequence. This stroking mechanism attenuates the vertical forces applied to the seat occupant by elongating the time for the force application and thereby reducing the maximum force peak. Even with this attenuation action occurring on both seats, the pilots sustained injuries during the ground impact. Also, both pilots were sprayed with broken windshield and roof (skylight) glass but neither was injured by this event. Both pilot seats were removed from the aircraft for further examination of the vertical forces energy attenuation stroking mechanisms.

1.16 Test and Research Activities

At the accident scene, the investigation team noticed that the hoist was in the full up position after ground impact. The use of the hoist override switch normally pays out about 5-6 feet of cable in 4-5 seconds. The team also examined the position of the main rotor RPM actuator and noted that it was in the full down (97%) position. Post accident activation of the main rotor "beep" switch moved the RPM actuator from the full down position to the full increase position (101%), indicating that the actuator and "beep" switch were functional at the time of the occurrence.

1.17 Aircraft Salvage

The aircraft crashed in the "Webber Drop Zone", a flat sandy area within the boundaries of 5 Wing. A passable road to the site pre-existed the accident for all but the last several hundred meters. The 5 Wing recovery and salvage (RAS) team used road-making equipment to allow a heavy lift crane and flat bed truck access to the site. After the aircraft was craned and secured on the flatbed, a bulldozer pulled it to the passable road and the aircraft was then transported to a storage site on 5 Wing. There was no fuel or liquids spilled in the accident.

1.18 Additional Information

The right seat collective has several switches located on its collective control panel. It includes the pilot hoist override switch and the main rotor RPM beep switch (see photo 5), which is located immediately below the pilot hoist override switch.

The rescue hoist is usually controlled by a crewmember (in this case the FE) using a hoist pendant control in the rear cabin. During Stokes litter transfers the litter is brought to the full up position and then the rear crewmember puts the hoist pendant on the floor so that both hands can be used to pull the Stokes litter into the cabin. To get slack on the hoist cable, the crewmember makes the call on intercom for "Pilot override out", which is the command for the non-flying pilot to move the hoist (override) switch on the right collective to the down position; thereby, paying hoist cable out.

The main rotor RPM beep switch serves to adjust the main rotor RPM (increase or decrease) within the 97% to 101% rotor RPM range.

2. ANALYSIS

2.1 General

The incident aircraft was being used for a scheduled training flight to practice hoisting with a Stokes litter for an FE who was new at the Sqn. The crew was performing a second hoist sequence in the Weber Drop Zone when the accident occurred.

2.2 The Aircraft

The aircraft, Griffon CH146475, is a military version of the Bell 412EP, a multi-person crew helicopter, operated by 444 Squadron in 5 Wing Goose Bay in the Combat Support (CS) role. The primary role for the aircraft is Search and Rescue (SAR) response and standby for the allied forces that conduct fighter operations in the Goose Bay area. In this role the normal crew is two pilots, one flight engineer (FE) and one SAR Technician (SAR Tech). All 444 Squadron aircraft are equipped with a rescue hoist on the right side of the airframe. The hoist is normally controlled by the FE, except for the final portion of the hoisting-in process during which control of the hoist is passed from the FE to the NFP.

2.3 The Accident

The first sequence, which was flown by the co-pilot sitting in the left seat, served as a demonstration to the new FE who observed it from the ground. Following that first demonstration, the aircraft was landed and the new FE came on board. The next sequence consisted of another hoisting with a Stokes litter demonstration; however, this time the new FE would observe it from inside the cabin area. The aircraft captain flew this second demonstration from the right seat with the co-pilot assuming the non-flying pilot duties in the left seat.

2.3.1. Non-flying pilot duties

The crew duties assumed by the non-flying pilot during hoisting are extensive. They include the hoist checks, monitoring and advising the flying pilot on power settings, selecting the hoist power switch, monitoring all temperatures and pressures, monitoring the radar altimeter, monitoring all radio frequencies and finally clearing his side (left hand side) of the aircraft from nearby obstacles. Frequently, he must prioritize his tasks and his attention. During hoisting operations with a Stokes litter, the non-flying pilot is often asked to manipulate the hoist override switch, located on the right collective control box, so that the FE can free both his hands to pull the Stokes litter inside the cabin. This is a standard procedure in CS units flying the CH146.

