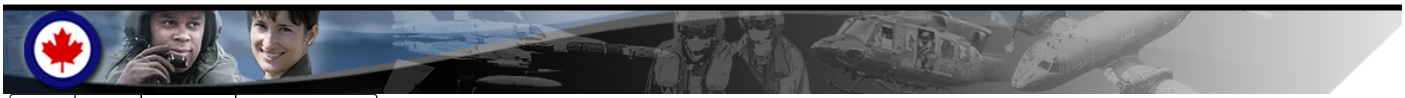



# CT156102 Harvard II - Epilogue - Flight Safety Investigation Report


**Report / January 24, 2014 / Project number: CT156102 - A Cat**

**Location**: 15 Wing Moose Jaw, Saskatchewan
**Date**: 2014-01-24
**Status**: Investigation Complete

FSIR - download PDF version, 818 kb

## Epilogue

While conducting an advanced clearhood training sortie in a CT156 Harvard II aircraft out of 2 Canadian Forces Flying Training School (2 CFFTS), a qualified flying instructor (QFI) and student pilot (SP) experienced a hard landing upon completion of a practice forced landing (PFL).

Recognizing that the approach was not ideal, the QFI took control of the aircraft from the student just as the landing gear contacted the runway. The instructor applied full power and the aircraft quickly became airborne again.

A Harvard II chase aircraft joined up to visually inspect and photograph the damage. The photographs were returned to base which allowed maintenance personnel to confirm that the left main landing gear (LMLG) brace had become detached from the strut. Meanwhile, a second Harvard II chase aircraft joined up with the accident aircraft. Several attempts were made by the accident aircraft to attain a symmetrical gear up configuration for a possible belly landing; however, a symmetrical configuration was not achieved.

Supported by the 15 Wing Commander (W Comd), the QFI decided that a controlled ejection was the safest option rather than attempting to land the crippled aircraft. After completing the ejection checklist, the QFI and SP successfully ejected. The QFI and SP suffered minor injuries during the ejection and parachute landing. The aircraft was destroyed in the subsequent crash.

With no evidence of aircraft unserviceability, the investigation focussed primarily on the PFL, which had been flown in a non-standard flapless configuration. The associated training plans (TPs) and PFL training were also examined.

The investigation found that a need to increase pilot production at 2 CFFTS had resulted in a revised TP. The new TP was put into effect coincidental with the QFI's pilot training in 2012. The revised syllabi made significant modifications to the previous syllabi; most noteworthy was a significant reduction in the number of flying missions that could include PFL training.

The investigation concluded that the practice of completing PFLs in a flapless configuration with no formal training was contributory to this accident, as was the decrease in PFL training which likely resulted in this QFI having significantly less PFL experience following the Flying Instructor Course (FIC) than previous pipeline QFIs in 2 CFFTS.

A preventive measure (PM) was implemented following this accident which established a safety window restricting the practice of flapless PFLs.  Additional PMs relating to Aviation Life Support Equipment (ALSE), the Integrated Data Acquisition Recorder (IDAR), QFI personal limits and unit culture are recommended.

Return to top of page

# CANADIAN FORCES FLIGHT SAFETY INVESTIGATION REPORT (FSIR)

## FINAL REPORT

FILE NUMBER:  1010–CT156102 (DFS 2-2-2)

FSOMS IDENTIFICATION NUMBER:  159282

DATE OF REPORT:  27 April 2016

OCCURRENCE CATEGORY:  "A"

AIRCRAFT TYPE:  CT156 Harvard II

AIRCRAFT REGISTRATION NUMBER:  CT156102

DATE OF OCCURRENCE:  24 January 2014

TIME OF OCCURRENCE (L):  12:18 L

LOCATION:  15 Wing Moose Jaw, SK

OPERATOR:  2 CFFTS, 15 Wing

This report was produced under authority of the Minister of National Defence (MND) pursuant to sections 4.2(1)(n) and 4.2(2) of the Aeronautics Act, and in accordance with A-GA-135-001/AA-001, Flight Safety for the Canadian Forces.

With the exception of Part 1, the contents of this report shall only be used for the purpose of accident prevention.  This report was released under the authority of the Director of Flight Safety, National Defence Headquarters, pursuant to powers delegated to him by the Minister of National Defence as the Airworthiness Investigative Authority for the Canadian Forces

## SYNOPSIS

While conducting an advanced clearhood training sortie in a CT156 Harvard II aircraft out of 2 Canadian Forces Flying Training School (2 CFFTS), a qualified flying instructor (QFI) and student pilot (SP) experienced a hard landing upon completion of a practice forced landing (PFL).

Recognizing that the approach was not ideal, the QFI took control of the aircraft from the student just as the landing gear contacted the runway.  The instructor applied full power and the aircraft quickly became airborne again.

A Harvard II chase aircraft joined up to visually inspect and photograph the damage.  The photographs were returned to base which allowed maintenance personnel to confirm that the left main landing gear (LMLG) brace had become detached from the strut.  Meanwhile, a second Harvard II chase aircraft joined up with the accident aircraft.  Several attempts were made by the accident aircraft to attain a symmetrical gear up configuration for a possible belly landing; however, a symmetrical configuration was not achieved.

Supported by the 15 Wing Commander (W Comd), the QFI decided that a controlled ejection was the safest option rather than attempting to land the crippled aircraft.  After completing the ejection checklist, the QFI and SP successfully ejected.  The QFI and SP suffered minor injuries during the ejection and parachute landing.  The aircraft was destroyed in the subsequent crash.

With no evidence of aircraft unserviceability, the investigation focussed primarily on the PFL, which had been flown in a non-standard flapless configuration.  The associated training plans (TPs) and PFL training were also examined.

The investigation found that a need to increase pilot production at 2 CFFTS had resulted in a revised TP.  The new TP was put into effect coincidental with the QFI's pilot training in 2012.  The revised syllabi made significant modifications to the previous syllabi; most noteworthy was a significant reduction in the number of flying missions that could include PFL training.

The investigation concluded that the practice of completing PFLs in a flapless configuration with no formal training was contributory to this accident, as was the decrease in PFL training which likely resulted in this QFI having significantly less PFL experience following the Flying Instructor Course (FIC) than previous pipeline QFIs in 2 CFFTS.

A preventive measure (PM) was implemented following this accident which established a safety window restricting the practice of flapless PFLs.  Additional PMs relating to Aviation Life Support Equipment (ALSE), the Integrated Data Acquisition Recorder (IDAR), QFI personal limits and unit culture are recommended.

Return to top of page

## TABLE OF CONTENTS

# 1. FACTUAL INFORMATION

## 1.1. History of Flight

1.1.1. The Harvard II aircraft was operating out of 15 Wing, Moose Jaw, SK. It was crewed by a B Category[1] qualified flying instructor (QFI) and a student pilot (SP) from 2 Canadian Forces Flying Training School (2 CFFTS).

1.1.2. On the morning of the occurrence, runway snow and ice control (SNIC) operations on 15 Wing's airfield (CYMJ) caused a delay to the start of the flying program. As a result, numerous changes were made to the flying program. Given the relatively strong wind that day, the occurrence QFI had initially seen an opportunity to improve proficiency in flying traffic patterns and practice forced landings (PFLs) in challenging conditions and had coordinated with scheduling to fly a Staff Continuation Training (SCT)[2] mission with an experienced QFI.

1.1.3. Once the SNIC was completed and the start of flying operations confirmed, the Flight Commander (Flt Comd) directed the Flt Scheduler to launch only student missions. The QFI was subsequently asked by the Flight Scheduler to change plans and fly a student mission instead of the anticipated proficiency mission. The QFI and SP were then scheduled to fly a Phase III[3] Advanced Clearhood 7 (ACH7) sortie with minimal notice due to the late scheduling change.

1.1.4. The QFI reviewed the SPs progress book and noted the ACH6 mission, flown on the previous day, did not have a completed progress card written; however, the ACH5 progress card was completed and showed the SP had achieved level 4[4] in all mission events including the PFL.

