CANADIAN FORCES
FLIGHT SAFETY INVESTIGATION REPORT (FSIR)

FINAL REPORT

FILE NUMBER: 1010-12414 (DFS 2-4-2)
DATE OF REPORT: 24 OCTOBER 2000

AIRCRAFT TYPE: CH124A SEA KING
DATE/TIME: 161420 Z JUNE 1999
LOCATION: SHEARWATER, NS
CATEGORY: C CATEGORY ACCIDENT

SYNOPSIS

At 1420 Z 16 June 1999, a crew from 406 (HT) Squadron, consisting of one Waterbird Instructor Pilot and one Airborne Electronic Sensor Operator (AESOP), had just completed a crew change of the right seat student pilot on the ramp at Shearwater. The student was a qualified co-pilot from 443(MH) Squadron, scheduled for proficiency training for water landings. Prior to taxiing, the crew discussed the fact that a sharp right turn would be required to ensure separation from other aircraft parked in the vicinity. The student pilot initiated the taxi by applying 20-30% torque and forward cyclic. He verified that the tail-wheel lock pin was unlocked by turning initially to the left and then commenced a rapid turn to the right. Both pilots had turned their heads to the right to confirm clearance from any obstacles in the direction of the turn, when they noted in their peripheral vision that the rotor tip path plane was descending relative to the horizon. The student pilot initially reacted with two shots of aft beeper trim. Both pilots became aware that the aircraft was rotating forward and the nose of the aircraft was in danger of striking the ground. They both pulled back on the cyclic, and the tail wheel returned sharply to the ground. The number five main rotor blade tip cap struck the tail rotor drive shaft. The crew felt vibrations and heard banging. The aircraft bounced several times and yawed 30 degrees to the right. The instructor pilot took control, ordered an emergency shutdown and the crew egressed safely from the aircraft. There were no injuries in this occurrence.

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1. FACTUAL INFORMATION

1.1. General

Sea King CH12414 had a main rotor blade strike on the tail pylon whilst taxiing on the ramp at Shearwater, NS.

1.2. History of the Flight

At 1420 Z 16 June 1999, a Waterbird instructor pilot and an AESOP from 406 (HT) SQN had just completed a 1.3 hour lesson plan on a qualified co-pilot and taxied to the ramp in front of "D" hangar. The co-pilot disembarked and was replaced by the occurrence co-pilot from 443(MH) Squadron. The intention was to conduct another water landing lesson plan. Prior to taxiing, the occurrence crew noted that another Sea King had taxied into a parking spot immediately in front of them and that a sharp right turn would be required to ensure aircraft separation. The co-pilot, occupying the right seat, initiated the taxi by applying 20-30% torque and what he believed to be a normal amount of forward cyclic. As per standard procedure, the student pilot verified that the tail pin was unlocked by initiating a brief turn to the left. Testimony indicated that this surprised the instructor because he had expected an immediate right turn. Just as the instructor was about to order a right turn, the student commenced a more rapid than normal turn to the right to depart the ramp. Both pilots turned their heads to the right to confirm clearance from any obstacles in the direction of the turn, when the co-pilot decided that the taxi speed was too slow and added an unknown amount of cyclic and collective input. The input was described as small, but was made without reference to the instruments or the tip path plane. It was at this time both pilots noticed that the rotor tip path plane was rapidly moving down relative to the horizon. The student pilot initially reacted with two shots of aft beeper trim. Both pilots subsequently became aware that the nose of the aircraft was in danger of striking the ground because the aircraft was rotating forward. Neither pilot could state precisely who pulled back on the cyclic first, but they believed that the actions were roughly simultaneous. The crew heard a bang, immediately followed by airframe vibrations. The aircraft bounced several times and yawed 30 degrees to the right. The instructor pilot took control, ordered an emergency shutdown and the crew egressed safely from the aircraft.

1.3. Injuries to Personnel

There were no injuries in this occurrence.

