Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A11H0001

INADVERTENT DESCENT DURING DEPARTURE

COUGAR HELICOPTERS INC.
SIKORSKY S-92A (HELICOPTER), C-GQCH
ST. JOHN'S, NEWFOUNDLAND AND LABRADOR, 200 NM E
23 JULY 2011

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Aviation Investigation Report

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23 July 2011

Report Number A11H0001

Summary

On 23 July 2011, at 1457 Newfoundland and Labrador Daylight Time, a Cougar Helicopters' Sikorsky S-92A (registration C-GQCH, serial number 920074), operated as Cougar 851, departed the Sea Rose floating production, storage, and offloading vessel, with 5 passengers and 2 flight crew members on board, for St. John's International Airport, Newfoundland and Labrador. After engaging the go-around mode of the automatic flight control system during the departure, the helicopter's pitch attitude increased to approximately 23° nose-up while in instrument meteorological conditions. A rapid loss of airspeed occurred. After reaching a maximum altitude of 541 feet above sea level (534 feet radar altitude), the helicopter began descending towards the water in a nose-high attitude at low indicated airspeed. The descent was arrested 38 feet above the surface of the water. After approximately 5 seconds in the hover, the helicopter departed and flew to St. John's. The helicopter's transmission limits were exceeded during the recovery. There was no damage to the helicopter and there were no injuries.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 History of the Flight

At 1241, [1] Cougar Helicopters Inc. (Cougar Helicopters) flight 851 departed St. John's International Airport (CYYT), Newfoundland and Labrador, on an instrument flight rules (IFR) flight plan, with planned stops at the Global Santa Fe oil rig and the Sea Rose floating production, storage, and offloading vessel. [2] The purpose of the flight was to transport offshore oil workers to and from these facilities, located approximately 200 nautical miles (nm) east of CYYT. The occurrence flight was conducted in accordance with *Canadian Aviation Regulations* (CARs) subpart 704.

The captain, seated in the right pilot seat, was the pilot flying (PF) for the first leg of the flight, from CYYT to just before the approach to the Global Santa Fe. The captain handed control over to the first officer, who flew an instrument approach to the Global Santa Fe and carried out the landing on the platform. While on the Global Santa Fe, 4 passengers disembarked and 1 passenger boarded the helicopter. From the deck of the Global Santa Fe, the flight crew could see the Sea Rose, approximately 3.4 nm away. [3]

The first officer resumed PF duties for the departure, and carried out a standard rig departure using the go-around (GA) autopilot mode. A standard rig departure consists of a vertical departure to 30 feet above the deck height, and then a 10° nose-down attitude to accelerate to the take-off safety speed (V_{TOSS}). [4] As the helicopter's airspeed reaches V_{TOSS}, the pilot increases the attitude of the helicopter to approximately 5° nose-up and continues to climb out at V_{TOSS}. At the same time, the pilot monitoring (PM) verifies that the helicopter is maintaining a positive rate of climb and then raises the landing gear. At that point, the PF will engage the desired autopilot modes, such as the GA autopilot mode or vertical speed (VS).

After levelling at 500 feet above sea level (asl), the captain took control of the helicopter. At that altitude, the flight crew members were able to see down through the 100 to 150-foot thick cloud layer and see the Sea Rose and the standby vessel, which was positioned 0.5 nm downwind of the Sea Rose. Based on the flight conditions, the captain elected to carry out a visual approach and landing on the Sea Rose platform, which is 120 feet above the surface of the ocean.

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1 All times are Newfoundland and Labrador Daylight Time (Coordinated Universal Time minus 2.5 hours).

2 The registered names of the 2 vessels are the GSF Grand Banks and the SeaRose FPSO.

3 At the time of the occurrence, the Global Santa Fe was 3.4 nm from the Sea Rose. The Global Santa Fe has moved since the occurrence.

4 The take-off safety speed is the airspeed that will produce a steady rate of climb, out of ground effect, of not less than 100 feet per minute (fpm) at maximum continuous power applied to the operating engine, and with the helicopter loaded to the gross take-off weight specified for the ambient condition. If the aircraft is below the maximum gross weight, the associated rate of climb for V_{TOSS} will be greater than 100 fpm. (Source: Cougar Helicopters *SK-92 Helicopter Standard Operating Procedures*)

After landing and hot refueling [5] on the Sea Rose, in accordance with Cougar Helicopters' *SK-92 Helicopter Standard Operating Procedures (SOPs)*, 5 passengers [6] boarded the helicopter for the return flight to CYYT.

The captain remained at the controls for the departure. After completing a full departure brief, the captain depressed the cyclic force trim release button [7] (Figure 1), and at 1457:27, brought the helicopter into a 10-foot hover above the heli-pad. The helicopter was then turned to the left to allow for an into-wind departure away from the Sea Rose. The collective lever was then increased to initiate a vertical climb, as per Cougar Helicopters' take-off procedure for category A rigs.

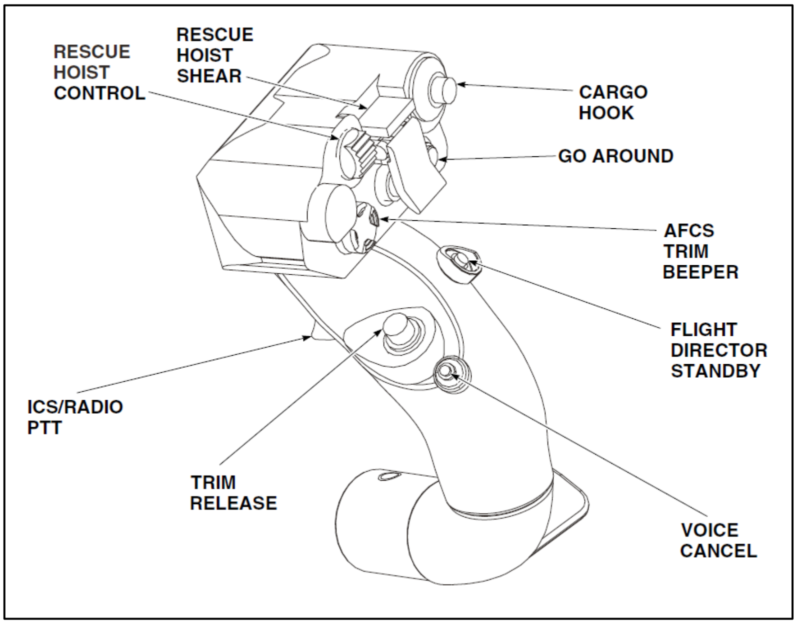

Figure 1. S-92A cyclic control stick (Source: S-92A Rotorcraft Flight Manual [2011])

As the helicopter climbed vertically towards the critical decision point (CDP), [8] its pitch attitude was approximately 8° nose-up. Once through the CDP, the captain moved the cyclic forward rapidly, [9] and adopted a 12° nose-down attitude for the initial acceleration. [10] This initial attitude change took approximately

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5 Hot refueling is a process in which a helicopter is refueled while the engines are still operating.

6 The total number of 5 passengers includes the passenger from the previous leg, as well as 4 other passengers.

7 In all automatic flight control system (AFCS) modes, pressing and holding the cyclic force trim release button disengages the magnetic brake, which provides artificial feel, allowing the pilot to move the cyclic with very little resistance. The alternative method for making attitude changes in attitude retention mode is to use the cyclic trim beeper. The lateral beeper function will move the cyclic left or right at a rate of 3 to 5° per second, to a maximum of 30° of bank. The longitudinal beeper function will change the commanded pitch attitude at a rate of 2 to 3° per second. (Source: *S-92A Pilot Training Manual* [2009])

8 For offshore rig departures, the CDP is used by flight crews to determine whether or not a take-off procedure shall be aborted if an engine fails. If an engine failure occurs prior to the CDP, the flight crew shall abort the take-off. If an engine fails at or after the CDP, the helicopter will be able to continue the take-off procedure by accelerating to the Category A rotorcraft takeoff safety speed (V_{TOSS}), and then to a speed that will allow for the best rate of climb (V_Y). For offshore rig departures, the CDP is 30 feet above the platform. (Source: *Cougar Helicopters S-92A SOPs*)

9 The longitudinal cyclic control movement from 6 to 22° was completed in 0.6 seconds.

3 seconds. After initially reaching 12° nose-down, the helicopter's pitch attitude stabilized at 9° nose-down. The first officer advised the captain that airspeed was indicating and then called V_{TOSS}, which corresponded to 36 knots indicated airspeed (KIAS). As the airspeed reached V_{TOSS}, the helicopter entered the cloud bank based at 200 feet asl. As per Cougar Helicopters' SOPs, the captain leveled the helicopter by applying aft cyclic to establish the normal climb-out pitch attitude (approximately 5° nose-up). The helicopter continued to climb, and both the airspeed and vertical speed continued to increase. Seconds later, as the helicopter accelerated through 55 KIAS, the first officer indicated that they had a positive rate of climb (600-700 feet per minute [fpm]).

In accordance with Cougar Helicopters' SOPs, the captain requested that the first officer raise the gear and place the flotation switch to SAFE. At 1458:00, the captain released the force trim release button on the cyclic. At 1458:04, the captain engaged the GA mode at 64 KIAS. At this point, the pitch attitude was not stable and was increasing through 2.4° nose-up. The helicopter's heading at the time was 073° magnetic (M), and the vertical speed was 1000 fpm up, and increasing. As the helicopter climbed, there was a noticeable increase in ambient light inside the helicopter, which was interpreted as meaning that the helicopter would soon be in clear skies above the cloud bank. Immediately following GA mode activation, the indicated airspeed index moved to 80 knots, [11] the vertical speed indicator (VSI) reference bug was set to 750 fpm, and the magenta command bars appeared on both primary flight displays (PFDs). Neither pilot noticed if the appropriate autopilot pitch and collective cues appeared on the top portion of the PFDs.

The captain then released hand pressure on the cyclic and used the automatic flight control system (AFCS) trim beeper on the cyclic to set the airspeed reference to 120 KIAS. While the captain was advancing the airspeed reference, the helicopter's pitch continued to increase, exceeding 9° nose-up. The airspeed, which reached a maximum of 67 KIAS at 1458:06, began to decrease rapidly. The rate of climb, which had peaked at 1500 fpm within 1 second of engaging the GA mode, also began to decrease. As the airspeed decreased through 56 KIAS, with the pitch attitude briefly stabilized at 9.5° nose-up, the captain momentarily pressed the force trim release button and made an abrupt aft cyclic input. [12] When the captain released the force trim release button, the airspeed reference reset to 54 KIAS. At 1458:13, the indicated airspeed dropped below 50 knots, which is the minimum control speed in instrument meteorological conditions (V_{MINI}) for the S-92A, and the autopilot automatically decoupled. The decoupling of the autopilot triggered a master caution, a flight director (FD) degraded caution, and an aural decouple alert. [13]

Once the autopilot decoupled, the pitch of the helicopter quickly increased to 15° nose-up, and then continued to increase at a slower rate. Eight seconds later, at 1458:21, at a 23° nose-high attitude, the helicopter reached a maximum altitude of 541 feet asl (534 feet radar altitude) and started descending and yawing to the right, at an indicated airspeed of 33 knots, and

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10 According to the SOPs, the pitch angle for departure is 10° nose-down, as indicated on the horizontal situation indicator (HSI).

11 The best rate of climb for the S-92A is 80 KIAS. (Source: S-92A Rotorcraft Flight Manual [2011])

12 The longitudinal cyclic position moved aft from 19.5° to 14.5° within 0.5 seconds.

13 This alert occurs when the flight director is decoupled either intentionally by the pilot or unintentionally due to a malfunction. The aural alert will sound twice.

decreasing. At that time, both flight crew members were focused on the flight instruments and were not looking outside.

As the aircraft began descending in a nose-high attitude at low airspeed, the first officer recognized the deviation from the standard profile and began making attitude and airspeed deviation calls. The captain, whose attention was focused on the attitude indicator, acknowledged these deviation calls and indicated that corrective action was being taken. At 1458:28, as the helicopter descended through 454 feet asl (437 feet radar altitude), the helicopter's enhanced ground proximity warning system (EGPWS) began making an automated "Don't sink" aural alert to the pilots, and remained on for 11 seconds. The rate of descent at the time was 1375 fpm. While descending, the first officer made attitude and airspeed calls at least 2 more times and also advised the captain to lower the nose of the helicopter. The captain acknowledged these calls and advised that corrections were being made. During the descent, the captain depressed and held the cyclic force trim release button, and attempted to lower the nose of the helicopter by gradually applying forward pressure on the cyclic. The gradual application of forward cyclic input caused the helicopter's pitch attitude to reduce very slowly from a maximum of 23° nose-up to approximately 10° nose-up just prior to descending below the base of the clouds.

As the helicopter descended through 200 feet asl, it broke out of the clouds, and the flight crew was able to see the water below. At 1458:38, the captain increased collective pitch; both engines increased power, reaching a maximum torque of 132% on engine No. 1 and 129% on engine No. 2. Despite the increased power outputs, the main rotor rpm (Nr) decreased from 105%, reaching a minimum value of 91.2%. As the main rotor speed decreased through 95%, the aural "Low rotor" alert sounded, and the associated red warning light appeared on the master warning panel. [14] At the same time, the EGPWS aural alert changed from the "Don't sink" alert to the landing gear aural warning ("Too low gear"), [15] due to the fact that the landing gear was in the up position at a radar altitude below 150 feet above ground level (agl).

In response to the low rotor warning, the first officer advised the captain to lower the collective. The captain acknowledged and lowered the collective slightly to regain Nr. The first officer then re-armed the flotation in anticipation of water impact. The heading, which had been increasing (nose turning to the right) during the descent, reached a maximum of 209°M as collective was applied to arrest the descent, and then slowly started to decrease.

At 1458:53, the descent was arrested 38 feet above the water, on a heading of 153°M. Sea spray was being kicked up by the helicopter's rotorwash and it was covering the windows. A total of 32 seconds elapsed from the time the helicopter reached 541 feet asl (534 feet radar altitude) and the time it was established in the hover. While in the hover, the flight crew quickly scanned the cockpit for any anomalies and then departed for St. John's a few seconds later. Neither pilot was aware that the helicopter had experienced a torque exceedance during the application of collective to arrest the descent. During the subsequent departure, the captain engaged the GA

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14 The LOW ROTOR light is located on the master warning panel above the outboard multi-function displays. If Nr drops below 95% and weight-on-wheels is not detected, the LOW ROTOR light will illuminate and the "Low rotor" aural alert will sound continuously until Nr increases above 95%, the helicopter has landed, or the VOICE CNCL button on the cyclic has been pressed.

15 This warning is activated when airspeed is below 60 KIAS and the radar altitude is below 150 feet.

mode, and the helicopter climbed through 200 feet radar altitude with an airspeed of 60 KIAS. The profile was carried out without any deviations in attitude or airspeed. The GA mode was disengaged at 1501:23 as the helicopter climbed through 1880 feet radar altitude and proceeded back to CYYT.

1.2 Injuries to Persons

Table 1. Injuries to persons

	Crew	Passengers	Others	Total
Fatal	-	–	–	-
Serious	–	–	–	–
Minor	-	-	–	-
None	2	5	–	7
Total	2	5	-	7

1.3 Damage to Aircraft

The aircraft did not sustain any damage.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

1.5.1 General

Table 2. Personnel information

	Captain	First officer
Licence	Airline transport pilot licence—Helicopter	Airline transport pilot licence—Helicopter
Medical expiry date	01 December 2011	01 November 2011
Total flying hours	18 094	18 643
Total instrument flight hours	3000	8000+
Total flying hours on helicopter	18 094	989
Hours on type	1203	804
Hours last 30 days	33	22

1.5.2 Captain

The captain was certified and qualified for the flight in accordance with existing regulations. The captain held a Canadian airline transport pilot licence (ATPL) — helicopter, with type ratings on the Bell 206, Bell 212, Bell 47, Eurocopter AS350, Eurocopter AS355, and Sikorsky S-92A. The captain's licence was endorsed with a Group 4 instrument rating valid until 01 July 2012.