1.1.5. The progress card for the ACH6 mission, which was unavailable to the QFI prior the ACH7 mission as it had yet to be completed, indicated a weakness in the SP's flapless final turn, specifying that the SP was initially setting the attitude too low due to a tendency to set land flap attitude.

1.1.6. Following the progress card review, the QFI consulted with the SP to develop a mission profile. The mission brief was constrained to approximately 10 minutes due to the late scheduling change. The SP provided the QFI with a weather brief highlighting the strong winds of the day and the QFI focused the mission brief on wind considerations during PFLs, making specific reference to only one technique; adjusting the angle of bank to maintain the circular PFL pattern.

1.1.7. With the QFI in the rear seat and the SP in the front seat, the sortie originated from CYMJ. Once airborne, they completed a brief period of area work and then returned to CYMJ to practice PFLs and traffic patterns.

1.1.8. Figure 1 illustrates the basic PFL pattern. The shaded circular line with aircraft along it depicts the ideal PFL pattern. Included are two approximated ground tracks flown during this particular sortie:

Figure 1. PFL pattern with overlay of approximate flight paths

1.1.9. Lack of sufficient correction for the strong northwesterly wind caused the first PFL to be elongated for the low key (LK) position, farther downwind and wider than ideal. Landing gear was selected down approaching LK in accordance with (IAW) the Harvard II Standard Manoeuvre Manual (SMM). Having recognized the effect of the strong wind at LK, the SP turned more directly towards the runway to cut inside of the final key (FK) position. No flap selections were made during this PFL and, realizing that a safe landing was not assured due to a lack of altitude when approaching the runway, the SP initiated a go around.

1.1.10. Following the go around, the QFI took control of the aircraft and was then cleared to climb back up to HK by Air Traffic Control (ATC) for a further attempt. During the climb back to HK, the QFI debriefed the SP on the first PFL. They discussed how to better compensate for the strong wind conditions using the varying angle of bank technique after which, approaching HK, the SP was given back control of the aircraft.

1.1.11. The second PFL had a similar ground track to the first PFL. The landing gear down selection was again delayed until LK and flaps were purposely left up in order to preserve energy. Soon after LK, the SP turned more directly towards the runway to compensate for the strong wind. Both the QFI and SP were aware the flaps were in the up position as they approached the runway. Though not ideal, neither the QFI nor the SP felt uncomfortable with the flapless approach to the runway. Both believed the altitude, position and energy state of the aircraft was sufficient to allow a safe landing to be made.

1.1.12. On final approach the SP was still working to align the aircraft with the runway while starting to roll the wings level and flare. During the flare in a flapless configuration, both the QFI and SP perceived an increase in the sink rate. The QFI grabbed the controls immediately prior to contact with the runway and applied full power coincidental with the hard landing. The aircraft's left main landing gear (LMLG) struck the runway first, which was followed by the right main landing gear (RMLG) and the nose gear (NG) prior to the aircraft becoming airborne again.

1.1.13. Following the touch-and-go, the QFI selected the landing gear up and noted a red LMLG indication meaning that it was an unsafe condition. Speed was maintained below the maximum landing gear (LG) manoeuvring speed and the LG was cycled down in an attempt to establish safe landing gear down indications. The LMLG continued to display a red indication meaning that it was 'unsafe down'. The QFI notified ATC that they were breaking out of the traffic pattern and departing towards the training area to trouble shoot their LG problem. The QFI then radioed for any other Harvard II aircraft to form up in a chase position and provide a visual inspection.

1.1.14. A Harvard II chase aircraft joined up to visually inspect the landing gear and confirmed that the LMLG appeared "bent". Photos of the aircraft's landing gear were taken [Figure 2] before the chase aircraft returned to base. The photos clearly depicted that the LMLG side brace was detached from the LMLG strut. With damage of this nature there was no way to lock the LMLG down because the downlocks for the main landing gear (MLG) are contained within the hydraulic actuators which control the struts through the now disconnected side brace.

Figure 2. Chase plane photo showing detached LMLG side brace

1.1.15 After varying yaw and G-loads that were applied in an effort to obtain a down and locked indication proved unsuccessful, 2 CFFTS operations instructed the accident aircraft to attempt to attain an all gear up condition, in order to provide the opportunity of a gear up landing at CYMJ. Meanwhile, a 2nd Harvard II chase aircraft had joined the occurrence aircraft to provide assistance with troubleshooting the landing gear malfunction. The landing gear was selected up and the nose gear and right main RMLG cycled up; however, the LMLG remained hanging down and a red unsafe LMLG indication remained in the cockpit.

1.1.16. The QFI was then instructed to roll the aircraft in an attempt to cause the LMLG to collapse into the wheel well. Two right rolls were completed during which the chase aircraft observed only slight movement of the LMLG. Both rolls proved unsuccessful in retracting the LMLG.

1.1.17. With the LMLG remaining down in an unsafe condition, options were presented to the QFI by the 15 Wing Commander (WComd) over the radio to either attempt a landing with the unsafe LMLG or consider a controlled ejection.

1.1.18. The QFI chose the controlled ejection as the preferred course of action given the unpredictability of landing with the asymmetric landing gear.

1.1.19. With the controlled ejection checklist procedures having been completed twice, and with the aircraft stabilized at 5400' mean sea level (MSL) (approximately 3400' AGL) at an indicated airspeed of 139 kts, a sequenced[5] ejection was initiated by the QFI after having passed the CYMJ airfield on a heading of 245º True IAW the published bailout vector.

1.1.20. The QFI and SP landed in a snow covered agricultural field.

Return to top of page

### 1.2. Injury to Personnel

1.2.1. Both the QFI and SP sustained minor injuries during the ejection and parachute landing. The QFI and SP were transported to the Moose Jaw Union Hospital for treatment of injuries and toxicology testing.

| Injuries | Crew | Passengers | Others | Total |
|---|---|---|---|---|
| **Fatal** | 0 | 0 | 0 | 0 |
| **Serious** | 0 | 0 | 0 | 0 |
| **Minor** | 2 | 0 | 0 | 2 |
| **Total** | 2 | 0 | 0 | 2 |

Table 1. Injury to Personnel

### 1.3. Damage to Aircraft

1.3.1. The aircraft was destroyed as a result of the ground impact. Three large aircraft segments were contained in the wreckage trail: the fuselage and tail section; the wing section, and; the engine.

### 1.4. Collateral Damage

1.4.1. The main aircraft wreckage was confined to a single, snow covered field approximately two nautical miles (NM) south of CYMJ. Damage to the field consisted of ground scars and contamination by a small quantity of fuel, oil and hydraulic fluid. The site was cleared of debris and soil samples were analyzed by Bombardier Military Aviation Training (BMAT). BMAT personnel returned to the site in the spring to conduct a final cleanup and soil analysis

### 1.5. Personnel Information

| | QFI | SP |
|---|---|---|
| **Total Flying Time Hours (Military)** | 543.9 | 120.1 |
| **Flying Hours on Type** | 502.1 | 94.8 |
| **Flying Hours Last 30 Days** | 18.9 | 10.7 |
| **Flying Hours Last 90 Days** | 60 | 17 |
| **Duty Hours - Last 48 Hours** | 20 | 23.5 |
| **Duty Hours - Day of Occurrence** | 4.5 | 5.5 |
| **Instructional Hours** | 155.5 | N/A |
| **Annual Proficiency Check (APC)** | 01 Nov 2013 | N/A |
| **Currency** | Current | Current |
| **Medical Category** | Valid | Valid |
| **Instructor Category Check** | B Cat - 26 Nov 2013 | N/A |
| **Supervisory Check** | 15 Nov 2013 | N/A |
| **Practice PFL Assessed** | 01 Nov 2013 | ACH5 - Level 4 |
| **Emergency Simulator** | 08 Jan 2014 | 13 Jan 2014 |
| **Ejection Seat / Egress Check** | 16 Dec 2013 | 14 Jan 2014 |

Table 2. Personnel Information

#### Qualified Flight Instructor

1.5.1. QFI was a graduate of the first courses conducted with a re-designed training plan (TP) for the Phase II & Phase III pilot courses and was a first tour flying instructor at 2 CFFTS. After having graduated to Royal Canadian Air Force (RCAF) wings standard on 14 Dec 2012, the QFI completed the Harvard II Flying Instructor Course (FIC) at the Flying Instructor School (FIS) and earned a C Category flying instructor rating upon completion on 21 Jun 2013. The QFI was then assigned as an instructor pilot and upgraded to a B Category instructor on 26 Nov 2013.