1.4. Damage to the Aircraft

The tail wheel strut collapsed and airframe damage was suffered at flight stations 493 and 607. (Figure 1) The number five main rotor blade tip cap contacted the tail rotor drive shaft cover and the number four tail rotor drive shaft. (Figure 2) The tail rotor drive shaft cover was extensively damaged and fragmented (Figure 3); the number 4 tail rotor drive shaft was broken into two pieces and thrown from the aircraft. Two other main rotor blades and one tail rotor blade were damaged by debris (Figure 4). The aircraft sustained C category damage.

Figure 1 - Tail Strut

Figure 2 - #5 Main Rotor Blade

Figure 3 - Tail Rotor Shaft Damage

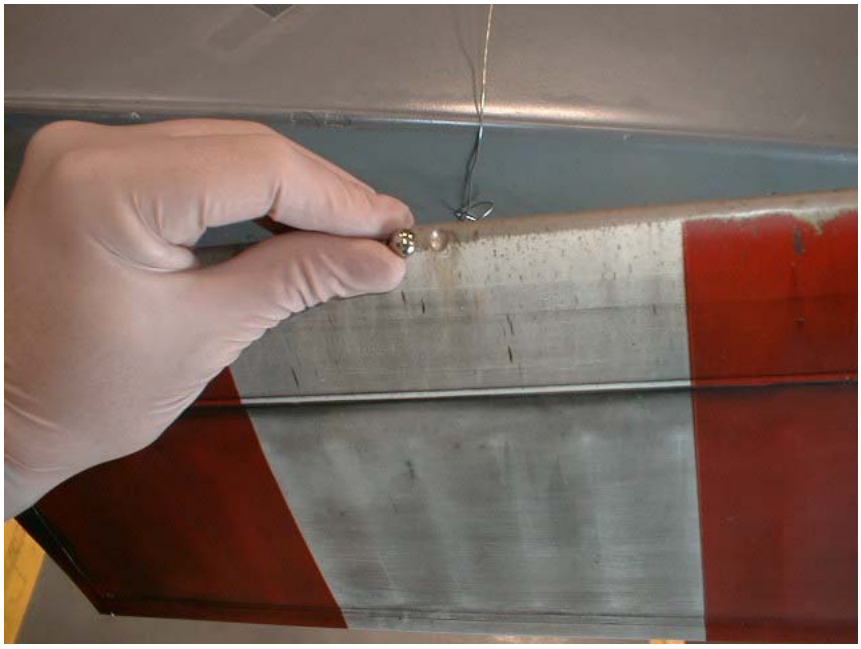

Figure 4 - Debris Damage

1.5. Collateral Damage

Other than superficial damage to the concrete on the inner ramp, there was no collateral damage. A claim against the crown is considered unlikely.

1.6. Personnel Information

1.6.1. Personnel Information

	LSP (IP HT 406)	RSP (MH 423)	AESOP (HT 406)
Rank	Capt.	Lt.	Cpl.
Age	30	23	34
Category valid	YES (MHCC/IP)	YES (MHCP)	YES (AES Op)
Medical Category valid	YES	YES	YES
Total Flying time	1996 hrs	412 hrs	88 hrs
Flying Hours on type	1684 hrs	113hrs	50 hrs
Flying hours last 30 days	24 hrs	30 hrs	9 hrs
Duty time last 24 hours	11 hrs	13 hrs	8 hrs

1.6.2. Cockpit Resource Management (CRM) Training

The co-pilot had received initial CRM training within the previous 6 months as part of the conversion course syllabus. The instructor pilot had not received CRM training since 1996.

1.7. Aircraft Information

The aircraft was serviceable at the time of the occurrence. There was, however, a minor technical discrepancy noted on the aircraft servicing set weight and balance form. Although the centre of gravity and aircraft weight was within prescribed limits, several discrepancies were noted between the recorded configuration and the actual inventory of aircraft equipment. These discrepancies included the removal of doppler system components, missing eye wash kit, a loose equipment stowage bag and a sonobouy loading tool. The Weight and Balance Clearance From [sic] (Tactical), DND 3131 listed a revised weight of 13,793.2 lbs. and a moment of 3,752.4. Using these numbers, dry weight at time of accident should have been 16,593.2 lbs. with the centre of gravity at station 266.5”. At the time of accident, the actual dry weight was 16,527 lbs. with the centre of gravity at station 266.2”.