2.3.2. The second demonstration

At the time of the occurrence, the aircraft was in an OGE hover at approximately 50 feet AGL over the hoisting area. The Stokes litter was attached to the hoist cable, and to a guide cable held by the SAR Tech on the ground. At approximately the halfway point, the hoisting was paused and the FE called for the aircraft to move 15 feet to the left in order to increase the angle of the guide cable. This placed the aircraft within a ½ rotor distance of taller trees in the 7 o'clock position. At that time, the co-pilot focussed his attention outside the aircraft to clear the movement of the helicopter. The reeling-in was resumed and the litter was raised completely to the aircraft right-hand main cargo door. The FE then placed the hoist pendant on the floor and grabbed the litter by both hands and asked for "Pilot override out". This command is the signal for the non-flying pilot to manipulate the hoist override switch to release some hoist cable and allow the FE to pull the Stokes litter inside the cabin area.

Upon this request, the non-flying pilot quickly refocused his attention from clearing the left side of the aircraft to the hoist override switch. He reached over to the right collective control panel and activated what he believed was the hoist override switch. At that time, the flying pilot saw the rotor RPM decrease and felt the aircraft beginning to sink. He noticed the triple tachometer indicating approximately 96-97 % and felt the aircraft yaw to the right. The flying pilot also reported hearing a deceleration noise from the engines and then called "Power loss". He rolled the throttles to idle and moved the aircraft forward and left slightly, while the SAR Tech on the ground ran in the opposite direction. The aircraft impacted the ground at approximately 5 Gs.

2.4 Active Factors

This accident can be broken down into 3 specific events. The first event was the co-pilot inadvertently activating the "Beep" switch that resulted in a decrease of the engine and rotor RPM. The second event was the flying pilot interpreting the reduction in RPM and settling of the aircraft as a loss of tail rotor, and the subsequent decision to conduct an autorotation. The final event was the improper autorotation technique which resulted in a decayed main rotor RPM.

2.4.1. Switch Ergonomics

Hoist Override Switch. The rescue hoist can be controlled by the pilot via a "Hoist Override Switch" located on the right hand collective. The hoist override switch is a paddle-shaped, three-position, spring-loaded switch.

"Beep" Switch. The "Beep" switch is used to fine-tune the main rotor RPM during any flight regime by increasing or decreasing the engine RPM by a maximum of 3%. It is located immediately below the hoist override switch. The "Beep" switch is pin-shaped, and has five-positions. The "Beep" switch can be moved in the same way as the hoist override switch, and other than the tactile feel of the switch itself, is difficult to distinguish from the hoist override switch if one is not looking. A second “Beep” switch (for use by the co-pilot) is located on the left-hand collective. Unlike the first pin shaped “Beep” switch, this “Beep” switch is paddle shaped – similar to the hoist override switch (photos 5 and 6).

The engines of CH146475 routinely came out of trim during the various power settings experienced on a typical flight. During this flight many attempts were made to re-synchronize the engine torques using the +2 / -2 trim (Beep) switch. This is normally the non-flying pilots job during any power changes. The NFP had made between 8-10 such attempts, therefore, establishing the habitual trend of reaching across to the right collective head and re-synching the engine torques.

The co-pilot intended to activate the hoist override switch, however, the “beep” switch was inadvertently toggled. The “beep” switch was inadvertently activated because the co-pilot did not confirm that his finger was resting on the proper switch prior to activation. Instead of visually confirming that he had placed his finger on the right switch, his attention was focussed on the activities of the two FE’s. The close location of the hoist override switch and the “beep” switch, combined with the very similar downward action of the two switches made the erroneous switch selection a high probability. The different shapes of the two switches are not sufficient to prevent such an unsafe act. The flat paddle shape of the hoist override switch and the pin shape “beep” switch are difficult to differentiate using the compulsory two-layer glove worn by aircrew. A visual confirmation of the finger position prior to switch manipulation is the only safe and effective way to confirm that the proper switch is about to be activated.