#### Student Pilot

1.5.2. The SP began Phase II pilot training at 2 CFFTS on 10 May 2013 and was subsequently selected to continue on the Phase III course which began on 12 Nov 2013.

### 1.6. Aircraft Information

1.6.1. The CT156 Harvard II (T-6A-1) is a single-engine turboprop, two-place, tandem seat, pressurized, low wing training aircraft manufactured by Hawker Beechcraft.

1.6.2. The aircraft is equipped with two Martin Baker C16LA fully automatic ejection seats that provide safe escape from zero altitude, zero speed, up to 35,000 feet at speeds up to approximately 370 knots. The escape system uses a canopy fracturing system to provide a clear path for the pilots during ejection. A mild detonating cord (MDC) on the rear transparency is installed around the periphery and down the centerline in a diamond pattern. By design, the portion of MDC along the rear seat canopy rail does not detonate during a rear seat airborne ejection. This MDC is designed to detonate only for ground egresses.

1.6.3. The landing gear is a tricycle type with hydraulically-actuated extension and retraction. A series of micro switches control the gear extension/retraction sequence. A side brace connects the MLG to the actuator, providing a means for extending and retracting the gear as well as geometric downlock for the MLG. A latch mechanism engages the MLG up-lock during the closing of the main (inboard) doors. Internal locks in the MLG actuators engage to lock the MLG down by means of the side brace.

1.6.4. There is a landing gear position and warning system which provides the pilots with indications of landing gear position. Green lights indicate the gear is down and locked while red lights warn of unsafe ‘up’ or ‘down’ conditions.

Return to top of page

### 1.7. Meteorological Information

1.7.1. The local weather at the time of the accident was Visual Meteorological Conditions (VMC), good visibility and a strong westerly surface wind. The Radar Display Playback System II (RDPS II) showed steady state wind of 20 knots (kts) from 310° degrees magnetic (°M) with no gusts immediately prior to or after the hard landing. The surface wind had a negligible crosswind component for landing given the runway heading of 287°M.

1.7.2. The most recent weather to the accident, recorded at CYMJ 18 minutes prior to the hard landing, was:

CYMJ 241800Z 31021/G27KT 15SM FEW 045 FEW 070 BKN 200 03/00 A2982

Forecast Winds valid 16-24Z Jan 24 2014 issued at 12Z: [Altitudes in feet above sea level (ASL) unless otherwise indicated]

| ALTITUDE (FT) | DIRECTION (ºT) / SPEED (KTS) | TEMPERATURE (°C) |
|---|---|---|
| 9,000 | 320 / 70 | -1 |
| 6,000 | 330 / 49 | +2 |
| 4,000 | 330 / 55 | +3 |
| 3,000 | 310 / 50 | +3 |
| 500 (AGL) | 290 / 25 | +3 |

Table 3. Forecast Winds and Temperatures

### 1.8. Aids to Navigation

Not applicable.

### 1.9. Communications

Not applicable.

### 1.10. Aerodrome Information

1.10.1. CYMJ has two principal parallel runways: 11/29 left (L) and right (R). Rwy 29L and 29R were both active at the time of the accident [Figure 3].

Circle depicts approximate touch down point during the hard landing. Arrow depicts direction of flight.

Figure 3. CYMJ Aerodrome Chart

### 1.11. Flight Recorders

1.11.1. The Harvard II has no cockpit cameras or voice recorders. It is equipped with an Integrated Data Acquisition Recorder (IDAR) which includes a crash protected memory unit that records flight data for accident investigation purposes. The crash protected memory unit is known as the Mishap File. The IDAR also collects aircraft and engine structural integrity data that is used for maintenance purposes. These files, the Aircraft Structural Integrity Program (ASIP) file and the Engine Structural Integrity Program (ENSIP) file, provide data to monitor the anticipated health of the aircraft as well as its estimated life expectancy (ELE).

1.11.2. The IDAR was recovered intact and the data was extracted and sent to the National Research Council (NRC) in Ottawa for analysis while the IDAR followed in shipping. Although it was intended that all files be sent to the NRC, only the Mishap File was sent. Upon realization that the ASIP and ENSIP files were missing and because the NRC did not have the capability to download these files at the time, the IDAR was returned to 15 Wing for investigation whereupon it was diagnosed that the files had become corrupted and the ASIP and ENSIP files no longer contained any data. As such, the NRC had to rely solely on data from the Mishap file.

1.11.3. Data recovered from the IDAR determined that the hard landing occurred at 12:18:20 local time (L), the ejections at 13:47:40L, and the aircraft impact at 13:48:28L. Position information was lacking in accuracy.

1.11.4. 15 Wing ATC communications and RDPS II recordings spanning the entire period of the accident flight were impounded. The RDPS II recording was sent to NRC in order to corroborate IDAR data.

Return to top of page

### 1.12. Wreckage and Impact Information

1.12.1. There were four separate aircraft wreckage locations [Figure 4]: landing gear components on runway 29L; the ejection seats and canopy fragments; the QFI and SP parachute landing sites, and; the main Harvard II aircraft crash site [Figure 4].

1.12.2. Landing gear components that were recovered from the runway included nine fragments of the left wheel rim and a bushing used to help secure the LMLG strut to the side brace. These components were recovered near tire marks on the runway that indicated the touchdown points of the aircraft's main and nose landing gear.

1.12.3. The bolt which secures the side brace to the LMLG was not recovered. Investigation by Quality Engineering Test Establishment (QETE) found sufficient evidence to conclude that this bolt failed in tension overload during the hard landing allowing the side brace which controls movement of the LMLG strut and provides a down lock to become detached.

Figure 4. Satellite photo with indications of key locations

1.12.4. The ejection seats landed one half NM south of runway 29L. Both seats and parachute equipment were recovered. Some canopy fragments were not recovered until after the snow melted in the spring and there remain some unrecovered fragments despite repeated searches.

1.12.5. The QFI and SP landed approximately two NM south southeast of the threshold of runway 29L.

### 1.13. Medical

1.13.1. The health records of the aircrew were reviewed. Their medical categories were valid and there were no medical employment limitations or health conditions found that may have been a factor in this accident.

1.13.2. Both aircrew were examined by the 15 Wing Flight Surgeon after the accident, each having suffered injuries as a result of the ejection. Toxicology was shipped to the Civil Aerospace Medical Institute for analysis. Work, rest, and sleep cycles were collected to facilitate fatigue analysis. The results from all tests and analysis proved negative, therefore non-contributory to this accident.

### 1.14. Fire, Explosives Devices, and Munitions

1.14.1. There was no post-crash fire.

Figure 5. CT156102 Main Wreckage Site

1.14.2 There were two pyrotechnic devices still live in the airframe. This is normal following an airborne ejection as these live devices are designed only for emergency ground egresses. As 15 Wing does not have onsite explosive ordnance disposal (EOD) personnel, all live devices were removed by Aerospace Engineering Test Establishment (AETE) personnel and rendered safe by 17 Wing EOD personnel.

1.14.3. 17 Wing EOD personnel also recovered as much unexploded MDC as possible and returned to the site in the spring to retrieve pieces of unexploded MDC which had not been found earlier due to snow cover.

### 1.15. Survival Aspects

1.15.1. The QFI ejected clear of the aircraft without incident. Once under a stable canopy, the QFI assessed direction of travel and steered the parachute into wind as per the correct procedure to reduce the overall landing velocity. During the descent the QFI had difficulty removing and discarding the oxygen mask IAW standard procedures due to interference by a telecom cord that connected the mask-microphone to a wiring harness on the helmet. Two attempts were made to disconnect the cord; a single-handed pull that was followed by a two-handed pull. With neither attempt successful, the QFI re-attached the oxygen mask to avoid landing with a loose oxygen mask.