1.8. Meteorological Information

Weather was not a factor in this occurrence.

1.9. Aid to Navigation

Not applicable.

1.10. Communications

Not applicable.

1.11. Aerodrome/Alighting Area Information

The accident occurred on the inner ramp in front of D Hangar. 406 (HT) Squadron utilises the aircraft parking spots immediately adjacent to "D" hangar. The occurrence aircraft came to rest on spot S-5, having moved approximately 5 feet, but remaining within the circle drawn around the spots, as indicated at Annex A. Each spot has a diameter of approximately 81' 2”. Another Sea King was parked on spot S-3, immediately in front of the occurrence aircraft. The distance from S-5 to S-3 is 42' 10". A third Sea King was parked on spot S-4, at the occurrence aircraft’s ten o'clock position.

1.12. Flight Recorders

There were no recording devices on this aircraft.

1.13. Wreckage and Impact Information

After the occurrence, the aircraft was shutdown on spot S-5 on a heading of approximately 338° magnetic. The majority of the debris was distributed on the

inner ramp along the Northeast side of the aircraft. The farthest piece of debris was a portion of the number four tail rotor drive shaft, located approximately 225 feet Northeast of the aircraft.

1.14. Medical

Blood and urine samples were taken from all three crewmembers and all tests were found normal. All three crewmembers stated they had received an appropriate amount of crew rest the previous night and were not under any particular stress.

1.15. Fire, Explosives Devices, and Munitions

Not applicable.

1.16. Survival Aspects

Not applicable.

1.16.1. Crash Survivability

The forces associated with this accident created no life threatening circumstances.

1.16.2. Life Support Equipment

Adequate Life support equipment was worn but not utilised in this occurrence. The crew did not experience any difficulties with aircraft egress.

1.17. Test and Research Activities

The Tail Wheel Strut assembly was sent to Quality Engineering Test Establishment (QETE) for failure analysis.

2. ANALYSIS

2.1. General

The mission was the second part of a planned two-part water landing lesson plan for qualified co-pilots. According to the instructor's statement, the complexity of the planned manoeuvres made the taxi portion seem routine. Given the experience of his student, the instructor was not anticipating difficulty manoeuvring the helicopter on the ground. Because no other cause factors were discovered, human factors relating to crew distraction were the focus of this investigation.

2.2. The Aircraft

The aircraft was fully serviceable at the time of the occurrence and there were no material cause factors determined during the course of the investigation.

The Waterbird, as this configuration of Sea King is known, was uniquely configured to be more favourably suited to water operations than those fitted with the normal mission suite. It is lighter than normal, due to the removal of non-essential water-sensitive equipment, and it is sealed wherever possible with tape to reduce the amount of water ingress.

2.3. The Aircrew

2.3.1. Qualifications

The aircrew were qualified and authorised to conduct the lesson plan. The weather was suitable and crew rest was not a factor.

2.3.2. CRM

Records indicate that the instructor pilot was not current in CRM training in that he had not attended, audited or monitored any CRM training since 1996. However, expert testimony indicates that in the context of this occurrence, CRM procedures would not likely have been effective in preventing the accident. This theory is supported by testimony to the effect that the time from the initial left turn to the onset of the nose down rotation spanned less than 5 seconds. It is anticipated that any momentary distraction at a critical moment could facilitate an occurrence despite the latest CRM procedures.

2.4. Active Factors

2.4.1. Ramp Congestion

As demonstrated by the photograph at Annex A, there were two helicopters parked in front of the occurrence aircraft when it started to taxi-out. Statements from the occurrence aircrew suggested that there was a certain amount of distraction due to the proximity of other aircraft in the immediate ramp area. Despite the expressed concern, the instructor anticipated no difficulty with the ground taxi manoeuvre, he simply wanted to pay close attention to the ramp traffic, and therefore no consideration was given to the possibility of hover taxiing or waiting for the traffic to clear. Photo-analysis indicated sufficient clearance in all directions to permit safe ground taxi clearance.