Prior to joining Cougar Helicopters, the captain accumulated extensive experience flying light single-engine and medium twin-engine helicopters, mostly under visual flight rules (VFR). In April 2008, the captain was hired by Cougar Helicopters as an S-92A first officer. The captain completed the initial S-92A conversion at Flight Safety International (FSI) on 14 May 2008. The captain's first 2 attempts at passing the pilot proficiency check (PPC) and the instrument flight check (IFC) were unsuccessful. The captain passed the PPC and IFR on the third attempt on 19 June 2008.

The captain returned to FSI in May 2009 for annual recurrent training. During training, it was noted that the captain had difficulties with unusual attitude recoveries due to miscues interpreting flight director information and some overcontrolling. The training report noted that the captain was able to fly a much more controlled recovery following retraining. The report stated that the captain tended to "overfly" the trim and "work harder than necessary", and struggled with turning manoeuvres due to a "lack of understanding with trim functions". The training report recommended more work with the coupled flight director.

Although not required by regulation, the captain completed a 2-day crew resource management (CRM) workshop at Cougar Helicopters in November 2009.

In April 2010, the captain underwent a line proficiency check (LPC) for captaincy. During that simulator session, the captain experienced difficulties with an emergency, which was followed by a decrease in airspeed, a nose-high attitude, and a loss of altitude. As a result of this LPC, the captain was not recommended for captain line indoctrination training. The LPC indicated that the pilot required better situational awareness and improved instrument scanning techniques.

In November 2010, the captain completed the line indoctrination and transition to captain training. [16] A total of 4 flights were carried out, with all items being assessed as satisfactory. The captain's training file included a form that indicated that the captain had been released to line duties as pilot-in-command (PIC). The captain had 1013 hours on type at the time of this upgrade.

In March 2011, the captain received additional CRM training during recurrent simulator training.

The captain's flight and duty time limits were not exceeded. On the day of the occurrence, the captain reported to work around 0800, and there was no indication that fatigue was a factor.

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16 This is an internal training program within Cougar Helicopters.

1.5.3 First Officer

The first officer was certified and qualified for the flight in accordance with existing regulations. The first officer held a Canadian ATPL — helicopter, with type ratings on the Kamov KA-32, the Robinson R-22, and the Sikorsky S-92A. The first officer's licence was endorsed with a Group 4 instrument rating valid until 01 May 2012.

The first officer was hired by Cougar Helicopters in December 2007. Prior to this, the first officer had no helicopter flight experience. The first officer had been employed as an offshore fixed-wing pilot, operating out of CYYT, for several years prior to this employment with Cougar Helicopters. The first officer was hired by Cougar Helicopters because of an extensive IFR experience in the offshore area of Newfoundland and a desire to remain in St. John's. At the time the first officer was hired, Cougar Helicopters was having a difficult time finding experienced IFR helicopter pilots who wanted to live in the St. John's area.

From December 2007 to January 2008, the first officer completed helicopter training on a Robinson R-22 and received a commercial helicopter pilot licence. From January to February 2008, the first officer completed the initial S-92A conversion at FSI in West Palm Beach, Florida.

Although not required by regulation, the first officer completed a two-day CRM workshop at Cougar Helicopters in November 2009. In May 2011, the first officer received additional CRM training during recurrent simulator training.

The first officer's flight and duty time limits were not exceeded. On the day of the occurrence, the first officer reported to work around 0800, and there was no indication that fatigue was a factor.

1.6 Aircraft Information

1.6.1 General

The S-92A is a four-bladed twin-engine medium-lift helicopter built by Sikorsky Aircraft Corporation. The occurrence helicopter was configured to carry 2 crew members and up to 17 passengers in the cabin. The helicopter was certified and equipped in accordance with existing regulations. Nothing was found to indicate that there was a system malfunction prior to or during the flight, and the helicopter was within its weight and centre-of-gravity limits.

The S-92A incorporates a feature built into the full-authority digital engine control (FADEC) which provides engine and main gearbox protection by preventing the pilot from exceeding posted limits during normal operations. The system is designed to limit fuel flow when either the all-engines-operating torque or temperature limits are reached. Once either of those conditions occurs, fuel flow limitation will cause the Nr to decrease or droop. However, these limits can be shifted upwards via a blowaway logic when additional power is required in extreme flight conditions. If the power demands cause the Nr to droop below 100%, the blowaway feature will activate and more power will be available to the pilots, even if it results in a torque exceedance.

In this occurrence, the helicopter's all-engines-operating torque limits were exceeded, reaching a maximum of 132% engine torque on engine No. 1 and 129% on engine No. 2. There is no normal or emergency in-flight procedure for a torque exceedance. Sikorsky does not require in-flight corrective action following a torque exceedance, but it does require a post-flight maintenance action. Since the duration of the torque exceedance above 120% was 1.5 seconds, Cougar Helicopters was only required to carry out a conditional inspection. The inspection revealed no faults, and the helicopter was returned to service.

Following the occurrence, Cougar Helicopters carried out additional flight testing, and no anomalies were detected. During this flight testing, the flight crew was able to recreate a sequence of events similar to those of the occurrence flight by applying forward cyclic pressure against the force trim, then engaging the GA mode and releasing the forward cyclic pressure.

1.6.2 Helicopter Aerodynamics

As a helicopter's airspeed increases, the increase of airflow through the rotor system causes a natural pitch-up tendency. This aerodynamic phenomenon is called blowback. To counteract this pitch-up tendency, the pilot must apply forward cyclic commensurate with the rate of pitch-up to maintain the appropriate accelerating attitude. [17] If not corrected, this could result in a significant nose-high attitude and a deterioration of airspeed.

1.6.3 Occurrence Flight Parameters

Based on the data recovered from the multi-purpose flight recorder (MPFR), the investigation was able to determine the rate of change and the position of the flight controls throughout the occurrence. During the initial portion of the departure, while transitioning to forward flight, the helicopter's pitch attitude decreased at an average rate of almost 7° per second, with a maximum pitch rate of 11.25° per second. Then, as the helicopter accelerated, the pitch attitude increased at a rate of 5.6° per second. In addition, the data revealed that the cyclic force trim release button was released at a significant aft cyclic control position, with a nose-high pitch-up rate approximately 10 times greater than the previous 4 GA engagements.

When the autopilot decoupled, the helicopter's rate of climb had decreased from 1500 to 850 fpm. The vertical speed briefly stabilized at a climb rate of 750 fpm, and then decreased rapidly. When the helicopter descended below the base of the clouds, the rate of descent reached a peak value of 1880 fpm at 152 feet above the water. The rate of descent then began to decrease in response to the large collective input initiated to arrest the descent. See Appendix B for a profile depiction of the occurrence helicopter's departure profile.

The flight data recorder (FDR) data also revealed that the helicopter remained in a near wings-level roll attitude during the inadvertent descent. It also revealed that the helicopter descended in a nose-high pitch attitude for approximately 16 seconds, with no increase in the collective. As the helicopter descended below the base of the clouds, the pitch was adjusted to slightly above the horizon, and collective was applied to arrest the descent. From GA engagement until established in the hover, the helicopter yawed unintentionally 120° to the right.

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17 United States Navy, *Introduction to Helicopter Aerodynamics Workbook*, CNATRA P-401 (Rev 09-00), 2000.

1.7 Meteorological Information

At the time of the occurrence, the reported weather at the Sea Rose was an overcast ceiling based at 200 feet above the water, with visibility of 5 to 6 statute miles. The top of the overcast layer was at approximately 300 to 350 feet asl. The winds were reported to be from 110°M at 6 knots, and the altimeter setting was 29.78 inches of mercury. At the time of the occurrence, the reported seas were gentle swells of 1.9 metres.

1.8 Aids to Navigation

There was no indication of problems with the available aids to navigation.

1.9 Communications

No difficulties were noted in the quality of radio transmissions.

1.10 Aerodrome Information

Not relevant to the incident.

1.11 Flight Recorders

The occurrence helicopter was equipped with a Penny & Giles MPFR, which records both FDR data and cockpit voice recorder (CVR) audio on crash-protected solid-state memory. The MPFR records 25 hours of FDR data and 2 hours of CVR data. It then overwrites itself.

The MPFR was not immediately secured following the occurrence flight. Instead, an engine wash was carried out along with some routine maintenance tasks. It was not until after this additional work had been done on the helicopter that the MPFR data was downloaded by Cougar Helicopters. As a result of these delays in preserving the MPFR data, all CVR data for the occurrence was overwritten. The CVR data begins shortly after the helicopter was established at its cruising altitude for the return flight to CYYT. At the time of the occurrence, Cougar Helicopters did not have a CVR protection policy or procedure in effect.

The Transportation Safety Board (TSB) has previously documented numerous examples where critical FDR or CVR data was not available to assist an investigation because it was not secured following an occurrence. [18]

While the CVR data for the occurrence was lost, all FDR data for the occurrence was retrieved from the MPFR. This data provided important details about the occurrence flight and was instrumental in the investigation. The data also provided details about the 4 previous GA engagements for comparison purposes.

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[18] Some examples include TSB aviation investigation reports A08Q0171, A08W0001, A08C0164, and A08C0108.

1.12 Wreckage and Impact Information

Not relevant to the incident.

1.13 Medical and Pathological Information

There are no known medical problems that would have affected the crew's performance.

1.14 Fire

There was no fire.

1.15 Survival Aspects

Not relevant to the incident.

1.16 Tests and Research

Not relevant to the incident.

1.17 Organizational and Management Information

1.17.1 General

Cougar Helicopters, which was established in 1986, holds operating certificates for operations under CARs subparts 704 and 702. The company has operating bases in St. John's, Newfoundland and Labrador, and Halifax, Nova Scotia. Cougar Helicopters is employed extensively in offshore transportation, and is also involved in search and rescue activities as well as emergency medical services. The Cougar Helicopters' fleet consists of 7 Sikorsky S-92As, 1 Sikorsky S-76A++, and 1 AugustaWestland AW139. At the time of report writing, the company had a total of 281 employees, as follows:

Table 3. Breakdown of Cougar Helicopters employees

Management	5
Dispatch	12
Rescue specialists	23
Pilots	56
Engineers	86
Support staff	99

In 2004, Cougar Helicopters was acquired by, and became a part of, the Vancouver Island Helicopters (VIH) Aviation group. VIH was established in Victoria, British Columbia, in 1955. In addition to charter helicopter operations around the world, the VIH Aviation Group operates a helicopter repair centre, a corporate aircraft operation, and a servicing facility at the Victoria International Airport

1.17.2 Cougar Helicopters' Safety Management System

1.17.2.1 General

Although not required to by regulation, Cougar Helicopters had implemented an integrated safety management system (SMS) that included a non-punitive reporting system. Cougar Helicopters' SMS manual outlined the company's safety policy, which stated in part that Cougar Helicopters' accountable executive is committed to:

> A culture of open reporting of all safety hazards in which management will not initiate disciplinary action against any personnel who, in good faith, discloses a hazard or safety occurrence due to unintentional conduct (non punitive reporting); and
>
> Requiring all employees to have the duty to maintain a safe work environment through adherence to approved policies, procedures, and training, and shall familiarize themselves, and comply with safety policies and procedures. [19]

It goes on to state:

> We consider ourselves a learning organization; to this end, management will initiate reviews of all incidents and accidents in the workplace, with the aim of determining cause rather than blame and address safety concerns at regular meetings of management and staff.
>
> All employees must accept their responsibility to comply with Aviation Safety and HS&E legislation, regulations, Company rules and procedures. Employees and contractors are expected to work in a manner which safeguards themselves, co-workers, passengers and all those connected with our business, and to bring to management's attention any process or activity which they consider is not in line with this policy. [20]

Cougar Helicopters' safety management system policy, dated 27 May 2010, states that "the company maintains a Just Safety Culture and will not impose discipline upon employees who report hazards or events unless actions found to be reckless violations, sabotage or malevolent acts." [21] Likewise, in a section of Cougar Helicopters' SMS manual, titled Non-Punitive Reporting, it is stated that:

> Cougar Helicopters Inc. supports a just and learning approach that does not seek to apportion blame as its primary thrust. It is recognized that human error can occur and when this happens it is vital that all possible lessons are derived and shared within the organization in a timely fashion. In such cases blame and subsequent punishment will not be

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[19] Cougar Helicopters safety management system (SMS) manual (2010).

[20] Ibid.

[21] Ibid., page 7

> delivered as the resolution to the problem, but this will not absolve all those involved, directly or indirectly, from accepting the responsibility for their part. In cases of gross negligence or deliberate violation, appropriate disciplinary action shall be taken, up to and including dismissal. [22]

The reporting of hazards is key to the effectiveness of safety management systems. A non-punitive reporting policy encourages open reporting of safety occurrences. If personnel are concerned that there will be disciplinary action as a result of reporting, there will be increased pressure to withhold that information for fear of career implications.

The importance of a non-punitive reporting system is also outlined in Cougar Helicopters' SOPs. According to the company SOPs, the Cougar Helicopters Aviation Resource Management (CHARM) program's effectiveness depends on 3 critical pillars:

> 1. Trust – both up and down the chain of accountability. Effective error management requires trust between management and employees regarding their shared commitment to safety;
> 2. A non-punitive policy toward error that encourages crews to share their errors and to participate in actions to prevent recurrence; and
> 3. Management commitment to taking action to reduce error-inducing conditions. [23]

While en route back to CYYT, the captain and first officer discussed the requirement to file an SMS report, and indicated that they would have to advise the director of flight operations (DFO) and the company chief pilot (CP) of the occurrence. Upon landing, the flight crew submitted an SMS report and cooperated with Cougar Helicopters' SMS investigation.

1.17.2.2 Helicopter Flight Data Monitoring

As part of its SMS, Cougar Helicopters has created a helicopter flight data monitoring (HFDM) program. Through careful monitoring of the FDR, the HFDM program helps determine trends and also monitors for exceedances of company-defined parameters. As described in a Cougar Helicopters presentation, the intent of the HFDM program is "to use the data for debriefing, education, and reviewing training and SOPs." [24] At the end of every day, flight data from each helicopter's flight recorder is downloaded and transferred to the HFDM workstation, where it is analyzed for flight control quality and to detect deviations from Cougar Helicopters' SOPs. When there is some type of abnormal reading, the data is reviewed by an internal HFDM committee. According to Cougar Helicopters' *Company Operations Manual*, the HFDM committee is "responsible for confidential handling and analysis of flight data, pro-active liaison with aircrew, training personnel and the flight safety committee . . . ." The HFDM committee is comprised of the HFDM manager, the flight data analyst, an engineering interpreter, a safety representative, and at times other employees who are requested to participate in HFDM activities. If a review of the HFDM data determines that a significant event has occurred, the DFO and CP are advised.

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22 Ibid.

23 Cougar Helicopters standard operating procedures (SOPs) (2010)

24 Cougar Helicopters presentation given on 28 July 2011

1.17.2.3 Just Culture Decision Tree Model

According to Cougar Helicopters' SMS manual, the company employs the "Just Culture Decision Tree Model" (see Appendix C) "to ensure consistent, objective, fair treatment of all of our staff, and to assist senior managers in decision making related to employee discipline." The "Just Culture" approach views human error as a symptom, not a cause. As explained in *Just Culture: Balancing Safety and Accountability*, "human error is an effect of trouble deeper inside the system. To do something about a human error problem then we must turn to the system in which people work: the design of equipment, the usefulness of procedures, the existence of goal conflicts and production pressure." [25]

Cougar Helicopters' SMS manual explains that the Just Culture decision tree model is a tool "that senior management can use to decide what post incident disciplinary action, if any is appropriate when considering the actions of employees involved in a particular incident."