1.15.2. The QFI landed in an agricultural field without incident. The right Frost Fitting which connects the parachute to the torso harness was immediately released single-handedly but the left Frost Fitting required the use of both hands to release.

1.15.3. The SP received a right knee injury during the ejection due to contacting part of the front seat canopy transparency while exiting the aircraft. Once under a stable parachute canopy the SP attempted to steer the parachute into wind to reduce the landing velocity, but was not entirely successful.

1.15.4. The SP was also unable to discard the oxygen mask during the descent having encountered the same telecom cord difficulties experienced by the QFI.

1.15.5. The SP landed in a field facing out of wind and received minor injuries due to tumbling while being dragged by the parachute. The SP was dragged 122 feet before being able to establish a stable drag position and release both Frost Fittings [Figure 6].

Figure 6. SP landing site showing drag distance

#### Emergency Response

1.15.6. The emergency response was exceptionally fast, attributable to the controlled ejection being anticipated by emergency response crews who pre-positioned in close proximity to the ejection area.

1.15.7. Of note, one emergency vehicle carrying the SP passed unnecessarily fast and close to the QFI and other rescue personnel while exiting the landing site field in transit to the hospital.

Return to top of page

### 1.16. Test and Research Activities

1.16.1. The NRC was utilized to analyze the flight data that was recovered.

1.16.2. QETE conducted a thorough analysis of the structural failure of the LMLG and analyzed whether it was possible for it to have been retracted in its damaged state.

1.16.3. Defence Research and Development Canada (DRDC) specialists conducted an analysis of this accident, looking into human factors as related to training plans, proficiency, fatigue and other human factor areas.

### 1.17. Organizational and Management Information

1.17.1. 15 Wing in Moose Jaw, SK is the site of the NATO Flying Training in Canada (NFTC) Program. The 15 Wing Commander is responsible to ensure that the activities of Individual Training and Education (IT&E) establishments under his authority are conducted IAW Canadian Forces Individual Training and Education System (CFITES) and Air Force Training and Education Management System (AFTEMS) policy.

1.17.2. 2 CFFTS, under 15 Wing, conducts the vast majority of Phase II pilot training for the RCAF. Phase II is the foundational, basic training for student pilots who then are streamed to either fighters & trainers, multi-engine or rotary-wing Phase III courses to obtain their pilot wings. At the time of the accident, 15 Wing was asked to produce 125 New Wings Graduates (NWG) per year. In order to accomplish this, 128 students were started on the Phase II course at 2 CFFTS per year. 2 CFFTS is one of two training establishments within the context of RCAF Qualification Standard[6] (QS) and is responsible to ensure the IT&E activities are managed IAW CFITES and AFTEMS directives.

1.17.3. As the NFTC prime contractor at the time of the accident, Bombardier was responsible for all support aspects of 2 CFFTS, including the provision of the training aircraft; specifically, the CT-156 Harvard II turboprop and CT-155 Hawk advanced tactical jet. The aircraft are owned by Milit-Air Inc. and were managed at the time of the accident by Bombardier Corporation's subsidiary – BMAT.

1.17.4. The Canadian Forces' Central Flying School (CFS) was located at Southport, MB. At the time of the accident[7], CFS was responsible for the standardization of aircrew that operate training aircraft and they had decentralized detachments at 4 Wing and 15 Wing. Additionally, CFS was the Training and Standards Evaluation Team (TRGSET) responsible for the development and maintenance of flying training standards for all undergraduate pilot training. CFS also provided standardization for the format of all training standards and training publications as well as oversight of the quality of instruction provided at all Operational Training Units (OTU) in the RCAF. CFS fell under the supervision of 2 Canadian Air Division (2 Cdn Air Div), Director Air Force Training (Dir AF Trg).

1.17.5. The requirement to generate 125 pilots per year with no increase in training assets placed substantial pressure on the leadership, QFIs and students at 2 CFFTS. The most significant issue to meet this requirement was dealing with weather related issues that reduced the number of sorties available to meet the production requirement. Since increased aircraft sorties could not be generated to replace lost sorties due to weather under the current organizational structure, the leadership needed to prioritize the flying after weather related shortages were encountered. Specifically, 15 Wing & 2 CFFTS leadership saw a need to maximize pilot production with the available sorties. This occurred at the expense of ensuring pilot skills development and QFI proficiency.

### 1.18. Additional Information

#### Training Plans

1.18.1. NFTC is controlled by the NFTC Statement of Work (SOW). TP changes for the Harvard II, Hawk and FIC TPs are drafted by 2 CFFTS and then must by reviewed by the contractor, partner nations, 2 Cdn Air Div Air Operations Training (AOT) staff and ultimately approved by both BMAT and the NFTC Steering Committee Chair – the Comd 2 Cdn Air Div.

1.18.2. The 2 CFFTS TPs which outline the syllabi for the flying courses provided on the Harvard II at 15 Wing saw significant modifications that were drafted in late 2011 and put in place when the occurrence QFI began pilot training at 2 CFFTS in early 2012. The primary goal of the newly generated TP was to expedite throughput to achieve the mandated 125 graduates per year. This was achieved through maximizing the utilization of the Flying Training Devices (FTD) for emergency training and streamlining the flight training to eliminate the perceived non-essential training of tasks on the Phase II course. Additionally, several new specific tasks were added to the Phase III course with the aim of improving the wings standard to better prepare students for the advanced Phase IV course on the CT155 Hawk jet.

1.18.3. Prior to the 2012 changes to the TPs, the PFL was introduced on CH10 of the Harvard Phase II course and graduates would complete the course with the possibility of 21 missions being flown where PFLs could be practiced. The Phase III course which followed offered a further 10 missions which could have included PFLs. Also, prior to 2012, Phase III was conducted on the Hawk jet. This is significant because PFLs flown in the Hawk are much more dynamic in nature, with a steeper final approach and higher sink rate, thus allowing for the development of more advanced skills.

1.18.4. To streamline the training and remove tasks deemed unnecessary from the syllabus when drafting the 2012 TP, it was rationalized that trainees who would be selected to fly multi-engine aircraft or helicopters upon completion of Phase II did not require PFL training because PFLs are not flown in multi-engine aircraft and helicopters fly auto-rotations which have little resemblance to PFLs. As such, pre-wings PFL training became limited to the revised Phase III course, now flown on the Harvard II, which included 17 missions where PFLs could be flown. The overall result of this change in the TP was a 45% decrease in the number of missions that provided an opportunity to fly PFLs thereby reducing the competence of graduating pilots and new QFIs in this skill area. As well, because the Hawk jet was no longer included in Phase III, NWGs selected to become pipeline QFIs no longer had the benefit of having expanded their envelope of experience and learned more advanced flying skills that only a more advanced aircraft such as the high performance Hawk jet can provide.

#### Unit Culture

1.18.5. Testimony as well as Flight Safety (FS) surveys conducted in 2012 and 2014 revealed concerns of cultural issues within 2 CFFTS. Unrelated to this investigation, the Directorate of Flight Safety (DFS) took initiative with the Director General Military Personnel Research & Analysis (DGMPRA) in collaboration with their Director Research Operational and Organizational Dynamics (DROOD) and DRDC to develop and conduct trial culture surveys at various RCAF units, including 2 CFFTS. Results of the FS Culture & Climate Survey conducted at 2 CFFTS[8] and terminated on 20 Feb 2015 indicated that the culture within 2 CFFTS may have improved somewhat since the time of the accident; however, the reliability of this survey is still being assessed due to the low response rate.

1.18.6. One concern raised in the 2012 and 2014 FS surveys was the perception of some respondents regarding a lack of proficiency amongst QFI's as a result of 2 CFFTS prioritizing student missions above SCT missions. It is important to understand the relationship between proficiency, SCT missions and currencies:

a. Proficiency is a level of pilot performance required to ensure the safe and effective operation of a specific aircraft;

b. SCT missions are intended to fulfill the requirements of contributing towards the achievement of currencies as well as maintaining pilot proficiency to the expected standard; and

c. Currencies include specific minimum flying hours as well as specified manoeuvres that are required to be flown within a specified period of time – typically annually, bi-annually, quarterly or monthly – mandated by HHQ in order for a pilot to remain qualified. Failure to achieve currencies suspends a pilot's qualification until re-certified.