2.4.2. Expectation

The pre-taxi briefing included the intention to execute an immediate right turn to clear the ramp area. The co-pilot, however, failed to mention that he also intended to briefly initiate a left turn into the traffic to confirm that the tail wheel was unlocked. Although the Standard Manoeuvre Guide (SMG) does not specifically mention a requirement to conduct the first turn to the left, it is taught as standard procedure on the conversion course. Given that a brief left turn was standard procedure, the co-pilot did not think it necessary to voice his intention. The instructor, however, stated that he expected an immediate right turn, and the left turn served to elevate his anxiety about the other aircraft in close proximity.

2.4.3. Distraction / Urgency

According to the Instructor's statement, the initiation of a left turn caught him by surprise. Further complicating the issue was the fact that the tail wheel seemed to remain locked and therefore, the co-pilot continued the turn approximately 30° to the left, much farther than initially (albeit silently) intended. Statements from the crew indicated that the left turn increased a perceived urgency on the part of both pilots to commence the turn-reversal and therefore may have distracted them both from the safe control of their aircraft.

2.4.4. Relative Motion

The right turn was initiated with very little forward motion, as indicated by testimony and the post-occurrence location of the helicopter. The co-pilot indicated that the taxi speed seemed very slow in the right turn and he added forward cyclic and some small increase in torque to accelerate.

The right turn, observed while looking out the right side pilot's window, would appear to have a slower than normal taxi speed because the right wheel is laterally offset to the inside of the turning axis. This is a normal situation, but was

interpreted by the co-pilot as a requirement for increased power and forward cyclic. As previously mentioned, both pilots were looking out to the right as the control inputs were made, so neither pilot observed the effect of the cyclic input on the tip path plane nor the exact amount of torque applied. The co-pilot had stated that he had initiated the taxi with 20-30% torque and did not subsequently lower the collective because he had not achieved the desired taxi speed. It is conceivable that the additional unmonitored increase in collective could have exceeded the 35% maximum suggested in the Standard Manoeuvre Guide (SMG). It is certain that the cyclic input caused the tip path to move lower down the windscreen than the 1/3 position (recommended in the SMG) which as indicated by testimony, was the initial placement at the start of the manoeuvre.

2.4.5. Rotational Moment

It is certain that some force caused the aircraft to pitch forward, and since aircraft unserviceability has been ruled out, there remain only three logical possibilities:

a. Unintentional braking against forward motion;

b. Side-loading of the main landing gear during the right turn, locking of one or both main landing gear (acting as a brake against forward motion); or

c. The unintentional application of sufficient cyclic and collective inputs to cause the aircraft to rotate forward.

2.4.6. Application of Wheel Brakes.

The co-pilot stated with certainty that he did not apply the brakes. This was supported by testimony that the aircraft rotation was sufficiently smooth as to remain unnoticed until a significant nose-low attitude had developed. Pitch induced by braking against forward motion would likely be abrupt and instantly noticeable. Testimony also indicated an almost complete lack of forward speed in the right turn; therefore it is unlikely that momentum was sufficient to cause the required nose down pitching moment.

2.4.7. Side Loading.

The main landing gear is laterally offset from the centre of rotation and turning with little forward velocity can cause side loading on the tires. It is possible that this side loading of the tires could have also had a braking effect sufficient to cause the aircraft to pivot about one or both main landing gear. It is, however, considered unlikely, because of the lack of forward speed, that there would be sufficient momentum to move the helicopter around a pivot point. It is likely that any such pivoting around stopped wheels would be sudden and therefore instantly noticeable to the crew. Finally, side loading would have also left ground skid marks indicating that the tires were not rotating. The only marks found, however, were those caused by the bouncing and rotation of the aircraft subsequent to the tail rotor drive failure.