1.17.2.4 Cougar Helicopters' Safety Management System Investigation

The day of the occurrence, Cougar Helicopters began an internal SMS investigation, which was completed on 02 August 2011. The members of the investigation team were the chief pilot type S-92A, the director of safety, and a senior S-92A training pilot. The chief pilot type S-92A and the senior training pilot had previously been appointed to the HFDM committee. The investigation team conducted interviews with the flight crew and reviewed the FDR and the health and usage monitoring system (HUMS) data gathered through the company's HFDM program. During discussions with the flight crew, the HFDM committee members conducting the investigation asked the flight crew for their consent to listen to the CVR in an effort to better understand what happened during the occurrence flight. Both pilots gave their consent, and the CVR was removed from the helicopter. However, it was quickly determined that the CVR had been overwritten. Consequently, the remainder of the CVR was not listened to. The occurrence pilots and the HFDM committee members were not aware that the CVR is privileged by the *Canadian Transportation Accident Investigation and Safety Board Act* and may only be accessed in circumstances permitted by the Act.

The Cougar Helicopters SMS investigation report indicated that the occurrence was due to improper trim techniques and the failure to take the necessary steps to recover from a nose-high attitude. The report also stated that the Just Culture decision tree model was applied to both crew members. Using this model, the company determined that the first officer's role in the occurrence met the criteria for a "no blame error". Senior managers at the company indicated that the Just Culture decision tree model was used up to the "substitution test" step. At that point, senior management considered that the event revealed an underlying deficiency in the captain's skill set, and that training would not correct this deficiency. On 28 July 2011, the company decided to terminate the captain due to a loss of management confidence in the captain's ability to operate safely in the offshore IFR environment. It was decided to send the first officer for additional simulator training and an evaluation.

Company pilots were briefed on the details of the occurrence and were told that crew experience, crew training, and the autopilot system were ruled out as possible contributing factors. They were also advised that the captain had been terminated because the captain "made

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25 Sydney Dekker, Just Culture: Balancing Safety and Accountability (Ashgate, 2007).

no attempt to recover the aircraft from an easily recoverable situation which resulted in coming as close to a crash as you can without crashing." [26]

The TSB investigation determined that a perception existed among some employees that the company did not appear to act in accordance with the Just Culture decision tree model and its non-punitive reporting policy. As well, some perceived the decision may have been influenced by other factors, such as pressure from the Newfoundland offshore operators [27] (offshore operators), who have final approval of the pilots who transport their personnel to and from offshore facilities.

Following the company's SMS investigation, Cougar Helicopters made changes to the departure SOPs, published memos on autopilot engagement and unusual attitude recovery procedures, and enhanced unusual attitude training for pilots during recurrent simulator training.

1.18 Additional Information

1.18.1 Controlled Flight Into Terrain

In June 2012, the TSB released its updated Watchlist, which identifies the safety issues investigated by the TSB that pose the greatest risk to Canadians. To date, inadequate action has been taken by the industry and the regulator to eliminate the risks identified in the Watchlist. One of the issues identified in the Watchlist is collisions with land and water, commonly referred to as controlled flight into terrain (CFIT).

A CFIT occurs when a serviceable aircraft under the control of the pilot is inadvertently flown into the ground, water, or an obstacle. This type of accident often occurs during periods of reduced visibility, at night, or during poor weather.

In addition to CFITs, safety professionals are also concerned with controlled flight towards terrain (CFTT) incidents. A CFTT occurrence can best be described as an occurrence that was almost a CFIT accident, but that was avoided due to some type of pilot intervention. The National Aeronautics and Space Administration's (NASA) Aviation Safety Reporting System database contains almost 3000 reports of situations where a CFIT would have occurred had there not been some type of intervention before impact.

1.18.2 Enhanced Ground Proximity Warning Systems

In 1995, the TSB issued recommendation A95-10 to Transport Canada (TC) calling for the installation of ground proximity warning systems on all turbine-powered, IFR-approved, commuter and airline aircraft capable of carrying 10 or more passengers. In a 2005 update on the status of its efforts pertaining to recommendation A95-10, TC advised that the terrain awareness warning systems (TAWS) technology supersedes the ground proximity warning system (GPWS), and is certified to overcome the deficiencies inherent in GPWS. TAWS

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26 Source: Presentation given by Cougar Helicopters to company pilots on 28 July 2011.

27 The Newfoundland offshore operators are Husky Energy, Suncor Energy Inc., and the Hibernia Management and Development Company Ltd.

"provide the flight crew with both aural and visual alerts to aid in preventing inadvertent controlled flight into terrain, obstacles or water." [28]

In 2012, the TSB's Watchlist identified that there should be wider use of technology, such as TAWS, to help pilots assess their proximity to terrain. On 04 July 2012, TC issued regulations under CARs 605.42, 703.71, 704.71, and 705.85, requiring private and commercial turbine-powered aeroplanes, configured with 6 or more passenger seats and operating under IFR and/or night VFR, to be equipped with, and operate TAWS. However, these proposed regulatory changes apply only to aeroplanes, and are therefore not applicable to helicopters. According to the proposed regulatory changes, newly manufactured aeroplanes must immediately be equipped with TAWS, and 2 years after the date of promulgation, this regulation will apply to all similarly configured aeroplanes manufactured prior to promulgation. Since these changes will substantially reduce the safety deficiency identified in TSB recommendation 95-10, TC's response was assessed as Fully Satisfactory. [29]

The occurrence helicopter was equipped with a Honeywell Mark XXII enhanced ground proximity warning system (EGPWS), which meets the *Canadian Technical Standard Order* (CAN-TSO) C151b Class A requirements for TAWS. The basic modes of the occurrence helicopter's EGPWS are based on radar altitude, and they are designed to "prevent descent into level or evenly sloping terrain." The enhanced or forward-looking modes are based on the GPS position compared to terrain and obstacle databases. The look-ahead mode is inhibited when the helicopter's airspeed is less than 70 KIAS. According to the S-92A Rotorcraft Flight Manual (RFM), "the system is designed to provide a warning to the pilot in sufficient time to take corrective action to prevent CFIT while avoiding unnecessary false alarms." [30]

The various EGPWS modes are described in the S-92A RFM. Mode 1 is intended "to detect when the aircraft is descending toward terrain at a high rate for its relative altitude above terrain," using information from the air data computer and the radio altitude. However, due to an excessively high number of false alarms during normal approaches, Sikorsky and Honeywell jointly elected to disable Mode 1, based on the rationale that an excessive sink rate is historically not as much of an issue for helicopters as it is for fixed-wing aircraft.

Mode 2 of the EGPWS is a look-ahead mode, which provides alerts when the aircraft is closing with terrain at an excessive rate, either due to a descent or the projected flight path ahead of the helicopter.

Mode 3 provides alerts when the aircraft loses a significant amount of altitude immediately after takeoff. According to the S-92A RFM, Mode 3 is active after takeoff when the landing gear is raised or when the airspeed is greater than 50 KIAS. Mode 3 remains enabled until the helicopter has gained sufficient altitude so that other modes will protect against CFIT (normally

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[28] Transport Canada, *Advisory Circular (AC) No. 600-003*, "Regulations for Terrain Awareness Warning System,"2011.

[29] "A Fully Satisfactory rating is assigned if the action taken will substantially reduce or eliminate the safety deficiency. An acceptable alternative course of safety action to the one suggested by the recommendation may have been taken." (Transportation Safety Board of Canada, "Assessment rating guide")

[30] S-92A Rotorcraft Flight Manual (2011)

60 seconds after takeoff). However, to allow for a rejected takeoff or closed traffic pattern, [31] Mode 3 deactivates when airspeed decreases below 40 KIAS. According to the aircraft manufacturer, this logic is based on the assumption that if an inadvertent descent occurs during takeoff, it will not be accompanied by a significant reduction in airspeed. If the helicopter descends and slows down below 40 KIAS, the logic assumes that the pilot intends to carry out an intentional landing. It does not take rate of descent into account. This logic was deemed to be an acceptable compromise in order to avoid unwanted aural alerts during a rejected takeoff.

Mode 3 is based on an altitude-loss variable that is established according to the altitude at the beginning of the inadvertent descent (Figure 2). The amount of altitude loss permitted before an alert is given is dependent on the height of the helicopter above the terrain and the length of time since takeoff.

When a sink rate is detected, Mode 3 remains enabled until a sufficient amount of altitude is gained. This will result in an aural "Don't Sink" caution and a corresponding DON'T SINK yellow caution indication on the attitude director indicator (ADI). According to Cougar Helicopters' SK-92 SOPs, the PF's response to this caution is to call "Adjusting", to immediately increase power to maximum takeoff power, and to adjust the attitude of the helicopter to regain a positive rate of climb. Although different for each type of aircraft, this type of procedure is commonly referred to as a CFIT avoidance procedure.

Mode 4 of the S-92A EGPWS is designed to provide alerts to the pilot when the helicopter descends below a predetermined terrain clearance value or floor. This mode has 3 sub-modes, depending on the helicopter's airspeed and landing gear configuration.

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[31] A closed traffic pattern consists of successive operations involving takeoffs and landings or low approaches where the aircraft does not exit the traffic pattern (Source: Federal Aviation Administration, *Aeronautical Information Manual*, Pilot/Controller Glossary, 2012.)

Mode 4A is active in cruise and during approach when the gear is up. A "Too low terrain" aural alert and yellow TERRAIN caution on the ADI is given when the airspeed is above 60 KIAS and the radar altitude is below 150 feet. A "Too low gear" aural alert, a yellow GEAR caution on the ADI, and LDG GEAR will be illuminated on the master warning panels when the airspeed is at or below 60 KIAS and radar altitude is below 150 feet.

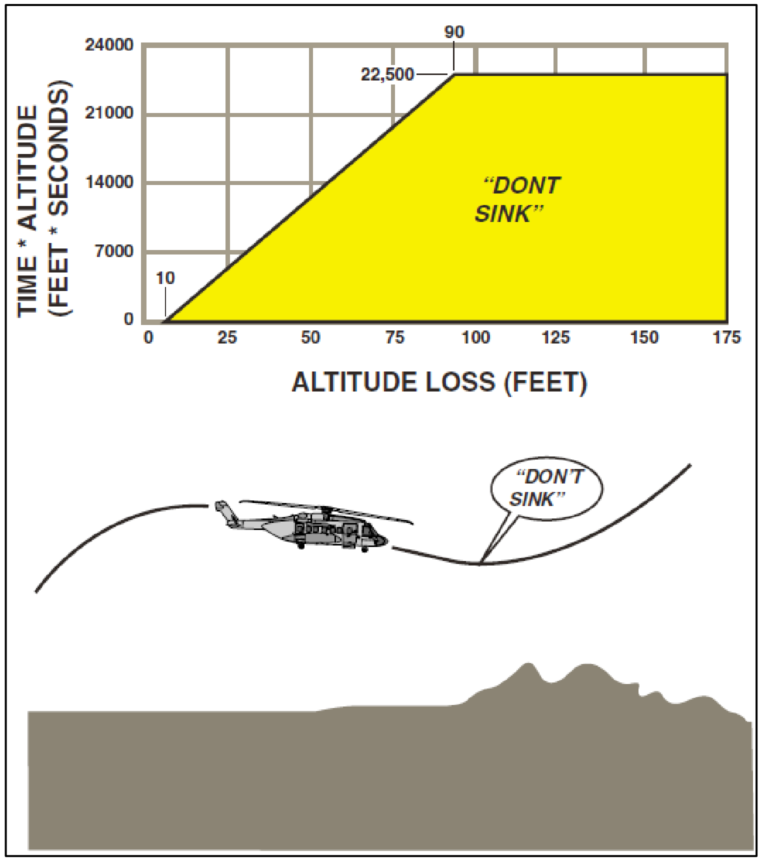

Figure 2. Mode 3 - Inadvertent descent after take-off envelope (Source: S-92A Rotorcraft Flight Manual [2011])

Mode 4B is active during cruise and approach when the gear is down. In this case, a "Too low terrain" aural alert is given when the radar altitude is below 100 feet and the airspeed is above 120 KIAS. As airspeed decreases, the alert boundary decreases to 10 feet and 80 KIAS.

Mode 4C is active during the takeoff phase when airspeed is greater than 50 KIAS and the gear is up. This mode ensures increasing separation with the ground after takeoff and is based on a floor of 75% of the current radar altitude. A "Terrain" aural alert is given when terrain clearance is less than the changing altitude floor. Alerts may still be generated if the helicopter has a positive rate of climb, which will indicate that the terrain underneath the helicopter is rising rapidly and penetrating the artificial 75% floor. In this mode, as airspeed decreases, the alert boundary decreases to 10 feet and 80 KIAS.

In this occurrence, Mode 3 of the EGPWS detected the inadvertent descent and issued the "Don't sink" aural alert and yellow caution on the PFD. The inadvertent descent commenced as the airspeed reached a maximum value of 67 KIAS, with the gear in the up position. In addition, Mode 4 issued the "Too low gear" aural alert, as well as the corresponding caution and warning indications on the ADI and the master warning panel, when the helicopter descended below 150 feet asl with the gear still in the up position.

1.18.3 Automation

1.18.3.1 Automatic Flight Control System

The occurrence helicopter was equipped with an automatic flight control system (AFCS) that stabilizes the helicopter in the yaw, roll, and pitch axis to allow for trimmed hands-off flight in most steady-state flight conditions.

The cyclic control incorporates an electromagnetic brake and spring. This allows the pilot to set an attitude that will then be used by the cyclic trim system as its reference for pitch and roll retention. A similar type of trim system is used on the collective to hold a reference position, an altitude, or a rate of climb, as selected by the pilot. Likewise, yaw is trimmed to a pedal position, a heading reference, or a lateral sideslip reference as directed by the pilot or the autopilot. Each actuator has a clutch system that allows the pilot to override trim actuator input if desired.

Four electric trim actuator motors provide control referencing and artificial control gradient. These actuators are responsible for attitude retention and coupled flight director (CFD) operations. The CFD will not couple to the pitch or roll axis when the airspeed is below 50 KIAS.

Inputs from the trim actuators can be disengaged by depressing the force trim release switches, located on the cyclic, collective, or yaw pedals. The actuators can also be controlled by the four-way trim switches located on the cyclic and collective (Figure 1 and Figure 3). When the cyclic force trim release button is depressed, rate damping is available. [32]

In attitude mode, [33] pressing and releasing the cyclic force trim release button will re-reference the cyclic trim force to the new stick position, as well as the pitch and roll attitude at the time of button release. If the helicopter is coupled to airspeed, pressing the cyclic force trim release button will re-reference the cyclic trim force to the new position, and the airspeed at the time of button release will become the new reference airspeed. The reference airspeed will be displayed in magenta over the airspeed indicator, and a reference airspeed bug will appear in magenta on the indicator.

Similarly, in attitude mode, pressing and releasing the collective trim release trigger (Figure 3) will re-reference the collective to the new position. If coupled to vertical speed flight mode, pressing the collective trim release trigger will set the reference vertical speed to the speed at the time of button release. Likewise, the collective trim beeper can be used to select a new vertical speed.

An integral part of the S-92A AFCS is the coupler, or CFD, which permits a number of different hands-off flight modes, such as the airspeed hold, heading hold, altitude hold, vertical speed, GA, altitude preselect, navigation, and approach modes. The coupler uses the trim actuators to

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32 The S-92A is equipped with a stability augmentation system (SAS), which provides basic aircraft stabilization. The SAS will sense an aircraft disturbance, such as an uncommanded nose pitch up due to wind gusts, and provide small but immediate control inputs to stop the aircraft disturbance. This is called rate damping. Source: *S-92A Pilot Training Manual* [2009].