Due to a lack of an aural tone associated with the “beep” switch, the flying pilot was unaware that the “beep” switch had been inadvertently activated. A tone associated with either the “beep” or the hoist override switch would likely have prevented the first unsafe act and by way of consequence, this accident would not have occurred.

As well, the pilot may not have been aware that the NFP was attempting to utilize the hoist over-ride switch as the only verbal direction is from the FE for “Pilot - over-ride out”, following which, the NFP automatically activates the hoist over-ride switch. A response from the NFP such as, “Roger – over-ride out”, may have made the flying pilot aware of an up-coming switch selection and prepared him for a possible inadvertent switch activation. Additionally, the FE “Pilot Over-ride Out” call is made is an extremely noisy environment that includes an open cargo door, and down-wash from the main rotor. This can result in missed calls.

This first unsafe act should not have caused this occurrence since a decrease of the “beep” switch will only result in a slight decrease in rotor RPM to 97 % with a slight decrease in height, accompanied by minor yaw to the right. The aircraft is easily controllable and a re-adjustment of the “beep” switch to 100 % will quickly re-establish the aircraft in a normal configuration.

2.4.2. Misidentification Of Engine Indications

The second event was a misinterpretation of a loss of tail rotor caused by the slight decrease in rotor RPM (approximately 3%), accompanied by a slight drop in altitude (approximately 10 feet), and a minor yaw to the right (approximately 2^{O}). The flying pilot did not notice and assimilate information that was present and accessible. The aircraft still had tail rotor authority, the rotor RPM drop wasn't increasing, and the aircraft wasn't violently yawing, as would be the case in a tail rotor failure. He did not properly diagnose a slight loss in rotor RPM created by the first unsafe event, and misinterpreted the information as a loss of tail rotor thrust. The following chart compares the symptoms and associated indications of a power loss and loss of tail rotor:

INDICATION	POWER LOSS	TAIL ROTOR LOSS
RPM	Decrease	No Change
YAW	Left	Right
NOISE	Decrease	No Change

The investigation revealed that there were several human factors that affected the rapid response to the information being processed by the pilot. First, the pilot was heavily influenced by a recent fatal Griffon crash which involved a tail rotor failure. He had recently read the draft Flight Safety Investigation Report distributed for comment by DFS a few days prior to the accident flight. As a result he may have incorrectly been pre-disposed to immediately assume a tail rotor failure when presented with the decrease in RPM, yaw and slight altitude loss during this accident. As well, during previous CH146 simulator training, when confronted to a loss of tail rotor thrust, the pilot found he could only land the aircraft by immediately rolling the throttles to idle and conducting an autorotation.

The decision to perform an autorotation was based on the incorrect perception of a tail rotor failure. However, the execution of a successful autorotation should not have resulted in the level of damage suffered by this airframe.

2.4.3. Autorotation

The flying pilot diagnosed the power reduction as a loss of tail rotor, although his initial warning to the crew was "Power Loss". The initial actions for power loss in the hover are:

<u>POWER LOSS IN HOVER</u>

1. Helicopter - Control
2. BEEP - Max
3. Collective - Raise to cushion

The completion of the above actions would have likely reduced the rate of descent and the severity of this accident. However, even though the pilot called "Power Loss", he believed he had suffered a loss of tail rotor and his intention was to conduct an autorotation. The initial actions for a loss of tail rotor in the hover are:

<u>LOSS OF TAIL ROTOR THRUST IN HOVER</u>

1. Throttles - Idle
2. Collective - Raise to cushion landing
   CAUTION – Do not allow rotor rpm to decay below minimum limits (B-GA-002-146/FP-001)

The initial actions for any autorotation are:

<u>AUTOROTATION – ENTRY TECHNIQUE</u>

1. Collective – Reduce to minimum or as required to maintain a safe rotor RPM
2. Cyclic - Adjust to attain desired airspeed

Information retrieved from the Flight Data Recorder (FDR) indicates that instead of lowering the collective, the flying pilot raised the collective to 80 % of its travel. Raising the collective to 80% caused the main rotor RPM to spool down further and the aircraft continued to sink at an increasing vertical speed. The pilot pulled the collective to 101 % travel just prior to impact. The aircraft impacted the ground in a near-level attitude with a deceleration force of nearly 5 Gs and with the main rotor RPM at approximately 52 %. At that RPM, the main rotor is producing very little lift and the aircraft is basically in a freefall. This last act resulted in the severe damage incurred by the aircraft.