2.4.8. Unintentional Flight Control Inputs.

One means to produce the imperceptible pitching moment would be a combination of forward cyclic and torque, sufficient to replicate the initial stages of a no-hover take-off. According to the CH124 TORQUE REQUIRED TO HOVER chart (C-12-124-A00/MC-001 - performance data), the calculated power required to hover out of ground effect (OGE) on that day, was approximately 76%. A no-hover take-off could likely be accomplished with approximately 60% torque, and the initial rotation would require even less power. A reasonable estimate of the power required to rotate, without becoming airborne, would be approximately 40-50% torque, when smoothly and continuously applied in concert with a lower than normal tip path plane position. Given the weather conditions, low take-off weight, forward cyclic position and torque possibly in the range of 35-50%, the cyclic and torque applications approximated those for a no-hover take-off. It is possible that sufficient power was unintentionally applied to allow the helicopter to rotate forward to align itself with the rotor disk. The rotation produced could occur at a rate undetectable without visual stimuli. In fact, the co-pilot stated that his first indication of a problem came when he noticed the rapid downward motion of the tip path plane in his peripheral vision.

2.4.9. Instinctive Reaction

Testimony indicates that both pilots were surprised by the forward rotation of the helicopter and therefore reacted instinctively rather than deliberately to the unusual attitude encountered. Once made aware of the attitude change, both pilots pulled back aggressively on the cyclic. While it remains unclear as to which pilot was first to initiate the cyclic input, it is certain that the results were cumulative and that the tail wheel returned to the ground with sufficient force to cause structural failure of the tail wheel assembly. This fact was corroborated by the QETE failure analysis (10081-D010399(Q1-RM) October 1999) which concluded that:

"the damage sustained was solely the result of the impact force generated when the tail wheel returned to the ground … No material defect was found that would have facilitated this occurrence."

From this fact it is deduced that flight control inputs, sufficiently large to cause the structural failure of the tail wheel assembly on ground impact, were also sufficiently large to cause the rotor disk to continue aft until it struck the tail rotor drive shaft. Because of the large cyclic input and simultaneous lowering of the collective, the following sequence of events is offered as the most likely scenario:

a. reduction of coning as the collective was lowered;

b. the tail section stopped descending due to ground impact and may have bounced slightly up into the path of the main rotor disk;

c. rotor blades flexed downwards at the tip (due to reduction in coning as torque was suddenly reduced) sufficiently to contact the tail rotor drive shaft.

2.5. Latent Factors

2.5.1. Relative Task Simplicity

The water landing is considered one of the most challenging tasks for a Sea King pilot. Instructors are specially selected and trained for this mission. According to testimony, Waterbird instructors are particularly vigilant during water take-off and landing manoeuvres because of the inherent dangers involved in practising single-engine operations at extreme low level. However, ground taxiing is considered somewhat of a mundane task and the instructor stated that he had initially relaxed because of the relative simplicity of the task.

The instructor had the expectation that a qualified co-pilot could safely manoeuvre the helicopter on the ramp, without the requirement to closely monitor the flight control inputs. The instructor therefore, was concentrating on the other helicopters in their vicinity, rather than the control of the aircraft.

2.6. Additional Issues

2.6.1. Standard Manoeuvre Guide (SMG)

Testimony indicated that it was standard procedure to use a slight left turn in the initial stages of the taxi procedure, to ensure that the tail wheel locking pin was unlocked. The description of the taxi manoeuvre is covered in the SMG, but the only mention of the tail wheel locking pin is to say that it should be unlocked prior

to taxiing. There is no description of a turn in either direction, nor is there a discussion of the rationale for such a turn. No written description of a standard means of unlocking the tail wheel locking pin was found in the course of the investigation.

Despite the absence of a documented procedure, testimony indicated that the procedures used by the co-pilot were accepted as standard procedure and taught during the pilot conversion course. The co-pilot had only recently graduated from the OTU, and testimony indicated that he interpreted the procedure as being obligatory. The instructor pilot, however, did not believe a left turn to be mandatory and did not expect one. The lack of a documented procedure likely contributed to differing expectations in the cockpit and the distraction of both pilots at a critical moment.