33 Attitude mode is the normal mode of operation and was the mode being used during the occurrence.

maintain the helicopter on a pilot-selected flight path. In order for the coupler to function properly, it is important that the trim actuators be centred prior to engagement. The trim actuators have 100% control displacement authority (stop to stop). Therefore, when the trim actuators move, the flight controls also move. However, the trim actuators are intentionally limited to a maximum displacement rate of 10% per second. The flight director range of control motion is intentionally rate limited to prevent any malfunction from becoming catastrophic. Therefore, the trim actuators are not able to make large, aggressive inputs to correct for deviations from the desired autopilot flight regime. To ensure a smooth transition from non-coupled to coupled flight, the Cougar Helicopters' SOPs state that "the crew shall confirm the aircraft is flying away in a normal trimmed attitude, prior to engaging the functions of the coupler." Likewise, it is also important that force not be applied against the spring. According to the S-92A RFM, "once trimmed any flight control movement without releasing the trim will result in an increasing force towards the reference."

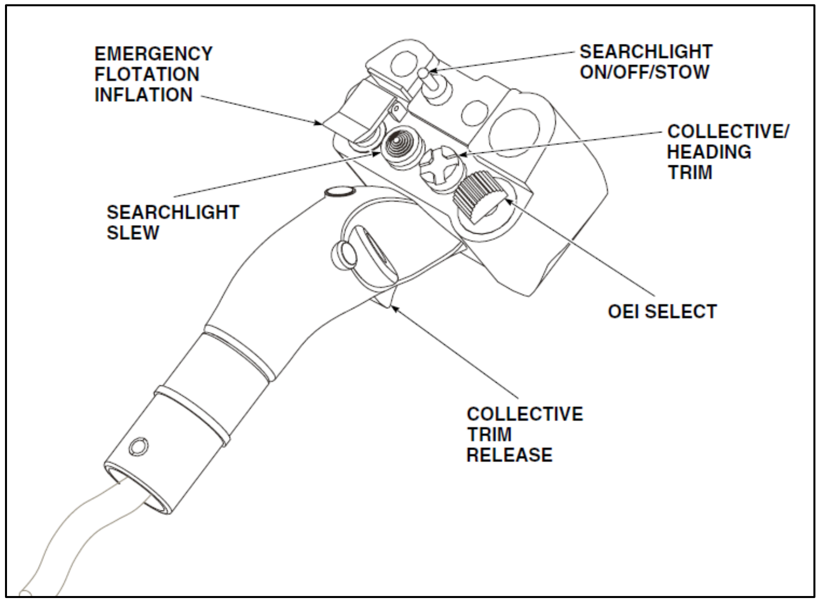

Figure 3. Collective level control head (Source: S-92A Rotorcraft Flight Manual [2011])

The active FD is indicated in the upper left corner of the PFD. If the helicopter is uncoupled, and FD 2 is selected, FD2 will appear in white (Figure 4).

If the helicopter is coupled, CPL will be displayed under FD1 or FD2, and the letters P (pitch), R (roll), and C (collective) will be displayed on the top row of the PFD. These letters correspond to the axis controlling each CFD mode. If a mode is captured, the letter will be displayed in green to indicate that the mode is now controlling that portion of the CFD. Modes that are armed, but not yet captured, are displayed in white letters. This means that control inputs are not being made based on this mode. In addition, magenta command bars will appear on the ADI portion of the PFD (Figure 5).

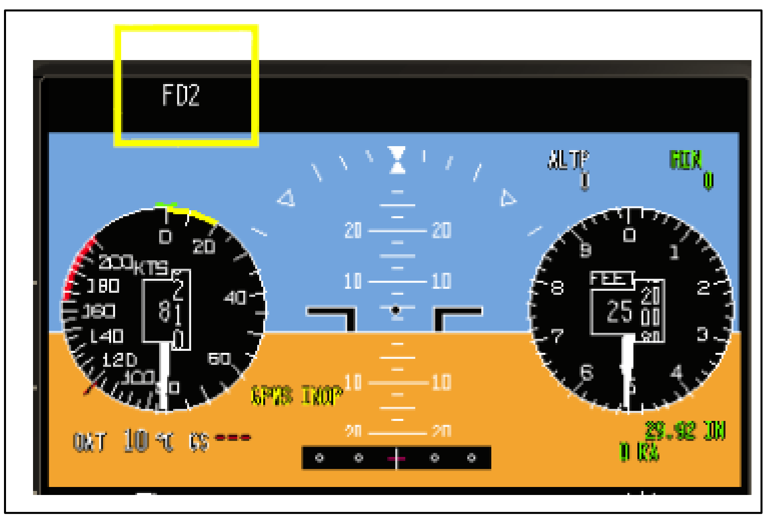

Figure 4. FD uncoupled (Source: *S-92A Pilot Training Manual* [2009])

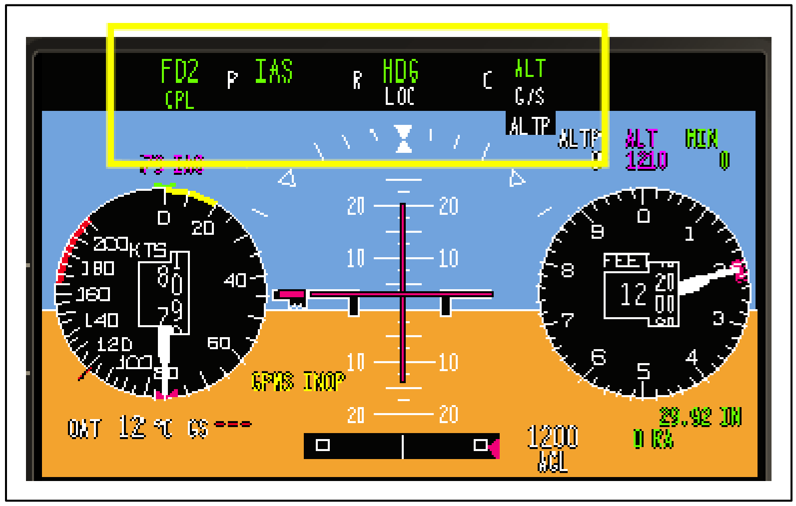

Figure 5. FD coupled (Source: *S-92A Pilot Training Manual* [2009])

At Cougar Helicopters, a lot of emphasis is placed on using automation as much as possible in order to maximize safety and passenger comfort. The SOPs state that "to standardize and enhance flight safety during departure and arrival phases of flight, the use of three-cue automation is mandatory." This SOP came about as a result of an earlier incident at Cougar Helicopters involving a flight crew that encountered control problems during a manually-flown instrument meteorological conditions (IMC) departure. The SOPs further state that by 400 feet agl (asl for offshore operations), the helicopter shall be in three-cue mode either by using the GA function or by directing the PM to engage the required autopilot modes. Three-cue automation means that the vertical speed or altitude is controlled via the collective axis. [34] As a result, pilots at Cougar Helicopters do not routinely hand fly the S-92A. The vast majority of offshore flights are flown making extensive use of coupled flight.

There have been enormous advances made in the technology used in modern helicopters. In many cases, helicopters are equipped with a level of automation that is comparable to the level of automation found on large commercial airliners. The benefits of automation are widely documented. In particular, automation is designed to help the crew and to increase the overall safety of the flight. [35] As in many other modern helicopters, the S-92A's automation suite is capable of doing much of the flying traditionally done by pilots. Billings (1997) identified some of the potential pitfalls of automation, including complacency and overtrust, excessive mistrust, degraded situational awareness, loss of perceived authority and control, and loss of manual proficiency. [36] However, in many cases, for operational and safety reasons, pilots are expected to make maximum use of automation. This can lead to a situation where the operator places too much trust in automation. When this occurs, pilots may not be gathering the information normally required when manually flying a helicopter. As a result, if a problem arises, pilots can easily find themselves out-of-the loop. In addition to the extra time that may be required for pilots to figure out what is happening, pilots may lack hands-on experience dealing with the resulting flight regime. In that regard, pilots act as the backup to the automation. [37] In some cases, arguments have been made that "automated aircraft may require a higher standard of basic stick and rudder skill, if only because these skills are practiced less often and maybe called

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34 Flight Safety International, *S-92A Pilot Training Manual* (2009), Chapter 15, Automatic Flight Control System and Flight Director Operations, Revision 1.8.

35 J. Drappier, *Air Carrier Training Insights: Maintaining Manual Flying Skills*. Presented at the World Airline Training Conference and Tradeshow (WATS) (2012).

36 C.E. Billings, *Aviation automation: The search for a human-centered approach* (Mahwah, NY: Lawrence Erlbaum Associates, 1997).

37 R.N.Charette, "Automated to Death", *IEEE Spectrum*, December 2009.

upon in the most demanding emergency situations." [38] The issue of erosion of manual flying skills was recently addressed during the 2012 World Airline Training Conference and Tradeshow (WATS). In a presentation by Airbus Industries, it was identified that automation may be leading to complacency and a loss of confidence. The presentation also highlighted the fact that manual skills are needed less often now because of automation; however, they are still needed. To combat the potential erosion of manual flying skills that may occur as a result of automation, the Airbus Industries' presentation identified the importance of proper initial training, proper command training, and more hands-on training at regular intervals. [39] The Airbus presentation also specifically identified the importance of upset recovery training for flight crews.

1.18.3.2 Go-Around

In the S-92A, the GA mode permits the pilot to initiate a wings-level climb by pressing the GA button on either cyclic, or by pressing the soft key on either mode-select panel. According to the S-92A RFM, the GA mode "can be used during an instrument approach procedure, during an instrument departure or to recover from an unusual attitude." According to the manufacturer, GA mode should be engaged from a trimmed, steady-state flight profile. However, other than the requirement to be above V_{MINI}, there are no other flight envelope restrictions on the use of the GA mode outlined in the S-92A RFM.

Cougar Helicopters actively encourages its pilots to use the GA mode for offshore rig departures, and it is used by the vast majority of the company's pilots. When engaged, the GA mode will command the collective axis to "capture a 750 fpm vertical climb, the pitch axis to capture 80 KIAS and the roll axis to maintain the present heading." [40] See Appendix D for the indications visible to the pilot following the GA selection. The areas delineated by the yellow boxes are indications to the pilot that GA mode is engaged. When GA is engaged, IAS will appear in green next to the pitch (P) axis, and GA will appear in green beside the collective (C) axis. In addition, the airspeed reference will be set to 80 KIAS, and the vertical speed reference will be set to a 750-fpm climb.

As previously mentioned in section 1.18.3.1, it is important that all control pressures be trimmed off, in a steady-state flight, before engaging GA mode. Otherwise, the helicopter may deviate significantly from the desired flight profile. This is due to the fact that the trim actuators may not be able to adequately compensate for changes in aircraft attitude.

According to the manufacturer, the FD will smoothly command the trim motors to establish the GA parameters highlighted above. Normally, the FD command rate is a maximum of 10% control travel per second. However, according to the manufacturer, in GA mode, the first 2° of attitude change are only limited by the speed at which the servos can move. In essence, the first 2° of attitude change will occur almost immediately. Once the initial 2° attitude change has occured, the FD command rate is reduced to 2° per second of attitude reference. Likewise, the first 5% of collective control is not rate limited. Once that initial 5% collective change has

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38 J. Drappier, *Air Carrier Training Insights: Maintaining Manual Flying Skills*. Presented at the World Airline Training Conference and Tradeshow (WATS) (2012).

39 J. Drappier, *The Erosion of Manual Flying Skills: Is it true, is it important, what do we do about it?* Presented at the World Airline Training Conference and Tradeshow (WATS) (2012).

40 S-92A Rotorcraft Flight Manual (2011)

occurred, collective changes are then limited to 2.5% per second, assuming there is no engine limiting active. This means that very small adjustments in cyclic and collective happen very quickly following GA mode engagement; however, larger movements are rate limited. Therefore, if pilot-induced command rates exceed the authority of the GA mode, the system may experience difficulties adopting the standard GA profile due to the slow speed at which the trim actuators are capable of commanding rate changes while in GA mode.

There is no specific guidance in the S-92A RFM regarding the ideal airspeed for GA engagement. However, in the "Departure from Rig/Vessel" section of Cougar Helicopters' SOPs, the sample full offshore briefing concludes with, "I will engage Go Around through 55 KIAS."

The investigation determined that the majority of pilots at Cougar Helicopters employed the GA mode in the following manner:

1. Pilots establish the helicopter at roughly the GA flight parameters (i.e., 80 KIAS and 750 fpm rate of climb) and use the cyclic force trim release button to ensure that all control pressures are removed prior to coupler engagement. This reduces the amount of control input changes that occur following GA mode engagement;
2. With all pressure removed from the cyclic control and the collective lever, the pilots use their right thumb to press the GA button on the cyclic;
3. Pilots look to see if the airspeed and vertical speed reference bugs are visible and indicating the appropriate value. Most pilots at Cougar Helicopters were not in the habit of using the top portion of the PFD to verify that the coupler was controlling the pitch and collective channels; and
4. Once GA is engaged, pilots use the AFCS trim beeper switch on the cyclic to increase the helicopter's airspeed to between 100 and 110 KIAS.

The investigation determined that pilots at Cougar Helicopters were aware that unexpected attitude changes could occur if the control pressures were not trimmed off prior to coupler engagement. Several pilots at Cougar Helicopters had at some point engaged the GA mode with residual pressure on the cyclic prior to GA mode engagement. In those instances, pilots intervened by assuming control of the helicopter and either resetting the helicopter's attitude and allowing the GA to resume coupled flight or hand-flying to a safe altitude. In this occurrence, the captain did not feel any pressure on the cyclic stick prior to engaging GA mode.

At Cougar Helicopters, there is no standard procedure for the use of the cyclic force trim release button. When Cougar Helicopters' pilots were informally surveyed, it was revealed that for rig departures, some pilots choose to press and hold the cyclic force trim release button down until just before autopilot engagement. Another technique employed by Cougar Helicopters' pilots is to center the trim actuators while in the hover and release the force trim release button prior to departing from an offshore facility. The pilots then simply fly through the spring pressure while adopting the appropriate accelerating attitude. This is done so that in the event of spatial disorientation, releasing pressure on the cyclic will return it to the pitch attitude it was in the hover, which is also the same attitude typically adopted after engaging the GA mode. As a result, the idea is that should a pilot encounter some type of spatial disorientation, simply releasing pressure from the cyclic and applying power should result in the helicopter adopting an attitude that will permit the helicopter to climb away safely.

1.18.4 Standard Operating Procedures

1.18.4.1 General

According to Cougar Helicopters' SOPs, a transfer of control is initiated by the PM saying, "I have control". The pilot relinquishing control will say, "You have control" and release control. In addition to this procedure, the SOPs outline a number of standard calls designed to "reduce the likelihood of an incorrect interpretation of a request or command and to initiate corrective action for undesirable situations." For example, the following standard phrases are identified in the Cougar Helicopters' SOPs:

- "Check descent rate" - during flight with passengers, other than on an instrument final approach, a descent rate of more than 500 fpm.
- PF response: "Check, correcting."
- "Check speed" - within 5 KIAS below the maximum or minimum allowable airspeed (V_{NE} [41] / V_{MINI}).
- PF Response: "Check, correcting."

While there are standard calls for such things as abnormal bank, abnormal rate of descent, and abnormal speed, there are no standard callouts related to abnormal pitch attitudes.

In the "After Take-Off Check" section of the Cougar Helicopters' SOPs, it is stated that after take-off checks should be completed at a convenient time, but not below 400 feet above the aerodrome or heli-pad elevation. The SOPs also dictate that the helicopter must be coupled in three-cue prior to 400 feet asl. There are no flight restrictions when the landing gear is extended. However, when departing from a rig or a vessel, the SOPs state that the landing gear shall be raised after the V_{TOSS} and positive rate of climb calls have been made. The SOPs also state that "automation should not be engaged prior to the 'Gear up' call during the departure, as this can be a critical stage of flight while under IMC conditions." In addition, the SOPs require that the flotation be switched to safe before reaching 80 KIAS, as the floats should not be deployed above 80 KIAS. The caution/warning system will be triggered if the flotation is armed at airspeeds above 80 KIAS. At Cougar Helicopters, the standard practice was for the PM to raise the gear and select flotation to safe on the PF's command, after the "positive rate" call was made by the PM. The flotation switch is located in the middle of the console between the pilots (Photo 1). From the left seat, the PM is required to lean a considerable amount in order to reach the landing gear switch (Photo 2).