2.5 Latent Factors

2.5.1. Switchology

The similarity of design of the "beep" switch and the hoist override switch, combined with their close proximity can lead to inadvertent activation of the incorrect switch. There is no tone associated with either switch, and tactile feel is similar, so there would be no audible indication to the flight crew if the wrong switch was inadvertently activated. As well, the left and right "beep" switches are of different design with the left "beep" switch being the same type as the hoist override switch.

2.5.2. Training

There are two main issues that must be addressed with respect to training. The first is the recognition of the symptoms of a tail rotor failure as opposed to a main rotor or engine related problem. In this accident a 3 % decrease of main rotor RPM was misdiagnosed as a tail rotor failure, even though the symptoms of a tail rotor failure are severe, while a slight power decrease can be relatively benign. During re-current simulator training, an un-commanded “beep” down scenario interposed with a tail rotor failure would allow a pilot to recognize the differences between these two scenarios.

The second issue is the execution of the autorotation. The pilot’s experience with autorotation to touch down was derived mainly from his “ab initio” helicopter training in 3 Canadian Forces Flight Training School (3 CFFTS) in Portage-la-Prairie, Manitoba. On the Griffon, his autorotation experience was limited to the OTU, and operational recurrency training. During the OTU he had conducted three autorotations to overshoot in the Griffon aircraft. The only autorotations to touch down were conducted in the simulator. Following his CH146 OTU, he carried out quarterly autorotation recurrency training in the aircraft to overshoot. His only autorotations to touch down were conducted annually in the simulator.

Autorotations are only practised to touch down in the simulator; however, the simulator does not provide adequate sensory inputs below 50 feet above ground level (AGL). Visual cues and depth perception from 0 to 50 feet AGL are somewhat limiting which can affect the training value.

2.6 Physiology

The pilot reported that he received approximately 6.5 to 7 hours of sleep the night prior to the accident and on the two nights prior to that. He reported that this is normal for him. The pilot was on temporary assignment in Goose Bay and was required to stay in the barracks which were reported as extremely hot for the last few nights while he was trying to sleep.

The pilot reported that on the morning of the accident his breakfast consisted of a granola bar. The pilot had a normal meal the night previous. The co-pilot had a normal breakfast. Both reported as being well hydrated.

An examination of medical documents revealed that the aircraft captain had recently completed his annual medical Part 1 and received a below Military Occupation Code (MOC) category. The examining physician had not yet signed the document and not yet recommended medical employment limitations. Therefore the medical was not completed and assessed as not valid.

Another member of the crew was still officially grounded for a medical illness and thought he had been given permission by the base surgeon to “self” un-ground.

One crewmember had self-medicated with a common over the counter medication the day prior to the flight.

There is no evidence to suggest that there were any physiological factors contributing to this accident.

2.7 Crash Response

The crash response team experienced difficulties separating and identifying the accident personnel at the scene mostly because all personnel were in Canadian Forces uniforms. All crewmembers and passengers from an aircraft accident should be isolated, assessed and treated by rescue personnel to ensure that all injuries are identified and that stable injuries are not aggravated.

The two pilots egressed the crash aircraft unassisted, while the two FEs required assistance. The SAR Tech assisted the injured crewmembers with medical first aid. The severely injured crewmember was transported to the LHC via another CH146 Rescue helicopter because the medical assessment team at the scene was concerned about aggravating the injuries. A second crewmember had sustained serious injuries, however this was only later identified by a specialist in Halifax. All the other crewmembers were transported to the LHC using ground transportation over some very rough terrain. The injuries to the other crewmembers who had experienced large vertical impact forces could have been aggravated as a result of this means of transportation.