2.6.2. Weight and Balance

The Waterbird is a special configuration of Sea King that is uniquely adapted to fresh water operations. Consequently, each year an airframe is selected for configuration as the dedicated Waterbird aircraft. A review of the servicing documentation showed that errors were made in the weight and balance form which indicated that certain pieces of equipment were installed, when in fact they had been removed. The change of Centre of Gravity was not significant and certainly not contributory in this occurrence; however, it did highlight an area of potential concern. It is critical that all configuration changes be accurately reflected in the documentation and that documentation be kept up to date.

3. CONCLUSIONS

3.1. Findings

3.1.1. The aircraft was serviceable prior to the accident.

3.1.2. The crew was qualified and authorised to conduct the mission.

3.1.3. Both pilots were medically fit at the time of the occurrence.

3.1.4. The weather was not a contributing factor to the accident.

3.1.5. The Instructor Pilot had not participated in CRM training since 1996.

3.1.6. Lack of current CRM procedures is not considered causal in this occurrence.

3.1.7. The instructor assumed that the co-pilot could safely ground taxi without supervision.

3.1.8. Both pilots were distracted by the proximity of other Sea Kings parked on the ramp in front of their aircraft.

3.1.9. The student co-pilot's unannounced left turn increased the instructor's concern about lateral clearance from the other aircraft.

3.1.10. Both pilots were concentrating their attention out the right side window while the student pilot was increasing collective and forward cyclic input.

3.1.11. The student co-pilot made flight control inputs in cyclic and collective without visual reference to the horizon, the tip path plane or the torque gauge.

3.1.12. The initial attitude change was gentle enough to be imperceptible to the aircrew without visual stimuli.

3.1.13. Both pilots reacted instinctively in that they pulled back abruptly on the cyclic and bottomed the collective as soon as they became aware that the nose of the aircraft was in jeopardy of striking the ground.

3.1.14. The tail wheel assembly failed under the forces of ground impact that resulted from the abrupt control inputs of both pilots.

3.1.15. The main rotor blade impacted the tail rotor drive shaft because of the abrupt aft cyclic input in concert with a rapid reduction of collective.

3.2. Cause and Contributing Factors

3.2.1. While conducting a ground taxi manoeuvre, both pilots were concerned about the proximity of other aircraft on the ramp. Thus concentrating on obstacle clearance, both pilots focussed their attention out the right side pilot's window during a rapid right turn, and lost situational awareness of the aircraft flight control inputs. Both pilots reacted instinctively when they suddenly realised that the aircraft was rotating forward and they pulled back abruptly on the cyclic. The result was C category damage to the aircraft.

3.2.2. Despite a clear briefing by the instructor as to his expectations for taxiing from the ramp, the co-pilot assumed that a learned procedure to unlock the tail wheel, although not published as a standard manoeuvre, had to be applied before starting to taxi. He did not communicate this belief to the instructor and when an unexpected turn started, the instructor pilot was surprised and distracted. This caused the instructor to focus on obstacle clearance at the expense of aircraft control.

3.2.3. Contributing to the occurrence was the relative simplicity of the required manoeuvre and the instructor’s belief that it was not necessary to closely monitor the co-pilot's flight control inputs.

4. SAFETY ACTION

4.1. Safety Action Taken

The Commanding Officer of HT 406 and the Wing Commander 12 Wing were debriefed on the preliminary findings of the investigation. The Squadron was subsequently briefed by the Commanding Officer and reminded to be vigilant even during the most benign flight conditions.

4.2. Safety Action Recommended

4.2.1. This occurrence should be used as a case study for future flight instructor training, to highlight the ease and rapidity with which an unsafe condition can develop, and to emphasise the techniques required to combat such occurrences.

4.2.2. The Standard Manoeuvre Guide should be amended to give specific direction about the techniques and procedures required for taxiing, including a procedure for unlocking the tail wheel.