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41 Never exceed airspeed

Photo 1. S-92A pilot reaching for flotation switch

Photo 2. S-92A pilot reaching for landing gear handle

1.18.4.2 Crew Pairing Policy

At the time of the occurrence, Cougar Helicopters had a crew pairing policy in place that prohibited 2 pilots with less than 300 hours on type from flying together. In addition, Cougar Helicopters had implemented a risk assessment matrix (RAM), which had to be completed before each flight. The form identified the following risk factor categories:

- Pilot currency: hours on type and recent flight hours;
- Environment: IFR or VFR, sea state, icing, turbulence, wind, etc.;
- Time of day: day or night;
- Fatigue: number of flights that day or first flight following long duty day;
- Complexity: 1 stop or multiple stops; and
- Personal: stress factors.

In order to remove some subjectivity from the process, each category is assigned a numerical value, depending on the risk factors that are present. Once all the numerical values are calculated, the RAM indicates the level of authorization required in accordance with the overall risk score. The RAM was completed for the occurrence flight, and the assigned risk level was low enough that it did not require consultation with the CP or the CP's designate.

In addition to the crew pairing policy in the Cougar Helicopters SOPs, all pilots must first be approved by the offshore operators before these pilots are permitted to fly their workers offshore. As part of the process, the offshore operators have established minimum requirements of 1000 flight hours on helicopters and a minimum of 250 flight hours of PIC time. The first officer had more than 16 000 flight hours on fixed-wing aircraft; however, the first officer did not meet the minimum helicopter requirements set out by the offshore operators. As a result, Cougar Helicopters submitted a waiver request to the offshore operators seeking permission to allow the first officer, who had 352 helicopter hours and 94 PIC flight hours, to fly offshore revenue flights. The waiver request indicated that the first officer "has met or exceeded the standards thus far," and that this, combined with this total flight experience, "provides an equivalent level of safety and alternative measurements of expertise as opposed to a purely flight hours approach." One of the conditions listed in this waiver request was that the first officer would only fly with designated training pilots until the minimum flight hour requirements set out by the offshore operators were met. A copy of the waiver was placed in the first officer's file and it was adhered to for several months. The first officer then began being paired with pilots who were not qualified training captains. The occurrence captain was not a qualified training captain. The investigation determined that due to an administrative oversight by Cougar Helicopters, the restriction concerning the first officer stopped being enforced after several months of flying on the line. In addition, the details of the restriction were not included in the handover to the new CP, who assumed these duties in July 2010. As a result, the first officer was scheduled with non-training captains prior to meeting the requirements established in the waiver.

1.18.5 Pilot Incapacitation and Spatial Disorientation

Under certain conditions, a pilot may encounter difficulties carrying out normal duties due to some type of temporary physiological impairment. This phenomenon is often referred to as incapacitation. According to Cougar Helicopters' SOPs, incapacitation is a ". . . physical condition which could adversely affect the operation of the helicopter . . ." Incapacitation may manifest itself in a variety of forms, ranging from a very subtle lack of responsiveness to a complete loss of consciousness. It can present itself in the form of fixation or a reduced ability to interpret and reconcile various cues. As explained in Cougar Helicopters' SOPs, subtle incapacitation "may manifest itself as 'tunnel vision' or just general overload and limited awareness of the situation."

Incapacitation can have a number of different causes. For example, it may occur as a result of fatigue, heat exhaustion, or any other type of physiological stressor. Incapacitation can also occur as a result of spatial disorientation, which is a phenomenon where the pilot's brain misinterprets cues from the environment concerning the helicopter's attitude.

Spatial disorientation may be accompanied by a sensation of movement. In such cases, this sensation of movement can be overwhelming, as the pilot believes the aircraft is doing something different from what it actually is doing. In situations where there is no outside visual reference, spatial disorientation can be overcome by trusting the flight instruments and reverting to instrument flight. In this occurrence, the captain did not experience any unusual sensations during the descent, nor did the captain perceive any sensations which made it difficult to manipulate the flight controls.

In many cases, pilots may not be aware that they are suffering from some type of incapacitation. In addition, it can be very hard for other crew members to determine if a pilot is incapacitated when it is subtle, and when the affected individual is still providing appropriate responses to challenges made by a concerned crew member. To help pilots recognize when a crew member is incapacitated, Cougar Helicopters' SOPs state that a pilot is deemed to be incapacitated if one or both of the following occurs:

1. The pilot does not respond intelligently to 2 radio, intercom, or directly spoken communications; and/or
2. The pilot does not respond to a single verbal challenge and a significant deviation from a standard flight profile has occurred. [42]

In the event that a pilot meets either of the pilot incapacitation conditions listed above, the Cougar Helicopters SOPs indicate that "the other pilot shall assume control and ensure that a safe flight profile is maintained." The procedure also states that the autopilot should be engaged, and ATC should be advised. In this occurrence, the first officer observed what was believed to be corrective action. At no time did the first officer believe that the captain had become incapacitated.

1.18.6 Unusual Attitude Recovery

One of the areas that represents the highest risk for helicopter operations is the departure phase. As outlined in the Federal Aviation Administration's (FAA) *Instrument Flying Handbook*, [43] departures under conditions of low visiblity, rain, or low ceilings are particularly challenging due to the fact that a sudden transition from visual to instrument flight can result in spatial disorientation and control problems.

According to the *Instrument Flying Handbook*, 3 critical skills are required to ensure smooth and positive control of a helicopter during instrument flight. These 3 skills are instrument cross-check, instrument interpretation, and aircraft control. A breakdown of any one of these skills could result in an unusual attitude. An unusual attitude is any maneouvre that is not required for normal helicopter instrument flight. As also stated in the *Instrument Flying Handbook*, unusual attitudes can be caused by "any one or combination of factors such as turbulence, disorientation, instrument failure, confusion, preoccupation with flight deck duties, carelessness in cross-checking, errors in instrument interpretation, or lack of proficiency in aircraft control." [44] Likewise, TC's *Flight Instructor Guide* states that "stress, disorientation or vertigo, and lack of recent practice can lead to insufficient attention or accuracy in instrument flying. This can result in attitudes, airspeeds and power settings falling outside the normal instrument flying envelope." [45] Given the inherent instability of helicopters, unusual attitudes represent a significant risk for helicopter flight crews and passengers. As a result, it is critical that timely action be taken to recover the helicopter to a safe regime of flight as soon as possible with minimum loss of altitude.

When attempting to recover from an unusual attitude, it is vital that pilots do not become fixated on a single instrument. In many cases, fixation occurs when the information does not match a person's mental model at that moment. In those instances, the individual can become fixated as the individual attempts to carefully interpret the information which is in conflict with their own understanding of the situation. Fixation on a single flight instrument, to the exclusion

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42 Cougar Helicopters standard operating procedures (SOPs) (2010)

43 Federal Aviation Administration, *Instrument Flying Handbook*, FAA-H-8083-15B (U.S. Department of Transportation, 2012).

44 Federal Aviation Administration, *Instrument Flying Handbook*, FAA-H-8083-15B (U.S. Department of Transportation, 2012), p. 8-16.

45 Transport Canada, *Flight Instructor Guide – Helicopter*, TP 4818 (August 2006), Part II, Exercise 30.

of other flight instruments, usually results in poor aircraft control. As a result, pilots must continue to cross-check all flight instruments while attempting to recover from an unusual attitude.

In the FAA's *Instrument Flying Handbook*, the following 6 errors have been identified as being common errors when recovering from an unusual attitude.

1. Failure to make proper pitch correction
2. Failure to make proper bank correction
3. Failure to make proper power correction
4. Overcontrolling pitch and/or bank attitude
5. Overcontrolling power
6. Excessive loss of altitude [46]

According to TC's *Flight Instructor Guide*, "Recovery should be made by reference to the airspeed indicator, altimeter, turn and bank, and vertical speed indicator. The attitude indicator can be used in the roll axis but can only be used for the pitch axis in conjunction with the other instruments." [47] This is consistent with the guidance provided by the FAA, which states that a pilot should correct bank and pitch, and then adjust power as necessary.

During the S-92A initial conversion course, pilots are taught the following unusual attitude recovery procedure:

1. Adopt a wings-level roll attitude;
2. Place the nose of the helicopter on or slightly above the horizon (2-3 degrees nose-up); and
3. Apply power to arrest the descent/climb to a safe altitude.

As a general rule of thumb, S-92A pilots are advised during initial and recurrent training to set engine torque to 80%. In most cases, this will result in a rate of climb of approximately 750 fpm or greater, depending on the helicopter's weight. Both occurrence pilots were aware of the above stated unusual attitude recovery procedure, and had been taught the procedure during their initial S-92A conversion course.

1.18.7 Simulator Training

Simulator training gives pilots the opportunity to practice maneouvres that are not normally practiced during actual flight operations. By practicing these maneouvres in a controlled environment, pilots can gain confidence in their ability to handle similar situations should they be encountered during actual flight operations.

Prior to the occurrence, Cougar Helicopters' recurrent simulator training did not include dedicated unusual attitude recovery training (i.e., multiple unusual attitude recoveries), nor is this type of training required by regulation. Instead, unusual attitude recoveries were only practiced if they occurred during the course of the training sequence. Therefore, if the pilots did

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46 Federal Aviation Administration, *Instrument Flying Handbook*, FAA-H-8083-15B (U.S. Department of Transportation, 2012), p. 8-16.

47 Transport Canada, *Flight Instructor Guide – Helicopter*, TP 4818 (August 2006), Part II, Exercise 30.

not accidentally induce an unusual attitude, it was not practiced in the simulator. As a result, pilots at Cougar Helicopters did not actively practice unusual attitude recoveries during recurrent simulator training.

Cougar Helicopters' recurrent simulator training typically included a subtle incapacitation exercise. The training scenario involved a situation where one of the pilots would become unresponsive. Pilots were advised before the training session that this would happen at some point during the session. The scenario was normally initiated by the instructor tapping one of the pilots on the shoulder. From that point on, that pilot would not respond to queries from the other pilot. The PM, aware that they would be simulating an incapacitated pilot scenario, would carry out the required actions and take control of the helicopter. These sessions did not involve scenarios where the PF continued to respond to queries from the PM, yet took no action to rectify the problem.

During simulator training, very little emphasis was placed on the importance of using the top portion of the PFD to verify autopilot engagement.

1.18.8 Crew Resource Management Training

Although not required by regulation for CAR 704 operators, Cougar Helicopters implemented an in-house training program called CHARM. According to Cougar Helicopters' SOPs, CHARM is a "holistic program that includes the basis of a traditional CRM program, but goes beyond the narrow definition of CRM to further address issues of human and team performance beyond what happens solely in the cockpit." The core of the CHARM course includes the following modules:

1. Threat and Error Management;
2. Human Information Processing;
3. Decision Making;
4. Nutrition and Stress;
5. Fatigue;
6. Rules, Regulations, and SOPs;
7. Communication;
8. Situational Awareness;
9. Task and Workload Management;
10. Team Performance; and
11. Automation.

Company employees are required to complete 6 hours of initial CRM training. Afterwards, there is an annual CRM training requirement of 2 hours.

One of the tenets of CRM in a multi-crew environment is that crew members must be ready to back each other up, and even take control if the safety of the flight is jeopardized. In the "Communications" section of the CHARM Handbook, it is stated that in an emergency situation, "give very specific directions or take action if necessary!" It also goes on to provide a number of sample emergency statements: "If we don't [action] immediately, I am going to take control," or "even a simple 'I have control!'" [48]

48 CHARM Handbook (2011)

The CHARM Handbook also identifies fixation or preoccupation (channelized attention) as "one of the greatest causes of a loss of situational awareness." The manual goes further to state that "this occurs when we focus our attention on any one item or event to the exclusion of all others, drawing our attention away from the big picture."

To assist pilots who may find themselves in a difficult situation where they are required to take control from another pilot, Cougar Helicopters' SOPs make reference to the 2-challenge rule, which is a widely-recognized CRM tool. According to the 2-challenge rule, any deviations from the desired flight profile should result in the PM advising the PF of the deviation. If appropriate action is not taken to rectify the situation, the PM should repeat what was said, using the approved terminology from the SOPs. If appropriate action is not taken after the second challenge, the PM's responsibility is to take control and continue the flight.

When the occurrence helicopter's nose first rose sharply, the first officer was selecting the landing gear to UP and placing the flotation switch to SAFE. During those brief moments, the first officer was not closely monitoring the flight instruments. Immediately following these switch selections, the first officer noticed that the helicopter was descending in a nose-high attitude with low airspeed. The first officer immediately verbalized concerns to the captain, making an attitude and airspeed deviation call. Shortly after making the first deviation call, the "Don't sink" aural warning also began to sound, and the first officer continued making attitude and airspeed calls to the captain. However, the first officer did not assume control of the helicopter following the second challenge. This was due to the first officer's belief that the captain was making the necessary corrections, and a belief that taking control of the helicopter would likely exacerbate the situation. Instead, the first officer re-armed the emergency flotation system in preparation for water impact. This was the first time that the first officer had ever been in a situation where deviation calls were made without positive corrective action taken by the PF to rectify the situation.

Studies have shown that first officers are often reluctant to question the captain, and even more reluctant to take control from them. [49] The investigation determined, through informal discussions with civilian and military pilots, that many less experienced pilots will defer to the captain, particularly if there is a significant difference in experience between the 2 pilots. In some training scenarios, PFs have tested their less experienced first officers by intentionally maintaining an excessive airspeed or an overly steep angle on approach. When probed by the PM, the PF would provide the response to the PM's challenge, yet the appropriate actions would not be taken. In many instances, the PMs may make repeated attempts to advise the PF of the perceived problem, however, they are often unwilling to physically take control of the aircraft, even if safety margins are compromised. This issue was previously identified in the 2009 Cougar Flight 491 accident (TSB Investigation Report A09A0016), in which the first officer was not assertive, preventing concerns about the helicopter's flight profile from being incorporated into the captain's decision-making process.

1.18.9 Previous Occurrences

On 26 August 2007, a Cougar Helicopters S-92A was involved in an occurrence following a missed approach to the Hibernia oil rig due to poor visibility. A second approach was

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[49] D.M. Milanovich, J.E. Driskell, R.J. Stout, and E. Salas, "Status and Cockpit Dynamics: A Review and Empirical Study,"*Group Dynamics: Theory, Research, and Practice*, Vol. 2., No. 3, 155-167 (1988).

attempted. During this approach, the PM was able to see the oil rig; the decision was made to continue with the landing on the rig. When the PM took control, an attempt was made to decouple the flight director. The indicated airspeed and heading modes decoupled; however, the radar altitude hold did not disengage. As a result, the helicopter attempted to maintain altitude when the collective was lowered to initiate the descent from 150 feet asl. The helicopter's pitch attitude increased from 10° nose-up to a maximum of 21° nose-high. This caused the indicated airspeed to drop rapidly to approximately 26 knots, where it continued to decelerate as low as zero at one point. The helicopter's rate of descent peaked at 790 fpm and was recovered at 31 feet asl. Following the inadvertent descent, another missed approach was carried out.