1.18.7. Minimum aircrew flying currency requirements are listed in the FOM. Para 3.3.2.1 of the FOM states the following regarding proficiency:

*"Proficiency, from both currency and Combat Readiness perspectives, is the product of training. The currency minima specified in this Order are designed so that aircrew will be capable of the safe and effective operation of their aircraft. Unit Commanding Officers (CO) and Flying Supervisors shall exercise judgement where situations warrant and adjust training to ensure proficiency is achieved by all Squadron aircrew."*

*"Continuous practice is required in a particular role in order to maintain proficiency. Annual Check Flights and exams are administered by individual Units to ensure this proficiency is maintained above the minimum skill level."*

1.18.8. The QFI involved in the accident had just begun a new year as far as currencies apply, so there were no lapses in this area. The QFI had completed an annual check flight on 26 Nov 2013 – approximately two months prior to the accident – and demonstrated the required level of proficiency. Proficiency, however, is a perishable skill, and the successful completion of a check flight simply demonstrates that the pilot being assessed was able to perform all tasks to the required standard in the conditions on that day – not necessarily when faced with different conditions. Flying skills being perishable, breaks from flying such as over the holiday period could negatively impact a pilot's proficiency.

1.18.9. While supervision with regard to pilot proficiency is important, individual pilots tend to be more cognizant of their level of proficiency than anyone else on a day-to-day basis. The accident QFI had a desire to improve proficiency flying traffic pattern tasks, including PFLs, in strong wind conditions. On the morning of the accident, the QFI had co-ordinated with an experienced QFI and the Flight Scheduler to have an SCT mission scheduled for the purpose of improving proficiency in strong winds; however, this SCT mission was replaced by a student mission.

### 1.19. Useful and Effective Investigation Techniques

Not applicable.

Return to top of page

## 2. ANALYSIS

### 2.1. GENERAL

2.1.1. The investigation determined that the aircraft was fully serviceable for the flight and that the crew members were qualified, current, properly authorized, fit and not fatigued prior to flying the mission. Having made these determinations, the investigation focused on potential contributing factors to the hard landing and related safety concerns, including the following:

a. TP Development;

b. PFL Training and Experience Levels;

c. Techniques to Compensate for Wind During PFLs;

d. Flapless PFL;

e. Mission Brief;

f. QFI Personal Limits;

g. Landing Gear Failure;

h. Landing Gear Troubleshooting;

i. Ejection Decision;

j. Post Ejection Procedures;

k. Emergency Response Plan;

l. Chase Plane Vulnerability;

m. IDAR Data;

n. Unit Culture; and

o. Pressing Mindset.

### 2.2. TRAINING PLAN DEVELOPMENT

2.2.1. The Harvard II TPs which were put in place in January 2012 incorporated significant changes that were generated in response to HHQ direction to attain contracted pilot production numbers of 125 NWGs per year using the existing allocated resources.

2.2.2. The modifications to the 2012 TP involved significant changes to the design of the course. The TP changes included the participation of CFS which included a Training Development Officer (TDO) to ensure that CFITES and AFTEMS formal processes were followed. Also included in the process were experienced QFIs from 2 CFFTS. Unfortunately, neither the expertise that developed the new TP nor the application of these processes highlighted the significant 45% reduction to in-flight PFL training that was created when the new TP was developed. Some experienced QFIs involved with the process claimed that too much was being cut from the prior syllabus. This accident possibly supports the validity of these claims.

2.2.3. The investigation determined that the significant reduction to in-flight PFL training was not recognized and, as such, no mitigating measures such as applying more restrictive limitations to PFLs were established. Had this been acknowledged, the increased risk could have been mitigated.

### 2.3. PFL TRAINING & EXPERIENCE LEVELS

2.3.1. A significant change to the January 2012 TP was the shift of PFL training from Phase II to Phase III. The result was a later introduction to PFLs and fewer missions during the course where PFLs could be practiced. This limited students' and future QFI's overall PFL exposure and experience which in turn limited the opportunity to practice PFLs under various wind conditions.

2.3.2. The result is that graduates from the Phase III course of the 2012 TP had approximately 45% fewer opportunities to fly PFLs as compared to those who graduated prior to this change. Also significant, the occurrence QFI lacked the benefit of having gained more advanced skills flying the more difficult and more dynamic PFLs in the Hawk. The FIC was also modified in 2012; however, no changes were made to its TP to address the reduced PFL experience of pipeline QFIs. The occurrence QFI was aware that this area of flying skills required more practice and attempted to have an SCT mission scheduled to work on improving proficiency. The Flt Comd, unaware of the reason the QFI had requested to fly an SCT mission, unknowingly intervened due to the push within 2 CFFTS to fly student missions.

2.3.3. The investigation determined that the revised TP which incorporated a reduction in available missions to practice PFLs was contributory to this accident because the QFI, a graduate of the first course using the revised 2012 syllabus, had significantly less experience in flying PFLs than prior pipeline QFIs. This contributed to less PFL exposure in various wind conditions and less opportunity to practice and be conversant using the different or combined techniques of compensating for wind during PFLs. This reduced PFL experience had a direct result of reduced PFL proficiency. Lack of experience and proficiency contributed to the QFI's late awareness of the high sink rate and the inability to recognize the unsafe conditions present in the final approach of the accident PFL.

Return to top of page

### 2.4. TECHNIQUES TO COMPENSATE FOR WIND DURING PFLS

2.4.1. The Harvard II SMM describes the following techniques which may be applied to compensate for wind during a PFL:

a. In lighter wind conditions, the angle of bank is adjusted as required to maintain the standard 1 mile diameter circular ground track of the PFL through the key positions;

b. In stronger winds, HK, LK and FK can each be moved into the wind to compensate for the effect of the wind. It is recommended that both methods be used in strong winds by moving the keys into wind and adjusting the pattern by varying bank as required to land on the runway.

2.4.2. Although not specifically stated, the concept behind the application of these techniques is to maintain a high enough energy state to successfully perform a PFL, with the expectation that flaps will be used prior to landing.

2.4.3. Although familiar with the two techniques, the QFI relied on, was most conversant with, and briefed only the first technique: adjusting angle of bank. Applying only the first technique was not ideal and not in accordance with the SMM given the strong wind conditions surrounding the time of the accident.

2.4.4. By design, the PFL pattern has approximately 300 ft of excess altitude built into it so that the aircraft can ideally be aligned with the runway with 300 ft of altitude on a final approach to a point 1/3rd down the runway. When circumstances are such that a PFL terminates with low energy and the 300 ft of excess altitude gets used up, such as during the occurrence PFL, there exists the possibility that the pilot may focus on the aim point while completing the turn to align with the runway. Doing so, while in a flare in close proximity to the ground, can present a potentially dangerous situation.

2.4.5. Being focused on the touch down point just prior to landing is not typical and can cause limited awareness of both height above the runway and rate of descent. IAW the SMM, pilots are taught to shift their focus from the touchdown aim point to the end of the runway when approaching the flare. This allows for better awareness of height above the runway and rate of descent, making effective use of peripheral vision. Given that both the QFI and SP sensed the ground unexpectedly rushing up at them just prior to the hard landing, it is likely that their late recognition of the high rate of descent was due to being focused on the aim point as the SP was completing the turn while flaring.

2.4.6. To guard against this, the investigation recommends that runway alignment criteria be added to the PFL window because the current window criterion does not prevent the possibility of turning to align with the runway while in the flare.

2.4.7. The investigation determined that both PFL attempts terminated in a flapless configuration due to a low energy state on final; the result of insufficient correction for the strong winds. The investigation also determined that the use of the second technique to compensate for wind (shifting the key positions into wind) would have been more effective and, in accordance with the SMM, would have most likely provided more altitude at FK which would have permitted the use of flaps for landing and likely would have prevented the hard landing.