3. CONCLUSION

3.1 Findings

3.1.1. The non-flying pilot (co-pilot) inadvertently activated the governor increase/decrease switch also called the main rotor RPM “beep” switch instead of the hoist over ride switch.

3.1.2. The command for “Pilot Over-ride Out” is a single call made by the FE in an extremely noisy environment.

3.1.3. The “beep” switch was inadvertently activated because the co-pilot did not confirm that his finger was resting on the proper switch prior to activation.

3.1.4. The left and right “beep” switches are of different design with the left “beep” switch being the same type as the hoist override switch.

3.1.5. The flying pilot diagnosed the power reduction as a loss of tail rotor, although his initial warning to the crew was “Power Loss“.

3.1.6. The flying pilot may have been pre-disposed to immediately assume a tail rotor failure when presented with the decrease in RPM, yaw and slight altitude loss.

3.1.7. During previous CH146 simulator training, when confronted to a loss of tail rotor thrust, the pilot found he could only land the aircraft by immediately rolling the throttles to idle and conducting an autorotation.

3.1.8. The pilot initiated an autorotation by rolling both throttles to idle and raising the collective to initially 80%, and ultimately to 101% of its travel.

3.1.9. Main rotor RPM quickly decayed as the aircraft was descending, reaching 52 % at ground impact.

3.1.10. The aircraft struck the ground at approximately 5 Gs.

3.1.11. The pilot’s experience with autorotation to touch down was derived mainly from his “ab initio” helicopter training in 3 Canadian Forces Flight Training School (3 CFFTS) in Portage-la-Prairie, Manitoba.

3.1.12. Griffon autorotations to touch down are only conducted in the simulator

3.1.13. The CH-146 simulator has degraded visual inputs in the 0 to 50 feet AGL range.

3.1.14. The aircraft Captain did not have a valid aircrew medical category, one crewmember tested positive for self-medication, and one crewmember had not been un-grounded for a medical illness.

3.1.15. All crewmembers on board the aircraft sustained various degrees of injuries from the impact. The SAR Tech was on the ground at the time of occurrence and did not sustain injuries.

3.1.16. A rescue helicopter as well as ground rescue personnel responded within approximately 15 minutes.

3.1.17. The two pilots egressed the crash aircraft unassisted, while the two FEs required assistance.

3.1.18. The SAR Tech assisted the injured crewmembers with medical first aid.

3.2 Cause Factors

3.2.1. While conducting an autorotation, the pilot allowed the main rotor RPM to decay below flying limits.

3.2.2. The pilot misdiagnosed engine indications and reacted to a "Loss of Tail Rotor".

3.2.3. The co-pilot inadvertently activated the main rotor RPM "beep" switch instead of the intended "Hoist Over-ride" switch.

3.3 Contributing Factors

3.3.1. The design and location of the "Beep" and "Hoist Over-ride" switches increase the possibility of activating the wrong switch.

3.3.2. The pilot's recent simulator training reinforced the belief that success was only achieved through immediate response, leaving minimal time for proper emergency assessment and diagnosis.

4. SAFETY ACTION

4.1 Safety Action Taken

The Sqn CO and acting Wing Commander were debriefed on the investigation team's preliminary findings in order to rectify minor points noted in the emergency response.

4.2 Safety Action Recommended

It is recommended that:

4.2.1. CH-146 flight simulator training should put more emphasis on proper identification and assessment of engine and tail rotor malfunctions using all available symptoms.

4.2.2. Simulator training should include an un-commanded/inadvertent "beep down" scenario interposed with loss of tail rotor in an out-of-ground effect hover scenario, i.e. Hoisting, slinging, or observation. This emergency must be identified in Annex C of the Training Guidance for CH146 Griffon Flight Simulator Recurrency Training.

4.2.3. The visual realism of the simulator in the 0 to 50 feet AGL range should be enhanced during the next simulator upgrade program.