On 12 November 2008, a Cougar Helicopters S-92A experienced a main gearbox overtorque during a night instrument approach to an offshore oil rig. During the approach, the first officer experienced difficulties controlling the helicopter. With the helicopter altitude coupled to radar altitude hold at 500 feet above the water, the first officer lowered the collective to correct for excessive airspeed. As the helicopter attempted to maintain the selected altitude, the airspeed decreased, and a high sink rate developed. The first officer recognized the sink rate and increased collective to arrest the descent. The helicopter pitched nose-up to approximately 20° nose-high. Recognizing that controlling the helicopter was becoming difficult, the first officer passed control to the captain. The captain then returned the helicopter to a safe altitude. The helicopter was then returned to the Global Santa Fe and was shut down. It was later determined that the flight crew experienced an eleven-second main gearbox torque exceedance of 135%, and a one-second transient torque exceedance of 127%. The helicopter descended to an altitude of 250 feet above the water.

Neither of the above-mentioned occurrences was reported to the TSB at the time. According section 2(1) of the *Transportation Safety Board Regulations*, a "'reportable aviation incident' means an incident resulting directly from the operation of an airplane having a maximum certificated take-off weight greater than 5 700 kg, or from the operation of a rotorcraft having a maximum certificated take-off weight greater than 2 250 kg. . . ." This section lists several criteria for a reportable incident. For example, an incident is reportable if "d) difficulties in controlling the aircraft are encountered owing to any aircraft system malfunction, weather phenomena, wake turbulence, uncontrolled vibrations or operations outside the flight envelope. . . ." [50]

1.18.10 Canada-Newfoundland and Labrador Offshore Petroleum Board

Following the crash of Cougar Flight 491, the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) established the Commission of Inquiry into Matters Respecting Helicopter Passenger Safety for Workers in the Newfoundland and Labrador Offshore Area. The Commission produced a series of recommendations aimed at reducing the risks of helicopter transportation of offshore workers to as low as reasonably practicable in the Newfoundland and Labrador offshore area.

As part of its implementation strategy, the C-NLOPB created a chief of safety position and added an aviation advisor to its aviation safety team. In addition, the recommendations from the inquiry have resulted in the creation of a framework in which the C-NLOPB will play an increased role in the safety management oversight of offshore operations. This will allow the C-NLOPB to have the necessary oversight functionality and tools to monitor the training, safety

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50 *Transportation Safety Board Regulations*, section 2.(1).

culture, and operations of service providers. The intent is to ensure that system safety deficiences are adequately addressed by the offshore operators and by Cougar Helicopters.

1.19 Useful or Effective Investigation Techniques

Not applicable.

2.0 Analysis

There was no indication that an aircraft system malfunction contributed to this occurrence. As a result, the analysis will focus on the operational factors that contributed to the inadvertent descent, which occurred during the departure from the Sea Rose.

In addition, some organizational factors will be analyzed with the objective of improving aviation safety.

2.1 Aircraft Handling

The initial portion of the departure from the Sea Rose was hand-flown by the captain, who made a rapid application of forward cyclic, at a rate of almost 7° per second, to adopt the accelerating attitude. As the helicopter accelerated through the take-off safety speed (V_{TOSS}), the captain made a large aft cyclic input at an average rate of 5.6° per second, which caused the helicopter to enter a nose-high, decelerating pitch attitude. As the pitch attitude passed through 2.4° nose-up, with airspeed and vertical speed increasing, the captain released the cyclic force trim release button and then engaged the go-around (GA) mode. The airspeed at the time was 64 knots indicated airspeed (KIAS). Following GA mode engagement, the captain released hand pressure on the cyclic stick, believing that the helicopter would adopt a wings-level, 750 feet per minute (fpm) climb-out in accordance with the standard GA profile.

Once the nose-high unusual attitude was recognized, the captain attempted to correct the problem by momentarily depressing the cyclic force trim release button. However, the captain did not set an appropriate attitude, as per the Cougar Helicopters standard operating procedures (SOPs), to recover from the nose-high unusual attitude that had developed as a result of the initial aft cyclic input. When the captain released the cyclic force trim release button, the helicopter's airspeed re-referenced to 56 KIAS and it continued to decelerate as a result of the aft cyclic stick position, and to a lesser extent as a result of the aerodynamic forces associated with blowback. As the airspeed of the helicopter decreased to within 5 knots of the minimum control speed in instrument meteorological conditions (V_{MINI}), the captain momentarily pressed the cyclic force trim release button and made an aft cyclic input. This caused the helicopter's airspeed to decrease below V_{MINI}, and the helicopter entered a 23° nose-high unusual attitude.

As the helicopter descended towards the water, the captain attempted to recover from the nose-high unusual attitude that had developed following GA mode engagement. However, even though the captain's attention was focused primarily on the attitude indicator, the captain did not correct the excessive nose-up attitude and did not recognize the severity of the descent until the helicopter descended below the clouds.

In addition, despite the sounding of the aural "Don't sink" alert, there was no initial attempt to arrest the descent, which reached a maximum value of 1880 fpm, while yawing to the right. It is likely that the captain had difficulties processing the information that was presented on the flight instruments because it was not what the captain was expecting to see. The captain, subtly incapacitated, possibly due to spatial disorientation, did not lower the nose of the helicopter and apply collective in a timely manner to recover from the nose-high unusual attitude. This contributed to the excessive amount of altitude that was lost during the inadvertent descent.

As the helicopter descended below the base of the clouds, its rate of descent peaked at 1880 fpm, at an altitude of 156 feet above the water. At that rate of descent, the helicopter was less than 5 seconds from impacting the water. In response to the rapidly approaching water, the captain aggressively pulled on the collective to arrest the descent. The rapid application of collective in order to arrest the inadvertent descent resulted in the transmission torque limits being exceeded. As designed, the occurrence helicopter's FADEC system went into blowaway when the rotor speed (Nr) decreased below 100%, with both engines operating. By going into blowaway, the pilots had more power available to them to arrest the descent before water impact. During the rapid application of collective, neither pilot realized that there had been an exceedance of transmission operating limitations during the recovery, and the flight continued back to CYYT.

2.2 *Multi-Purpose Flight Recorder*

The multi-purpose flight recorder (MPFR) was not secured immediately following the occurrence. As a result, valuable information, which could have assisted the investigation, was lost. The TSB has documented numerous examples where critical flight data recorder (FDR) and cockpit voice recorder (CVR) data was lost because it was not secured following an occurrence. In this occurrence, the FDR data was critical in determining what happened on the occurrence flight. However, the lack of CVR data made it difficult for investigators to analyze the actions of the flight crew during the occurrence. If proper measures are not taken to secure FDR and CVR data following an occurrence, there is increased risk that valuable safety information will be lost.

2.3 *Enhanced Ground Proximity Warning System*

Shortly after the inadvertent descent began, the occurrence helicopter's enhanced ground proximity warning system (EGPWS) began issuing a Mode 3 "Don't sink" aural caution. Then, as the helicopter descended through 150 feet radar altitude, the EGPWS also provided the Mode 4A "Too low gear" aural alert. The "Don't sink" aural caution provided the flight crew with timely notification that the departure was not going as planned. However, the "Don't sink" aural caution was only received because the gear was in the up position at the time of the inadvertent descent. On the S-92A, Mode 1 is disabled due to a high number of false alarms during normal approaches, and a belief that excessive sink rate is not as common for helicopters as it is for fixed-wing aircraft. In addition, with the gear down, Mode 3 protection ceases when the helicopter's airspeed drops below 40 KIAS. The decision to use 40 KIAS as the lower airspeed threshold for Mode 3 with the gear down was deemed an acceptable compromise in order to avoid false alarms during rejected takeoffs. In addition, the manufacturer's decision was also influenced by the belief that if an inadvertent descent occured during takeoff, it would not be accompanied by a significant reduction in airspeed. However, this creates a gap in the coverage provided by the S-92A's EGPWS. For example, if the helicopter is climbing away while the gear is still down and an inadvertent descent develops prior to attaining 50 KIAS, or if the airspeed drops below 40 KIAS after having reached 50 KIAS, the EGPWS will provide no protection against controlled flights into terrain (CFIT), regardless of the rate of descent. Likewise, if a helicopter is on approach with the landing gear down and the airspeed drops below 40 KIAS, there is no EGPWS protection against an inadvertent descent. There is no rate of descent threshold established for EGPWS purposes to differentiate between a controlled descent and an inadvertent descent which could result in a CFIT accident.

Due to the nature of offshore operations in Newfoundland, flight crews are routinely required to fly in instrument meteorological conditions (IMC). In these conditions, pilots must rely on aircraft flight instruments and are susceptible to spatial disorientation. As seen in this occurrence and in the 2 previous occurrences identified in this report, the transition to and from an offshore facility resulted in an inadvertent descent at low airspeed and a high rate of descent. Fortunately, in all 3 occurrences, the flight crew was able to arrest the descent prior to impact with the water. The S-92A's EGPWS provides no warning of an inadvertent descent at airspeeds below 40 KIAS when the landing gear is down. As a result, there is increased risk of CFIT during those phases of flight.

As identified in the TSB Watchlist, CFIT accidents represent a significant risk to the travelling public. One of the greatest developments to combat the risk of CFIT is the introduction of terrain awareness warning systems (TAWS) and EGPWS. However, in order to realize the full benefit of an EGPWS, flight crews must be taught the appropriate CFIT avoidance procedure and have opportunities to practice this procedure. Despite the fact that Cougar Helicopters had established a CFIT avoidance procedure in its SOPs, the procedure was not carried out in response to the "Don't sink" aural alerts. In this occurrence, the collective was increased approximately 16 seconds after the aircraft began descending. As a result, the helicopter developed an excessive rate of descent and came within seconds of impacting the water. If there are delays initiating the CFIT avoidance procedure in response to an EGPWS alert, there is an increased risk of a CFIT.

2.4 Automation

Pilots at Cougar Helicopters are encouraged to make maximum use of the S-92A's automation, and three-cue automation is mandatory for offshore rig departures. While there are valid reasons for adopting this philosophy, it is equally important that pilots retain a sufficient level of manual flying skills in case pilot intervention is required due to an autopilot malfunction or an unexpected flight regime, such as an unusual attitude. The SOP at Cougar Helicopters requiring the use of three-cue automation during departures came about as a result of handling difficulties experienced by another flight crew. This underscores that retaining a sufficient level of flying proficiency is still a vital element of a pilot's duties. Implementing a rule that requires the use of automation does not address the underlying issue of skill erosion, which may have actually occurred as a result of reliance on automation. As seen in this occurrence, system design limitations prevented the S-92A's automation from recovering from an unusual attitude. However, the captain experienced difficulties recovering from the unusual attitude in IMC. Also, the first officer did not attempt to take control of the helicopter; the first officer felt that taking action would likely make matters worse. Although the first officer had almost 1000 total flight hours on the S-92A, many of those hours were spent in coupled flight during instrument flight rules (IFR) flights to and from the offshore facilities, and not hand flying the helicopter. As a result, the first officer did not feel confident about having the necessary instrument flying skills to safely recover from the unusual attitude that had developed. It is vital that pilots of highly-automated aircraft remain vigilant when it comes to autopilot usage, and that they be trained on its proper use and limitations. If pilots of automated aircraft do not maintain their hands-on visual and instrument flying proficiency, there is increased risk that they will be reluctant to take control and experience difficulties recovering from unexpected flight profiles that require pilot intervention.

When the GA mode was engaged, the helicopter was being operated within the approved flight envelope in the S-92A Rotorcraft Flight Manual (RFM). However, the helicopter was not in a stable flight regime. As the nose-up attitude of the helicopter increased, the helicopter's flight director would have been trying to establish the GA profile. However, the vertical speed at the time was twice the standard 750 fpm rate of climb for the GA mode. As a result, the flight director would not command an immediate increase in collective. In addition, the flight directors would have been slowly trying to regain 80 KIAS; however, the trim actuators are designed to make adjustments smoothly and slowly in response to flight director commands. In the GA mode, the flight director is limited to a 2° attitude change, and then additional attitude changes at a maximum rate of 2° per second. Therefore, if a large pitch attitude change is required, it could take a considerable amount of time before the system is able to adopt the desired flight profile. As seen in this occurrence, this could result in the airspeed dropping below V_{MINI}, causing the autopilot to disengage. The S-92A's GA mode is designed with reduced control authority. As a result of this reduced control authority, the flight director experienced difficulties recovering from the nose-high pitch attitude that occurred following the GA mode engagement. This highlights the importance of ensuring that the helicopter is properly trimmed, in steady-state flight, prior to engaging the autopilot.

In this occurrence, the pilots did not use the top portion of the primary flight display (PFD) to confirm and monitor the operation of the coupler. The investigation determined that most pilots at Cougar Helicopters were not taught to rely on the top portion of the PFD to verify autopilot engagement. Instead, most pilots relied on the reference markers on the airspeed and vertical speed indicators as their primary means of verifying proper GA mode engagement. While it did not contribute to the severity of this occurrence, this practice represents a potential risk to flight crew and passengers. If S-92A pilots do not consult the top portion of the PFD to confirm proper autopilot engagement, they may not recognize that the system is degraded or not engaged.

2.5 Go-Around

The S-92A RFM states that the GA mode can be used to recover from unusual attitudes. However, as seen in this occurrence, the ability of the GA mode to recover from an unusual attitude is largely dependent on the flight profile at the time of the GA mode engagement. If the helicopter is not in steady-state, trimmed flight, the automatic flight control system (AFCS) may not have the required command authority to make the necessary pitch and collective inputs to recover from the unusual attitude and adopt the standard GA flight profile. This could result in an excessive loss of airspeed and altitude during an unusual attitude. If the airspeed is below V_{MINI} at the time of the unusual attitude, the GA mode will not engage, and the pilot will be required to recover manually from the unusual attitude. This could delay the recovery time and result in an excessive loss of altitude.

Likewise, if the airspeed drops below V_{MINI} after the GA mode is engaged, the GA mode will disengage and stop making any control inputs. Again, the pilot will be required to intervene and manually recover from the unusual attitude. In both situations, pilots could find themselves in a very precarious situation if they have relied on the GA mode to recover from an unusual attitude, as per the S-92A RFM's guidance. Therefore, it is important that S-92A pilots understand the limitations of the GA mode and recognize that the GA mode may be unable to recover from an unusual attitude due to system design. The S-92A RFM is misleading in that it states that the GA mode can be used to recover from an unusual attitude. The GA mode will not function below 50 KIAS and it is limited in how fast it can make attitude and power changes. As a result, pilots and passengers are at an increased risk of collision with terrain if pilots attempt to use the GA mode to recover from an unusual attitude at low altitude.

The GA mode is designed to reduce workload by allowing the pilot to command a wings-level climb by pushing a single button. The GA mode also provides a standard flight profile that is desirable from a passenger comfort standpoint. At Cougar Helicopters, pilots are actively encouraged to use the GA mode for offshore rig departures, and this practice has been adopted by the vast majority of pilots. In the rig/vessel departure section of the Cougar Helicopters' SOPs, there is reference to engaging the GA mode through 55 KIAS. While within the operating envelope of the S-92A autopilot system, this speed is very close to V_{MINI}. If the airspeed were to decrease below V_{MINI} following GA mode engagement, as it did in this occurrence, it would cause the system to decouple, and the pilot would be required to manually fly the helicopter. If a pilot is not closely monitoring the departure, this could result in an unexpected deviation from the standard profile. If the GA mode is engaged at 55 KIAS in accordance with Cougar Helicopters' SOPs, there is increased risk that the GA mode will disengage as a result of a transitory decrease in airspeed below V_{MINI}.

In this occurrence, the captain pressed and held the force trim release button until just prior to engaging the GA mode. The investigation determined that this technique was used by some pilots at Cougar Helicopters. In contrast, other pilots at Cougar Helicopters engage the cyclic force trim release button in the hover just prior to transitioning forward. This technique establishes the helicopter in an attitude that is very close to the standard GA attitude. When employing this technique, the transition from non-coupled to coupled flight occurs following a gradual reduction of forward cyclic pressure until the helicopter returns to the previously trimmed attitude. In addition, this technique also places the cyclic stick in a trimmed position, which facilitates the recovery from an unusual attitude should one develop. Using this technique, the pilot releases the pressure from the stick and applies collective, and the helicopter attitude will adopt a wings-level climb-out profile. There is no standard procedure at Cougar Helicopters for the use of the cyclic force trim release button during departure. This could lead to difficulties if a rapid transfer of control is required during departure.