### 2.5. FLAPLESS PFL

2.5.1. Completing a PFL in a flapless configuration was neither an approved nor prohibited manoeuvre at 2 CFFTS, but rather a technique some Harvard II QFIs used when dealing with a low energy state. A low energy state is defined as low airspeed (less than 120 kts in the PFL pattern), less than desired altitude, or both. The Harvard II SMM did not provide information about aerodynamic or landing considerations if landing from a PFL without flaps. The SMM did explain that a PFL is an exercise in energy management (airspeed and altitude) and that flaps are used to bleed off energy in anticipation for landing. Therefore the selection of flaps, either half or full, is typically expected prior to landing from a PFL. However, the SMM did not dictate that flaps shall be selected prior to landing. In this accident, the less than desired altitude from FK to the runway created a low energy state which led to a flapless landing.

2.5.2. Flapless straight-in approaches are part of the Harvard II training syllabus and are explained in Chapter 3 of the Harvard II SMM. The flapless straight-in approach is explained in detail and highlights that a higher pitch attitude on approach and landing is required.

2.5.3. The final approach to landing from a PFL is steeper by approximately three degrees than a straight-in approach; therefore a greater change in pitch attitude is required in order to reduce the higher rate of descent prior to landing. The vast majority of Harvard II PFLs were completed with flaps, therefore the landing attitude in this configuration was well known by Harvard II aircrew, whereas the landing attitude from a flapless PFL was less well known to Harvard II aircrew. In this accident, an insufficient nose-up landing attitude was set just prior to landing; therefore the rate of descent was not sufficiently reduced, resulting in the hard landing.

2.5.4. While the QFI and SP were both aware that the flaps had not been selected, their lack of experience prevented them from understanding and adapting to the aerodynamic requirements for a safe and effective flapless landing from the PFL. IDAR data indicates that the attitude applied during the flare was similar to the attitude in the flare from a PFL with flaps selected.

2.5.5. The investigation determined that the hard landing was the result of an insufficient flare from the flapless PFL, which was ineffective in sufficiently reducing the aircraft's rate of descent prior to contact with the runway.

2.5.6. Following this accident, 2 CFFTS issued Standards Bulletin 140 which prohibits the termination of a PFL in a flapless configuration.

### 2.6. MISSION BRIEF

2.6.1. Last minute changes to the flying program are not ideal; however, having this flexibility is necessary in order to keep the training system running while reacting to variables such as weather, SNIC, illness, student preparedness, etc. Flt Comds and Schedulers need to consider many factors when deciding on schedule changes, particularly those which leave little preparation time. QFIs and SPs who are low in experience tend to be less able to cope with short notice changes than those with more experience.

2.6.2. Typically, mission briefs are allocated 30 minutes, although a full half hour is not always required. The 10 minute pre-flight brief prior to this mission could have been adequate given the stage in training and past performance of the SP; however, it was less than ideal for the QFI having little experience and not being familiar with the SP's recent performance.

2.6.3. Regarding the content of the pre-flight brief, the main focus was on adjusting the PFL in consideration for the strong wind conditions. Only the basic technique of adjusting bank angles was briefed despite the recommended technique IAW the SMM was compensating for strong winds by adjusting PFL keys into wind.

2.6.4. The investigation determined that the short amount of time to brief the mission was not contributory to this accident; however, the omission of briefing the specific techniques which may be used in strong wind conditions is considered contributory because their application could have prevented the low energy state on final approach which would have pre-empted the hard landing.

Return to top of page

### 2.7. QFI PERSONAL LIMITS

2.7.1. 'Personal limits' is a term used by QFI's in describing how far they will allow a SP to err before the QFI takes control of the aircraft to ensure safety of flight. This requires the QFI to monitor present actions of the SP and recognize and predict SP actions to determine if the SP is about to exceed the QFI's personal limits such that the QFI can take control in time to keep the aircraft in a safe flight envelop.

2.7.2. It is essential for each QFI to understand their own personal limits and ensure that they never allow a student to push the aircraft beyond these limits. Personal limits are very critical during landing sequences because the proximity to the ground presents the highest potential for accidents while also making the timing element of when to take control more crucial. Personal limits develop and narrow as experience is gained, meaning that this relatively inexperienced QFI should have maintained large safety margins.

2.7.3. The FIC TP and related manuals made no mention of personal limits. As such, there was no requirement to document if or when personal limits were taught or verified.

2.7.4. Personal limits have always been a known topic that were often discussed during the FIC; however, they were not formally incorporated into training documentation. The occurrence QFI was knowledgeable about personal limits concepts but personal limits were not formally taught during ground or air lessons during the FIC.

2.7.5. Although the investigation could not determine if formalized teaching of personal limits at the FIC would have prevented this accident, the investigation did determine that personal limits should be formally taught, as a minimum, in ground lectures. Further, whenever taught or challenged during FIC air lessons, grade sheets should be documented to ensure this area of instruction is tracked and properly documented. The investigation also concluded that personal limits are difficult to teach in the aircraft and that the availability of tandem seat simulators could greatly enhance this training during the FIC.

### 2.8. LANDING GEAR FAILURE

2.8.1. Examination of maintenance records and post-crash analysis by QETE confirmed that the aircraft was serviceable prior to the hard landing and that there is no evidence to support a pre-existing problem with the LMLG.

2.8.2. The NRC calculated the descent rate at the point of impact of the hard landing to be 1700 feet per minute; an impact of approximately +4G. The aircraft attitude at the point of impact was 6º nose up and 8º left wing down, causing the LMLG to absorb the most kinetic energy. QETE concluded that the excessive sink rate - over twice the design limit of 780 feet per minute - caused a rim burst of the left wheel segment preventing wheel spin up and failure of the side brace attachment bolt under tension, allowing the lower side brace to separate from the strut.

2.8.3. The investigation determined that the LMLG side brace failure occurred as a result of the hard landing that exceeded design limits. The side brace separation meant that the LMLG could not retract or remain in a down lock position for a safe gear down landing.

### 2.9. LANDING GEAR TROUBLESHOOTING

2.9.1. The landing gear emergency was well handled by the aircrew, displaying good Human Performance in Military Aviation (HPMA) and sound decision making. While it was impossible to get the LMLG to lock down due to the failure of the LMLG side brace, a gear-up configuration, if possible, would have presented the option to conduct a gear-up belly landing.

2.9.2. Yawing and two separate rolls were flown, both to the right, to determine if airflow and/or gravitational forces could collapse the LMLG into the wheel well. Landing gear sounds were heard by the crew during the rolls, likely caused by the little movement of the LMLG as observed by the chase aircraft or the loose LMLG side brace; however, all attempts to collapse the LMLG into an up and locked position failed.

2.9.3. The NRC determined that there was little force applied to the LMLG during the rolls. Had the roll rates been faster, the moment of force applied to collapse the LMLG into the up position would have been greater. IDAR analysis also indicated that the rolls did not produce any negative G. The least amount of G applied during the rolls was +0.23 G. The combination of the aerodynamic forces acting on the LMLG, the ineffective moment from the slow roll rate and the lack of negative G produced too little force to retract the LMLG.

2.9.4. QETE concluded that had the in-flight rolls been successful in collapsing the LMLG into the wheel well, it is not likely that the necessary electrical sequencing conditions to lock the gear up would have occurred. Potential upper and/or lower sidebrace interference could also have inhibited the possibility to lock the gear up.

2.9.5. The investigation determined that it was not likely that the necessary conditions to achieve a symmetrical LG up configuration were present due to the damaged LMLG.