4.2.4. Standardized challenge and response calls between the FE an NFP should be developed for hoisting operations in B-GA-002-146-FP-001-SMM, Chapter 2, Task 302.

4.2.5. The design of the "Beep Switch" should be of a consistent type on both the left and right collective, and, it should be of a different feel than the Hoist Override switch.

4.2.6. Improved audio communication between FE and pilots is required through use of enhanced, sound/wind dampening microphones.

4.3 Other Safety Concerns

4.3.1. Due to the high number of physiological collateral findings, recommend that the Commander of 1 Canadian Air Division direct local Commanders to liase with local Medical Authorities to put procedures in place that will ensure that aircrew and the supervisory chain are aware of their flying status immediately following medical care or attention.

4.3.2. The Flight Recorder Playback Centre of NRC does not have the capability to download the HUMS data. It is recommended that NRC be provided with the associated software and hardware to accomplish the download and data analysis of both damaged and undamaged HUMS.

4.4 DFS Comments

There are two main points that need to be highlighted as a result of this investigation. The first is that the pilot of the accident aircraft felt that he was faced with a time critical emergency that required immediate and decisive action. Unfortunately, a number of factors combined to result in an aircraft accident. One of these factors was the pilot's training, which had not adequately prepared him to carry out an effective autorotation. Specifically, the Griffon simulator is the only place in which pilots are exposed to autorotations to touchdown. However, the realism of the simulator is lacking in the zero to fifty-foot range and the training benefits derived from the simulator in this critical regime of an autorotation are not optimal. Therefore, either the capabilities of the simulator must be enhanced to provide real, effective training for this manoeuvre or an alternative flying training procedure must be developed and implemented.

The second point involves the emergency response to this accident. A number of important lessons were identified from the reaction to this occurrence. Some of these concerns could not, in all likelihood, have been foreseen and they therefore need to be shared with other Wings and units. Accordingly, DFS will ensure that these points are passed to the OPI for the On Scene Commander Course as well as the OPI for the Advanced Flight Safety Course.