2.6 Standard Operating Procedures

2.6.1 General

Cougar Helicopters' SOPs outline several standard callouts designed to increase crew effectiveness and improve crew communications. These standard calls address a number of different deviations from the desired flight profile; however, there is no standard callout for deviations in helicopter pitch. As a result, there are no pre-defined limits established for standard callouts to identify excessively low or high pitch attitudes, typically associated with unusual attitudes. The lack of standard callouts for pitch deviations increases the likelihood of miscommunication during unusual attitude recoveries.

2.6.2 Crew Pairing

The occurrence flight crew met Cougar Helicopters' crew pairing policy requirements, which prohibited 2 pilots with less than 300 hours on type from flying together. The risk assessment matrix (RAM) did not indicate an abnormally high level of risk for the occurrence flight. However, additional crew pairing risk control measures had been put in place to meet customer requirements. These additional measures were not adhered to in this occurrence. As a way of establishing an equivalent level of safety for not meeting the customer's minimum helicopter flight hour requirement, the first officer was only to fly with designated training pilots until the minimum required flight hours were reached. This restriction was applied for several months; the first officer then started being paired with non-training captains. In addition, this restriction was not communicated to the new chief pilot. There was no formal process in place at Cougar Helicopters to ensure adherence to crew pairing restrictions. As a result, the first officer was paired with pilots who were not qualified training pilots. Therefore, any possible reduction in risk as a result of this risk control measure was not realized.

2.7 Simulator Training

There are no regulatory requirements to practice unusual attitude recoveries during recurrent training, either in the aircraft or in the simulator. Therefore, the onus is placed on the operator to decide whether or not to carry out unusual attitude recovery training. While today's modern aircraft offer enhanced levels of safety because of the automation that is available, it is vital that flight crews maintain sufficient hands-on proficiency in the unlikely event that they are required to assume control in a precarious flight attitude, such as an unusual attitude. If flight crews do not receive recurrent training in unusual attitude recovery, they are more likely to experience difficulties recovering from unusual attitudes.

Cougar Helicopters included a subtle incapacitation exercise in its recurrent simulator training; however, this excercise was typically done by having the pilot flying (PF) act unresponsive, which required the other pilot to assume control. In addition, flight crews were typically briefed beforehand, so they knew that an incapacitation situation would arise at some point during the simulator session. As a result, this training situation was not realistic and not representative of a more likely type of subtle incapacitation, where a pilot appears to be attempting to make appropriate corrections, but those corrections are inadequate to rectify the situation. If flight crews are not trained to recognize and respond to subtle incapacitation, they may not have the confidence to take control from a more experienced pilot.

2.8 Crew Resource Management

Despite a lack of regulations requiring crew resource management (CRM) training for *Canadian Aviation Regulations* (CARs) 702, 703, or 704 operators, Cougar Helicopters actively promotes the concepts of CRM and has developed in-house initial and recurrent CRM training. The CHARM course promotes respect for the captain's authority; however, it also advocates the responsibility of other crew members for ensuring the safety of flight. To enhance the effectiveness of the flight crew, the CHARM course provides the flight crew with practical strategies that can be used in the cockpit. In particular, the CHARM course provides the flight crew with a series of communication strategies that begin with gentle probing questions and escalate to a more assertive approach, designed to eliminate ambiguity and restore safety margins to acceptable levels. However, these communication strategies will only be effective if flight crews are trained in their use and have opportunities to apply them in training and during operations. If CRM strategies are not practiced during simulator and flight training, there is increased risk that flight crews will experience breakdowns in CRM that could reduce safety margins.

In this occurrence, the first officer provided several verbal cues to the captain to assist with the recovery from the unusual attitude. However, despite having made the decision to re-arm the flotation because it was believed water impact was imminent, the first officer did not attempt to assume control from the captain. The first officer did not recognize the symptoms of subtle incapacitation, which are outlined in Cougar Helicopters' SOPs. As a result, the first officer did not assume control from the captain because the captain was providing appropriate verbal responses to the challenges. This is not unusual. As identified earlier in the report, first officers are often reluctant to assume control from their captains. In this occurrence, the first officer believed the situation would be made worse by attempting to take control. This is an indication that the first officer doubted having the necessary manual flying skills to recover from the inadvertent descent, despite the fact that Cougar Helicopters' pilots had been taught a standard unusual attitude recovery procedure. This is contrary to guidance in the CHARM course handbook, and it is not in accordance with the two-challenge rule published in the Cougar Helicopters SOPs, which call for an automatic assumption of flying duties if appropriate action has not been taken after the second challenge. The first officer did not take control of the helicopter, as per the two-challenge rule in Cougar Helicopters' SOPs, when the appropriate action was not taken to recover from the inadvertent descent.

During an offshore rig departure, workload is increased due to the number of actions that must occur prior to the helicopter reaching 400 feet above the water. In particular, several things occur at or around the time that the helicopter accelerates through V_{TOSS}. When those actions all come together at the same time, the pilot monitoring's (PM) attention is taken away from the flight instruments for a brief period of time while the gear is raised and the flotation is placed in the SAFE position. In this occurrence, the first officer's head was down momentarily when the GA mode was engaged. As a result, the first officer was not actively monitoring the flight instruments at that moment. When the first officer looked at the flight instruments, it was recognized that the helicopter was descending in a nose-high unusual attitude; the first officer began to advise the captain. If autopilot modes are engaged while one pilot is occupied with other duties, that pilot is not able to properly perform the PM functions. This increases the risk that deviations from the standard flight profile will go undetected or not be detected in a timely manner.

2.9 Cougar Helicopters' Safety Management System

2.9.1 Just Culture and Non-Punitive Reporting

Cougar Helicopters' safety management system (SMS) manual and other related company documents advocate a non-punitive reporting system as a core element of a healthy SMS. In this occurrence, both pilots reported the occurrence and cooperated fully with the company's SMS investigation.

The decision was made to terminate the captain's employment based on the company's determination that the captain could not operate safely in the offshore IFR environment. To some employees, this appeared to be in conflict with the principles and processes outlined in Cougar Helicopters' SMS and with non-punitive reporting.

The reporting of hazards is a cornerstone of a robust SMS. A non-punitive reporting policy encourages open reporting of safety occurrences. At the same time, companies have a responsibility to ensure that their employees are competent to carry out their duties in a safe manner. This means that, from time to time, companies may take significant measures, including termination of employees who are involved in safety incidents. Therefore, when introducing a non-punitive reporting system and a Just Culture decision tree model, organizations must be clear with their staff about the types of situations that could result in disciplinary measures, or other company actions including termination. Otherwise, subsequent management actions may undermine the trust employees have in such systems.

When actions taken by a company are perceived by employees to be inconsistent with its non-punitive reporting and Just Culture policy and processes, there is a risk that employees will not report safety occurrences for fear of reprisal.

2.9.2 Cougar Helicopters' Safety Management System Investigation

Cougar Helicopters actively uses helicopter flight data monitoring (HFDM) to assist its SMS investigations. This information can provide valuable details about an occurrence that might otherwise be lost. In addition, HFDM is used proactively to monitor all flights to identify trends before an occurrence. In this occurrence, the CVR had been pulled from the helicopter for use as part of the SMS investigation. None of the management team members at Cougar Helicopters was aware that CVR data is protected under the *Canadian Transportation Accident Investigation and Safety Board* (*CTAISB) Act* and that it is not to be used by an operator. The operator was unaware that the CVR is privileged by the *CTAISB Act*.

Prior to the completion of the SMS investigation, Cougar Helicopters ruled out crew experience, crew training, and the S-92A autopilot system as factors. However, follow-up training evaluations with the first officer revealed some manual flying skill proficiency issues that may have been contributory in this occurrence. In particular, the first officer lacked hands-on flying proficiency. A better proficiency would have given the first officer increased confidence in the ability to take control and recover from the unusual attitude that had developed. Likewise, the flight crew members were paired together, despite the fact that they did not meet restrictions put in place by the offshore operators. In addition, after the occurrence, Cougar Helicopters published pilot memos on autopilot engagement and unusual attitude recovery procedures and amended company SOPs regarding the departure procedure.

2.10 Previous Occurrences

In August 2007 and November 2008, Cougar Helicopters conducted 2 internal SMS investigations resulting from inadvertent descents in the offshore environment. In one instance, the helicopter descended to an altitude of 31 feet above sea level (asl) and in the other, there was a main gearbox torque exceedance. Neither of these occurrences was reported to the Transportation Safety Board (TSB) at the time, despite the fact that both met the requirements for a reportable incident in accordance with TSB Regulations. If reportable incidents are not reported to the TSB, there is increased likelihood that opportunities to advance Canadian transportation safety will not be realized.

3.0 Findings

3.1 Findings as to Causes and Contributing Factors

1. During the departure procedure, the captain made a large, rapid aft cyclic input just before the cyclic trim button was released and the go-around mode was engaged, which caused the helicopter to enter a nose-high, decelerating pitch attitude.

2. The S-92A's go-around (GA) mode is designed with reduced control authority. As a result of this reduced control authority, the helicopter experienced difficulties recovering from the nose-high pitch attitude which occurred following the GA mode engagement.

3. As the airspeed of the helicopter decreased to within 5 knots of the minimum control speed in instrument meteorological conditions (V_{MINI}), the captain momentarily pressed the cyclic force trim release button and made an aft cyclic input. This caused the helicopter's airspeed to decrease below V_{MINI}, and the helicopter to enter a 23° nose-high unusual attitude.

4. The captain, subtly incapacitated possibly due to spatial disorientation, did not lower the nose of the helicopter and apply collective to recover from the nose-high unusual attitude. This contributed to the excessive amount of altitude that was lost during the inadvertent descent.

5. Contrary to what is stated in the two-challenge rule in Cougar Helicopters' *SK-92 Helicopter Standard Operating Procedures*, the first officer did not take control of the helicopter when the appropriate action was not taken to recover from the inadvertent descent.

3.2 Findings as to Risk

1. If cockpit and data recordings are not available to an investigation, this may preclude the identification and communication of safety deficiencies to advance transportation safety.

2. The S-92A's enhanced ground proximity warning system provides no warning of an inadvertent descent at airspeeds below 40 knots indicated airspeed with the landing gear down. As a result, there is increased risk of controlled flight into terrain during those phases of flight.

3. If there are delays initiating the controlled flight into terrain (CFIT) avoidance procedure in response to an enhanced ground proximity warning system alert, there is an increased risk of CFIT.

4. If pilots of automated aircraft do not maintain their hands-on visual and instrument flying proficiency, there is increased risk that they will be reluctant to take control and that they will experience difficulties recovering from unexpected flight profiles that require pilot intervention.

5. If S-92A pilots do not consult the top portion of the primary flight display to confirm proper autopilot engagement, they may not recognize that the system is degraded or not engaged.

6. The S-92A Rotorcraft Flight Manual is misleading in that it states that the go-around (GA) mode can be used to recover from an unusual attitude. The GA mode will not function below 50 knots indicated airspeed and it is limited in how fast it can make attitude and power changes. As a result, pilots and passengers are at increased risk of collision with terrain if pilots attempt to use the GA mode to recover from an unusual attitude at low altitude.

7. If the go-around (GA) mode is engaged at 55 knots indicated airspeed, in accordance with Cougar Helicopters' *SK-92 Helicopter Standard Operating Procedures*, there is increased risk that the the GA mode will disengage as a result of a transitory decrease in airspeed below the minimum control speed in instrument meteorological conditions (V_{MINI}).

8. There is no standard procedure at Cougar Helicopters for the use of the cyclic force trim release button during departures. This could lead to difficulties if a rapid transfer of control is required during a departure.

9. The lack of standard callouts for pitch deviations increases the likelihood of miscommunication during unusual attitude recoveries.

10. There was no formal process in place at Cougar Helicopters to ensure adherence to crew pairing restrictions. As a result, the occurrence first officer was paired with pilots who were not qualified training pilots. Therefore, any possible reduction in risk as a result of this risk control measure was not realized.

11. If flight crews do not receive recurrent training in unusual attitude recoveries, they are more likely to experience difficulties recovering from unusual attitudes.

12. If flight crew members are not trained to recognize and respond to subtle incapacitation, they may not have the confidence to take control from a more experienced pilot.

13. If crew resource management (CRM) strategies are not practiced during simulator and flight training, there is increased risk that flight crews will experience breakdowns in CRM that could reduce safety margins.

14. If autopilot modes are engaged while one pilot is preoccupied with other duties, that pilot will not be able to properly perform the pilot monitoring functions. This increases the risk that deviations from the standard flight profile will go undetected or not be detected in a timely manner.

15. If actions taken by a company are perceived by employees to be inconsistent with its non-punitive reporting and Just Culture policy and processes, there is a risk that employees will not report safety occurrences for fear of reprisal.

16. If reportable incidents are not reported to the Transportation Safety Board (TSB), there is increased likelihood that opportunities to advance Canadian transportation safety will not be realized.

3.3 *Other Findings*

1. The rapid application of collective in order to arrest the inadvertent descent resulted in the exceedance of transmission torque limits.

2. During the rapid application of collective, neither pilot realized that there had been an exceedance of transmission operating limitations during the recovery, and they continued the flight back to St. John's International Airport (CYYT).

3. The operator was unaware that the cockpit voice recorder is privileged under the *Canadian Transportation Accident Investigation and Safety Board Act*.

4.0 Safety Action

4.1 Safety Action Taken

4.1.1 Cougar Helicopters Inc.

Following this occurrence, Cougar Helicopters published a Pilot Memo titled "S92 Engaging Autopilot Functions" (Appendix E). The information included in this memo has also been incorporated into the Cougar Helicopters SK-92 standard operating procedures (SOPs).

Cougar Helicopters also published a Pilot Memo titled "Unusual Attitude Recovery". The memo states that its intent is to "clarify and reinforce the Company policy on Pilot Incapacitation and Unusual Attitude Recovery." [51] The memo also outlines the recommended recovery procedure:

1. Accept that the aircraft is not doing what was anticipated, trouble shoot later
2. Put the nose on the horizon
3. Level the wings
4. Pull minimum 80% Q
5. Accelerate to a minimum of Vy;
6. Climb to 1000′ or MOCA before trying to stabilize or trouble shoot the problem [52]

The memo also states that,

> If an aircraft attitude deviation has occurred the PM must call the deviations as per SOP. If the PF acknowledges but does not take **physical action** to correct the attitude you must consider the person to be incapacitated. . . . If a PM determines that an appropriate correction is not being made **after it is called for and acknowledged** then the PM should take control and apply the appropriate correction.

Cougar Helicopters made the following amendments to its *Company Operations Manual*:

- Additional information was provided to clarify the types of events (i.e., occurrences) that should be reported through Cougar Helicopters' safety management system (SMS) reporting system.
- Company pilots are now required to conduct a minimum of 2 manually-flown approaches to minimums every 90 days.
- Specific procedures have been added to ensure the protection of flight data recorder information following an incident or accident.

Cougar Helicopters made the following amendments to its SK-92 SOPs*:*

- A procedure has been added requiring pilots to crosscheck the top strip of the primary flight display for proper mode engagement.

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51 Cougar Helicopters, Pilot Memo, "Unusual Attitude Recovery" (26 July 2011).