Return to top of page

### 2.10. EJECTION DECISION

2.10.1. The emergency procedures section of the Canadian Forces Approved Flight Manual (CFAFM) for the T-6A-1 Harvard II aircraft contains the following two warnings applicable to landing with this particular gear malfunction:

*a. A gear up landing to a suitable area is preferred if any gear is confirmed unsafe; and* *b. If it becomes necessary to land with one main gear up or unsafe and the opposite gear extended, and all gear cannot be retracted, touch down smoothly on the same side of the runway as the extended gear. Roll on the down and locked gear while holding opposite wing up and the nose straight as long as possible. Use rudder and brakes as necessary to maintain a straight path down the runway.*

2.10.2. A gear up configuration was attempted, however without success. The second warning allows for the possibility of recovering the crippled aircraft; however, it is contained within a "Warning" which is defined in the CFAFM as:

*An operating procedure, technique, etc. which could result in personal injury or loss of life if not carefully followed.*

2.10.3. Although a landing could have been attempted with the unsafe LMLG IAW the CFAFM and the Harvard II Pilot Checklist, there existed the risk of losing control of the aircraft with the collapse of the LMLG. The risk that such an attempt could prove catastrophic and result in loss of life, as the definition of warnings suggests, is inversely proportional to a pilot's level of experience. The QFI had relatively little experience so the risk would have been high.

2.10.4. After considering the above and supported by the 15 Wing Commander, the QFI made the decision to execute a controlled ejection. The ejection was carried out within the ejection seat envelope at 3400 ft AGL and 139 kts after having completed all required checks.

2.10.5. The investigation supports the QFI's decision to carry out a controlled ejection as the best and safest option taking into consideration the limited experience of the QFI combined with the difficulty of landing on an asymmetrical MLG which was likely to collapse.

### 2.11. POST-EJECTION PROCEDURES

2.11.1. The ejections were successful, however not without some difficulties encountered and minor injuries sustained.

2.11.2. Both the QFI and SP were unable to discard the oxygen mask IAW standard post-ejection procedures during the parachute descent due to the telecom cord (which connects the mask-microphone to a wiring harness on the helmet) failing to disconnect as expected.

2.11.3. BMAT Safety Systems subsequently conducted trials with a variety of helmets using the P/N Nexus U-179A/U connector which is used on all helmets in the RCAF. The trials revealed that this connector would not disconnect when fitted to the Gentex RDVK, worn by the QFI and SP on this mission, or the newer 2008 Gentex NFTC 90. Disconnection was easily achieved during trials of the connector when fitted to the Alpha MK10R and the older 2001 Gentex NFTC 90 helmet.

2.11.4. The investigation determined that the P/N Nexus U-179A/U connector design does not reliably facilitate disconnect when fitted to the Gentex RDVK helmet. The investigation concluded the post-ejection procedure needs to be amended to take this fact into consideration or a system redesign is necessary.

2.11.5. The investigation also determined that the SP was injured upon landing likely as a result of an elevated speed over the ground due to not pulling the appropriate riser early enough to turn fully into wind in order to reduce ground speed prior to landing. The investigation concluded that additional parachute training for all ejection seat aircrew would be beneficial in response to this deficiency. It is recommended that modern parachute training be researched as a possible solution to this issue.

### 2.12. EMERGENCY RESPONSE PLAN

2.12.1. There existed no documentation to alert emergency response personnel of the existence of unexploded MDC on canopy fragments following Harvard II rear seat airborne ejections, nor procedures on how to deal with the dangerous material. Such directives and procedures have since been implemented and documented within all relevant 15 Wing and 4 Wing publications.

2.12.2. The rescue vehicle which had picked up the injured SP drove close to the QFI at a relatively high speed. There was no reason to expedite exiting the field and the actions of the driver could have resulted in further injuries.

2.12.3. The investigation determined that emergency response and recovery crews arrived on site in a timely manner. It is recommended that emergency response and recovery crews require training which highlights the importance of vigilance and care when operating a vehicle within an often dynamic and chaotic post-crash area.

### 2.13. CHASE PLANE VULNERABILITY

2.13.1. The LMLG door fell off the accident aircraft during a roll while the second chase plane was in close proximity.

2.13.2. Chase planes can be vulnerable to such foreign object damage (FOD) when in a line astern position, below and behind a damaged aircraft. Photos taken from this position behind the accident aircraft proved valuable while dealing with this particular emergency. Nonetheless, compromised components fell off the accident aircraft which could have struck the chase aircraft, possibly resulting in a secondary critical situation.

2.13.3. It is recommended that the FOM include a section with SOPs regarding chase plane positions, practices and procedures, with a caution regarding the possibility of encountering FOD from a damaged aircraft.

### 2.14. IDAR DATA

2.14.1. The NRC did not have the ability to download data from the Harvard II IDAR so the data was downloaded by BMAT technicians and then sent to the NRC for analysis. The NRC confirmed that there was missing data, specifically the ASIP and ENSIP files, and re-examination of the IDAR showed those files empty. The investigation could not find a subject matter expert (SME) within BMAT or the NRC who could clearly explain how the ASIP and ENSIP files got deleted from the IDAR. Although the missing data from the IDAR was not crucial to this investigation, understanding the reason for the loss of this information could prove helpful to future investigations.

2.14.2. The NRC discovered that the resolution of latitude and longitude recorded by the IDAR is 0.088º which corresponds to approximately 9 kms at the equator. This resolution is not useful for flight path reconstruction making it of little value to accident investigations. This is due to the IDAR recording the macro positional figures vice the micro figures. Because of this, the NRC had to use a combination of radar and IDAR data in determining the flight path.

2.14.3. It is recommended that the IDAR original equipment manufacturer (OEM) modify the IDAR to record the smallest value location figures. It is also recommended that BMAT, the NRC and the OEM collaborate to ensure a procedure be developed to effectively extract all the data contained in the IDAR. The NRC has since been provided with their own capability to read the IDAR.

### 2.15. UNIT CULTURE

2.15.1. While it is difficult to assess and measure the culture of a unit, there was sufficient testimony to indicate the likelihood that the 2 CFFTS culture was unhealthy at the time of the occurrence. The findings of the 2012 & 2014 2 CFFTS Flight Safety (FS) Surveys support this notion.

2.15.2. Testimony related to this investigation as well as feedback from both the 2012 & 2014 2 CFFTS FS Surveys indicate that flying student missions routinely took priority over QFI proficiency missions. The surveys also highlighted concerns about QFI and student workloads, length of work days, fatigue, quality of life, low proficiency levels among QFIs, pressure to complete missions, among others.

2.15.3. The pressure to produce 125 graduate pilots per year appears to have been behind the cultural issues within 2 CFFTS. This pressure created a culture to prioritize student missions over SCT missions – intended for pilots to maintain currency and proficiency – and played a direct role in this accident.

2.15.4. The FOM states the importance of maintaining proficiency. Para 4.09 in Section 3 of the 2 CFFTS Orders states the following regarding proficiency:

*"Flight Commanders are to ensure that Staff Continuation Training (SCT) is given sufficient priority to ensure that the 1 Cdn Air Div minimum flying requirements are respected. This will ensure that QFIs maintain a high level of instructional and flying proficiency and may, on occasion, require that SCT flying have priority over Student Training."*

This order suggests that SCT missions are an important factor in QFIs maintaining their proficiency; however, the statement *"…may, on occasion, require that SCT flying have priority over Student Training"* minimizes their importance.

2.15.5. Most notably, while defined currencies must be achieved in order to stay qualified and fly as a QFI, SCT missions are not specifically mandated. Specific minimum hours of SCT flying, covering all tasks that a QFI can be expected to fly and teach, are expected to be completed on a quarterly basis; however, Para 4.10.7 in Section 3 of the 2 CFFTS Orders states:

*"C Stand O shall notify the Commandant (Cmdt) if a QFI fails to meet quarterly proficiency requirements. In the next quarter the QFI must complete sufficient local proficiency missions to account for the deficiency in the previous quarter. These missions will not count towards the requirements of the new quarter. The Cmdt may at his/her discretion waive this requirement under exceptional/extenuating circumstances".*

Allowing SCT missions to be delayed into the following quarter once again minimizes their importance. While 2 CFFTS does not maintain records of QFIs who fail to achieve their SCT flying in any given quarter, the investigation found evidence to support that this was a fairly common occurrence. It was decided that filtering through data banks to obtain specific numbers would be too exhaustive and that the evidence provided in testimony and supported by the FS Surveys was sufficient to arrive at this determination.