//ORIGINAL SIGNED BY//

A.D. Hunter
Colonel
DFS

Annex A: Photographs

Photo 1: Final Resting Place

Photo 2: Landing gear damage

Photo 3: Aft area damage

Photo 4: Windshield damage

Photo 5 – Pilot's collective control box

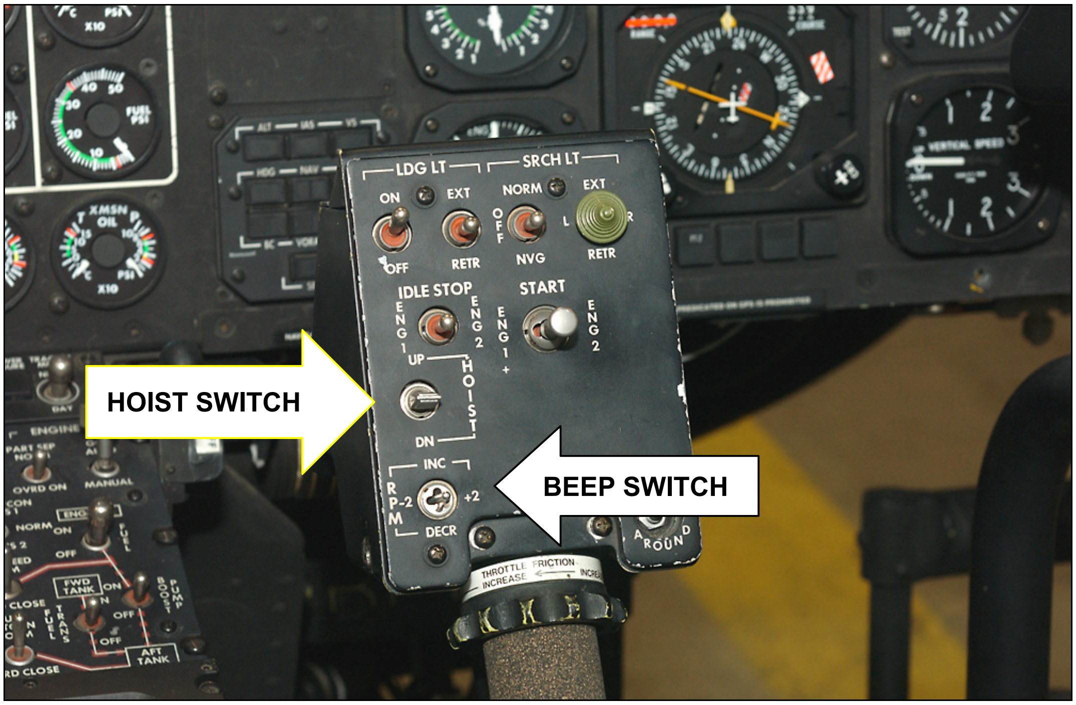
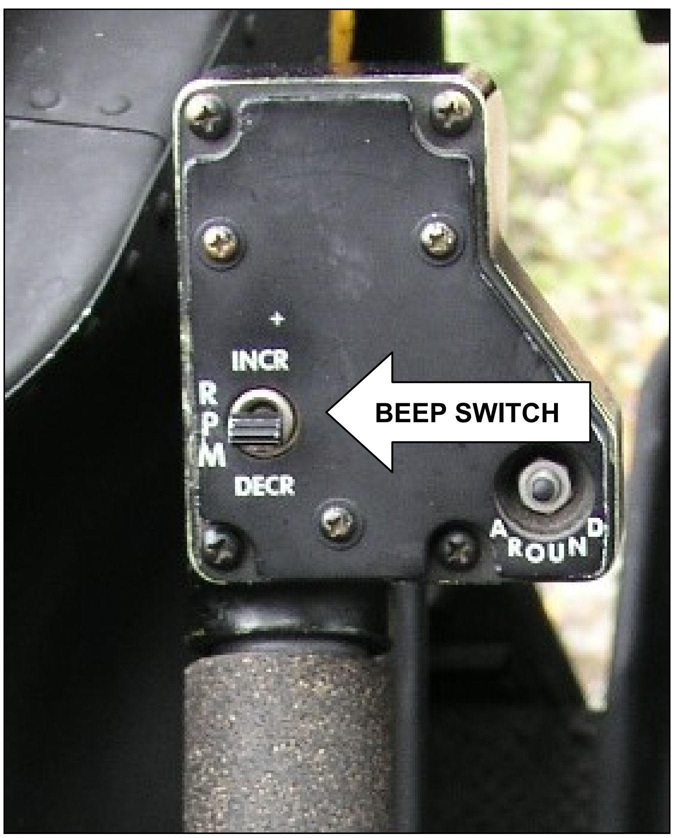


Photo 6 – Co-Pilot's Collective



Annex B: Abbreviations

AGL: Above Ground Level
AIA: Airworthiness Investigative Authority
BFO: Basic first Officer
Capt: Captain
Cat: Category
CFFTS: Canadian Forces Flying Training School
CO: commanding Officer
Cpl: Corporal
CS: Combat Support
CVFDR: Cockpit Voice Flight Data Recorder
CVR: Cockpit Voice Recorder
DFS: Director of Flight Safety
FDR: Flight Data Recorder
FE: Flight Engineer
FSIR: Flight Safety Investigation Report
HUMS: Helicopter Usage Monitor System
IRT: Instrument Rating Test
G: gravity
LHC: Labrador Health Centre
Max: Maximum
MCpl: Master Corporal
MDAU: Modular Data Analysis Unit
MND: Minister National Defence
MOC: Military Occupation Code
NFP: Non-Flying Pilot
NRC: National Research Council
OGE: Out of Ground Effect
Ops: Operations
OTU: Operational Training Unit
PDI: Person of Direct Interest
RAS: Recovery And Salvage
RPM: Revolutions Per Minute
SAR: Search And Rescue
Sgt: Sergeant
ST: Search And Rescue Technician
Sqn: Squadron
TD: Temporary Duty
THS: Tactical Helicopter Squadron
VFR: Visual Flight Rules
WComd: Wing Commander
Z: Zulu