52 Ibid.

- A warning has been added advising pilots not to use the flight director bars as a means of determining proper mode engagement.
- Information has been added to highlight the importance of ensuring the aircraft is properly trimmed prior to engaging any autopilot function.
- Flight crews are also reminded that to couple in any autopilot mode (exept RAD ALT and SAR modes), airspeed must be above 50 knots indicated airspeed (KIAS) and altitude above 50 feet radar altitude. If engaged below these parameters, the flight director command bars will appear, but the autopilot will not be coupled.
- The pilot monitoring shall make all autopilot selections (with the exception of the go-around) below minimum safe altitudes. The pilot flying will engage the go-around mode, as control pressures must be neutral for correct engagement. The landing gear is now raised during the after-takeoff check to mimimize any distractions during a critical phase of flight.
- Guidance has been added regarding recovering from an unusual attitude and the expected actions of the pilot monitoring in these situations.
- Additional guidance has been provided and standard terminology has been clarified as it relates to deviations from coupled flight, abnormal rate of descent or climb, and abnormal airspeed.

Cougar Helicopters has enhanced its simulator training by including more specific exercises focused on the basic unusual attitude recovery technique. In addition, the training incorporates situations where the pilot flying responds to cues from the pilot monitoring, but does not carry out the correct physical actions to rectify the situation.

Cougar Helicopters has developed a process for ensuring that pairing restrictions are followed. All restrictions are entered into an electronic flight operations information management system (FOIMS). The restrictions are reviewed weekly by the schedulers when crew schedules are prepared. In addition, on the day of a flight, both the dispatcher and the flight crew review the FOIMS to ensure that no restricutions have been missed prior to the flight.

Cougar Helicopters provided all first officers with a dedicated CHARM training session that covered escalation strategies for communicating concerns to captains.

Cougar Helicopters established a chief training pilot position within the company. The chief training pilot is responsible for providing instructor training and guidance to maintain consistent evaluation standards.

In 2012, Cougar Helicopters began a Just Culture training program. Numerous sessions were held with small groups of employees throughout the year, and all employees completed the training sessions in 2012.

4.1.2 Sikorsky Aircraft Corporation

In 2013, Sikorsky issued Temporary Revision 11 to the S-92A Rotorcraft Flight Manual (RFM). This revision required S-92A operators to add the following information to the RFM concerning the use of the coupled flight director:

> If a pilot accelerates from a hover to climb or cruise speed without depressing the cyclic trim release (i.e. against trim) and then attempts to couple to vertical speed, the CFD may not hold the requested climb rate and may not automatically level off at the

> requested altitude. Whenever possible, airspeed changes should be made with the cyclic trim button depressed or with the beeper trim. Additionally, the use of three-cue coupling (collective controlling climb rate or altitude) is recommended during climb and descent. [53]

In addition, it also required that the following information related to the go-around function be added to the S-92A RFM:

> When selecting GA, ensure the aircraft is in a stable climb and cyclic is trimmed to zero force. Whenever possible, airspeed changes should be made with the cyclic trim depressed or by using the cyclic beeper trim. [54]

4.1.3 Canada-Newfoundland and Labrador Offshore Petroleum Board

Discussions between the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) and the offshore operators are currently underway to develop enhancements to the safety oversight of helicopter operations in the Newfoundland and Labrador offshore area.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 26 June 2013. It was officially released on 12 September 2013.

Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

53 Sikorsky, S-92A Temporary Revision 11 (April 2013).

54 Ibid.

Appendices

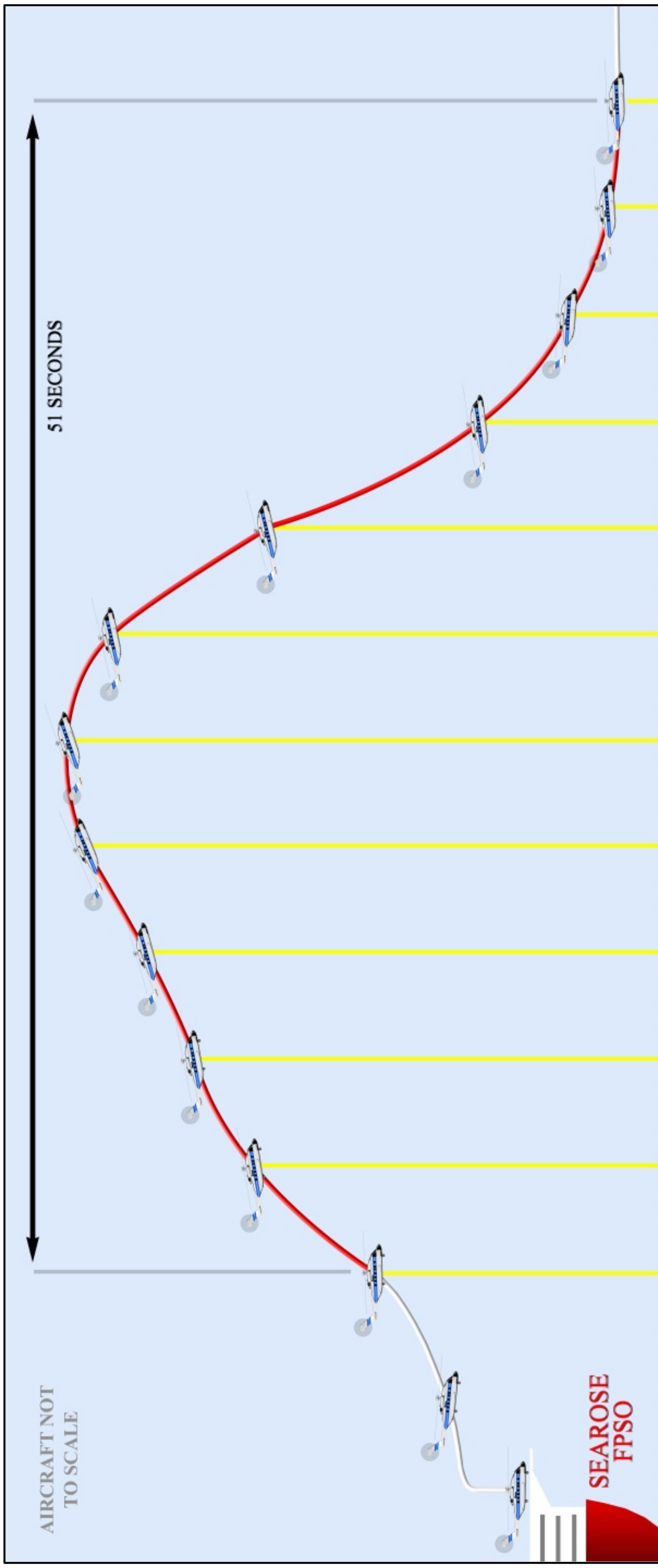
Appendix A – List of TSB Laboratory Reports

The following TSB Engineering Branch Laboratory Reports were completed:

1. LP 091/2011 – FDR/HUMS Data Analysis
2. LP 067/2012 – Graphic of Occurrence Flight

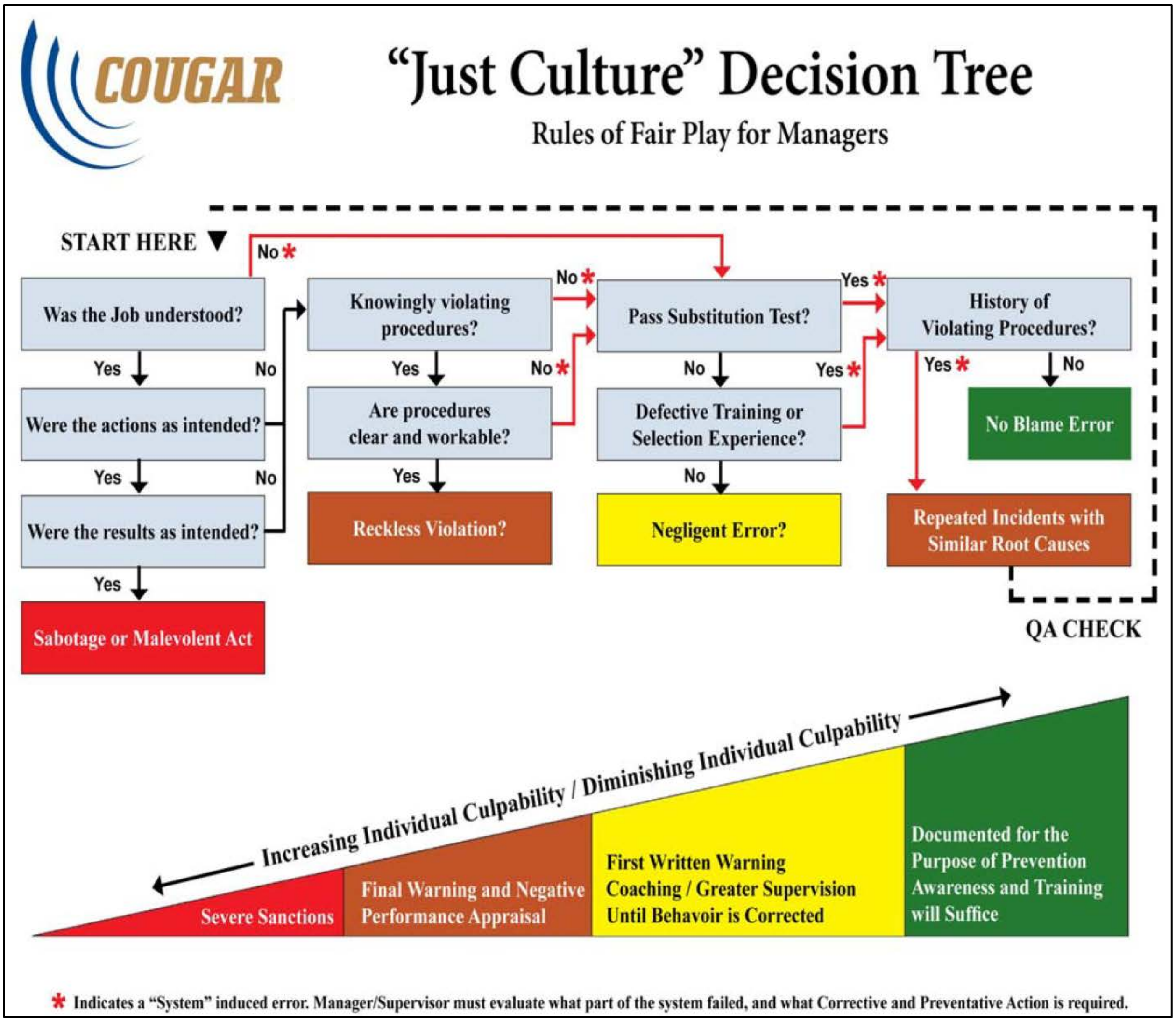
These reports are available from the Transportation Safety Board of Canada upon request.

Appendix B – Departure Profile (Derived from FDR Data)



	Go-Around Engaged	Pitch Increasing	Pitch 10° Nose-Up	Autopilot Disengaged	Maximum Nose up Pitch	Maximum Altitude	"Don't Sink" Warning	1500 ft/min Descent Rate	"Too Low Gear" / Maximum Descent Rate	Maximum Torque / Low Rotor Warning	Main Rotor RPM 105%	Lowest Altitude
Bar. Altitude	259 ft	386 ft	423 ft	467 ft	521 ft	541 ft	454 ft	329 ft	161 ft	81 ft	54 ft	54 ft
Radar Altitude	255 ft	391 ft	424 ft	467 ft	520 ft	533 ft	437 ft	306 ft	152 ft	72 ft	44 ft	38 ft
Pitch Attitude	2.11°	9.84°	10.9°	15.82°	22.85°	18.63°	12.66°	13.71°	8.09°	-3.52°	2.11°	4.57°
Airspeed	64 kt	58 kt	54 kt	47 kt	37 kt	32 kt	25 kt	27 kt	28 kt	1 kt	0 kt	21 kt
Vert. Speed (/min.)	1000 ft	1125 ft	875 ft	750 ft	750 ft	-125 ft	-1375 ft	-1500 ft	-1875 ft	-875 ft	-250 ft	125 ft
Eng. Torque (avg.)	84 %	60 %	58 %	52 %	60 %	54 %	52 %	56 %	97 %	130 %	102 %	78 %
Heading	73°	73°	73°	74°	82°	93°	127°	153°	185°	198°	206°	153°

Appendix C – Just Culture Decision Tree Model



The safety management system (SMS) manual outlines how the model is to be used, stating that it is only used "after an incident has been fully reviewed, and senior management is confident they have all pertinent information." [55] At that point, the process is initiated by starting to go through the flow chart. The Just Culture decision tree consists of a series of yes or no questions. The answer to each question determines the next step in the process. Once the process is completed, the decision maker will arrive at a final point in the tree which determines what action, if any, is most appropriate for a given situation.

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55 Cougar Helicopters safety management system (SMS) manual (2010).

Appendix D – Go-Around Indications on Primary Flight Display [56]

56 Flight Safety International, *S-92A Pilot Training Manual* (2009).

Appendix E – Pilot Memo: S-92A Engaging Autopilot Functions

Pilot Memo

Date: 26 Jul 2011

To: Cougar Pilots

From: Chief Pilot

Re: S92 Engaging Autopilot Functions

The intent of this memo is to clarify and reinforce the engagement and use of autopilot functions on the S92. The concern is initial engagement of modes e.g. GA.

1. Prior to engaging **ANY** autopilot function – GA, IAS, ALT, VS etc. the pilot must **NOT** apply any pressure to the collective or the cyclic. Any pressure will cause an error in the system and result in unanticipated aircraft attitudes.

2. The aircraft attitude should be set in a stable condition prior to the initial engagement of autopilot functions. Crews are reminded that to couple in any mode, KIAS must be above 50KIAS and altitude above 50' RADALT. If selected below these parameters the FD bars will appear but the autopilot is not coupled.

3. Prior to selecting an airspeed, altitude or VS autopilot functions (these include GA and ALTP modes) the cyclic trim release shall be momentarily depressed and released to remove all pressures from the flight controls. If 3 cue coupling is desired then the collective should be set and the trigger released. Then the desired function may be selected.

4. Verbal Terminology for describing autopilot functions shall be as follows:

   a. **Selected** – indicates a desired mode has been physically selected
   b. **Engaged** – the PF has confirmed by checking the top of the PFD that the selected mode has in fact engaged and the autopilot is functioning. Mode will be displayed in Green
   c. **Armed** – the PF has confirmed by checking the top of the PFD that the desired mode is armed. Displayed in white.
   d. **Captured** – when a mode has "captured" the desired reference. E.g. aircraft is climbing in VS with ALTP armed, when the mode shifts to altitude hold and a/c starts to level. The PF confirms by checking the top of the PFD to ensure the desired mode is displayed, green and states "altitude captured".

5. The pilot selecting an autopilot function **SHALL** state "______ selected", the PF shall crosscheck the top of the PFD and confirm the appropriate mode is displayed in green and **SHALL** state either "_____ engaged" or "____armed" or "_____ captured" or "____did not engage". This indicates the appropriate mode is in operation as expected.

6. Anytime a mode changes, e.g. from armed to captured, the PF shall verbalize the change.

7. If the caption at the top of the PFD is displayed in yellow the autopilot has not coupled to the selected mode even though the FD bars may be displayed and the pilot must still manually fly that mode.

8. Crews **SHALL NOT** rely on the FD bars as an indication that the autopilot is engaged.

9. Care must be exercised not to induce errors by applying pressure to the flight controls while coupled as this may result in FD degrades and unanticipated aircraft attitude changes. This does not restrict pilots from manually making a change in one axis when coupled to another e.g. coupled to airspeed and the pilot manually changes heading by inputting a roll but care must be exercised to allow the cyclic to move fore and aft while maintaining a bank angle. Another example would be using the trim button to change the desired airspeed reference setting (bug) when coupled. The pilot must allow the cyclic to move while using the trim button.

When modes are selected Pilots must be vigilant and ensure that the modes have engaged as expected. If the aircraft does not respond as anticipated the PF must be ready to manually fly the aircraft and set a safe attitude for the condition of flight.

It is the PICs responsibility to ensure the safety of the aircraft by preventing unexpected excursions from developing into large deviations from the desired safe flight envelope.