4.3. Other Safety Concerns

N/A

4.4. DFS Comments

The circumstances surrounding this accident seemed benign: a qualified pilot at the controls under the supervision of a Qualified Flight Instructor conducting a routine manoeuvre. Yet it very quickly degenerated into an expensive accident which could have been even worse. This is another example of why instructors, whatever their aircraft or situation, must expect the unexpected. Aircraft captains without the benefit of flight instructor training, and indeed every member of every crew, must also remain vigilant because this scenario could have been repeated with any crew. This accident also highlights the absolute requirement for a confluence of expectations. While cockpit communication and crew co-ordination do not come out as causal, it is never wrong to verbalize intentions; that may have prevented this accident. In this situation, more detail in the documented standard procedures would have also helped to avoid differing expectations and thus confusion in the cockpit. Finally, while CRM training may not have made a difference here, it is disappointing that we can still find crew members lacking currency in this mandated programme.

R.E.K. Harder
Colonel
Director of Flight Safety

Annex A

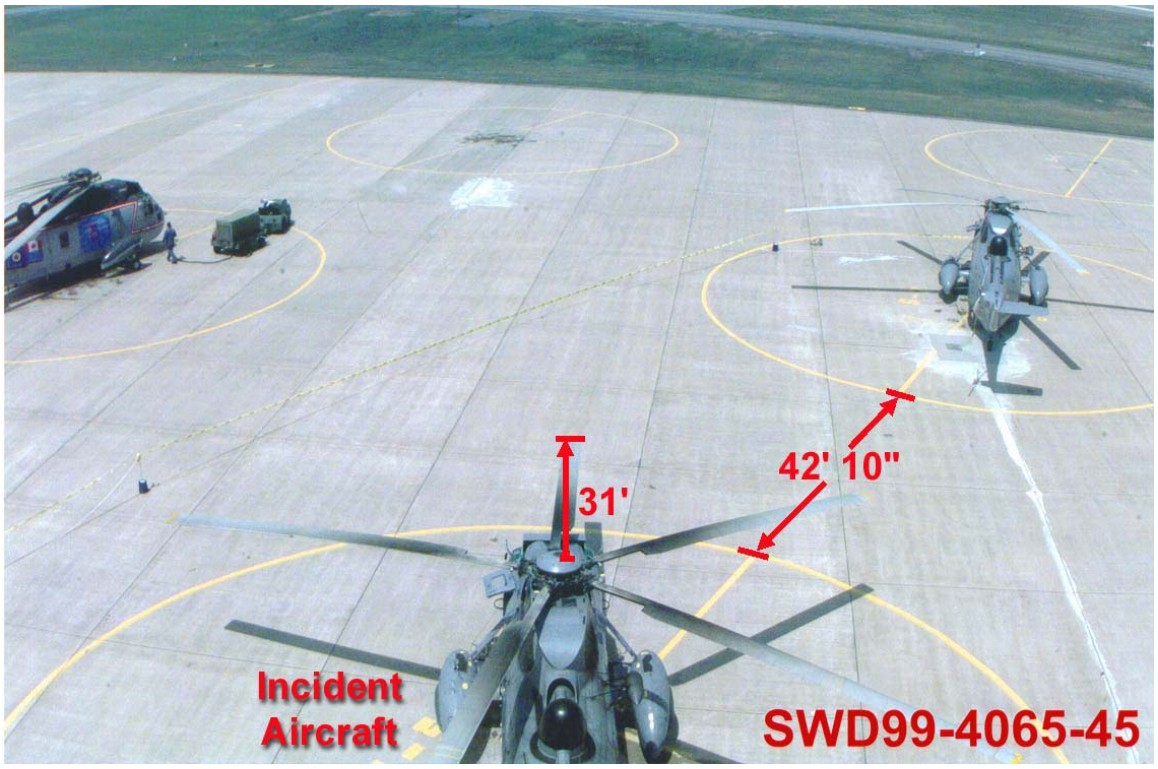

Figure 5: Post-Crash Location of Incident Aircraft