2.15.6. The investigation found that sections 4.09 and 4.10 of the 2 CFFTS Orders are not clear about the relationship between currencies, proficiency and SCT missions and that the wording of these orders is at times inappropriately intermixed making them ambiguous.

2.15.7. Testimony also described circumstances where people outside the flights, whether senior leadership or operations personnel, would on occasion address Flight Schedulers directly to have them replace QFI currency or proficiency missions with student missions, undermining the Flt Comd's plans in scheduling SCT missions. Such instances served to solidify the notion that flying student missions was a higher priority over QFI proficiency. Further, one interpretation of the rules was that a QFI who required an Annual Proficiency Check (APC) didn't necessarily need to complete minimum currency requirements because the APC would essentially reset the requirements given that an APC re-qualifies a QFI whose currency has lapsed.

2.15.8. On the morning of the occurrence, the Flt Comd directed that only student missions be scheduled for that particular wave due to pressure within 2 CFFTS to push student missions. The QFI was reluctant to object cognizant of the culture to prioritize student training over QFI proficiency.

2.15.9. Several CFS and 2 CFFTS staff members testified having tried to make QFI currency and proficiency missions a higher priority. The 2012 & 2014 FS Surveys also highlighted concerns about proficiency taking a back seat to student mission accomplishment. Recommendations to make QFI proficiency a higher priority were not supported by the CoC within 15 Wing in that a culture had been established to prioritize student missions as a result of scheduling micromanagement by the CoC.

2.15.10. An indication reflecting the high tempo of 2 CFFTS operations is the fact that the mission card for the ACH6 mission, flown the day prior, had not been written prior to the QFI being scheduled to fly the ACH7 mission. The comment regarding the lack of sufficient nose up attitude by the SP during the flapless final turn on the previous mission may have alerted the QFI to anticipate the error which resulted in the hard landing, thereby providing the QFI with a greater chance of preventing it.

2.15.11. The results of the FS Cultural & Climate Survey conducted by DFS in 2015 did not reveal as dire a culture within 2 CFFTS as the 2012 & 2014 FS Surveys. Even though the results indicate that the culture may have improved since the time of the accident, the report acknowledges that the low 15% response rate and the sample of 72 participants does not proportionally represent the 2 CFFTS population due to a lack of participation from NCMs and civilian personnel. Comparisons are also difficult given the difference in questions between the FS surveys and the FS Cultural & Climate Survey. The primary concerns identified in the 2015 FS Cultural & Climate Survey were fatigue and the possibility that some individuals may have taken substances hazardous to aviation without the consent of a Flight Surgeon or may have flown within the 12 hour alcohol policy.

2.15.12. The investigation determined that there existed, at the time of the accident, an underlying culture that QFI proficiency was not a high priority, and that Flt Comds and schedulers acted within that culture. The investigation recommends that 2 CFFTS Orders be amended to remove the existing ambiguity WRT currencies, proficiency and SCT missions and clearly highlight the importance of QFIs developing and maintaining a high level of proficiency. The investigation also recommends that fatigue within 2 CFFTS be examined. Initiatives are already in motion in the RCAF to address substance abuses.

### 2.16. PRESSING MINDSET

2.16.1. The organizational pressure from RCAF senior leadership to produce 125 NWGs per year was the root cause of the pressure that created the cultural issues which were felt all through the CoC within 15 Wing, all the way down to the Flt Comds, QFIs and SPs.

2.16.2. Once this pressing mindset was set in motion, the organization did what it felt appropriate and necessary to achieve the aim. Stakeholders quickly modified and implemented revised TPs, arguably prematurely, and then the 15 Wing CoC micromanaged mission scheduling with the emphasis on prioritizing student missions simply to ensure that the new TPs were followed to allow their full benefits to be realized; however, repeated micromanagement with direction to replace SCT missions with student missions implicitly sent the message that student missions were of a higher priority than QFI proficiency.

2.16.3. The investigation determined that, despite cautions from senior and experienced staff within the QFI cadre at 2 CFFTS, 15 Wing leadership remained focussed on achieving the challenging target that had been established.

Return to top of page

## 3. CONCLUSIONS

### 3.1. FINDINGS

3.1.1. The mission was properly authorized IAW orders and procedures and the aircraft was fully serviceable to conduct the planned mission. [2.1.1]

3.1.2. The QFI was current and qualified IAW existing orders to fly the ACH7 mission. [2.1.1]

3.1.3. The QFI had planned to fly an SCT mission on the morning of the accident to address a self-identified lack of proficiency and confidence in flying traffic patterns and PFLs in strong wind conditions. [2.3.2]

3.1.4. Due to an understanding that student missions were of a higher priority than QFI proficiency missions within 2 CFFTS, the Flt Comd directed that only student missions be launched for that particular wave. This resulted in a schedule change for the QFI to fly the ACH7 student mission instead of the previously scheduled SCT mission. [2.15.8]

3.1.5. Late scheduling of the ACH7 mission allowed only 10 minutes for the pre-flight brief which touched on only one of two techniques to compensate` for wind during PFLs. [2.6.2]

#### Findings Concerning the Training Plans

3.1.6. In response to a directive to increase pilot production, Phase II & III courses were re-designed and underwent significant changes, implemented in January 2012. These changes resulted in a 45% reduction in airborne PFL training. [2.3.2]

3.1.7. The FIC had no formal QFI personal limits training. [2.7.3]

3.1.8. The absence of a simulator with both front and rear seats – mimicking the aircraft – impeded the ability to teach personal limits on the FIC. [2.7.5]

#### Findings Concerning PFLs

3.1.9. There was no information regarding flapless PFLs in either the Harvard ll SMM or the TP. [2.5.1]

3.1.10. Until the release of Standards Bulletin 140 following this accident, there were no restrictions to flying flapless PFLs. [2.5.1; 2.5.6]

3.1.11. Harvard ll PFLs were flown without a safety gate as a means to better ensure safe landings. [2.5.1; 2.5.6]

3.1.12. Adjusting the angle of bank was the only technique briefed by the QFI both on the ground and in the air to compensate for wind during a PFL. This was the only technique applied during the two PFLs flown. [2.4.3]

3.1.13. Both PFLs flown resulted in a low energy state on final approach and in a flapless configuration. [2.4.7]

#### Findings Concerning the Hard Landing & LMLG Failure

3.1.14. Both the QFI and SP were late to recognize the high rate of descent immediately prior to the hard landing, likely resulting from the late alignment with the runway causing them to be focused on the touchdown aim point. [2.4.4; 2.4.5]

3.1.15. Due to insufficient flare and slight left bank, the second PFL ended in a hard landing which placed forces on the LMLG beyond its design limits, resulting in failure of the LMLG side brace strut bolt. [2.5.5; 2.8.2; 2.8.3]

3.1.16. Unable to achieve a positive LMLG locked down indication, attempts were made to raise the LG in an effort to attain a symmetrical LG up configuration for a gear up landing. [2.9.2]

#### Findings Concerning the Ejection

3.1.17. Unable to obtain a symmetrical LG configuration, the QFI made the decision to carry out a controlled ejection. [2.10.3; 2.10.4]

3.1.18. The controlled ejection was initiated by the QFI IAW 2 CFFTS orders and within the ejection envelope at an altitude of approximately 3400 ft AGL and at a speed of 139 kts. [2.10.4]

3.1.19. Both crew members were unable to disconnect the telecom cord IAW post-ejection drills. [2.11.2]

3.1.20. The helmet's Nexus U-79A/U connector mounting did not reliably enable the telecom cord to be disconnected in the event of an ejection. [2.11.3; 2.11.4]

3.1.21. Parachute training did not teach appropriate post-ejection drills given the inability to discard the oxygen mask and parachute steering training consisted only of verbal direction, lacking any form of practical training. This deficiency was causal to the SP's inability to steer into wind for the parachute landing. [2.11.2; 2.11.5]

3.1.22. There was a lack of awareness that unexploded MDC will typically be found on canopy fragments following an airborne Harvard II rear seat ejection. [2.12.1]

#### Other Findings

3.1.23. Rescue vehicles arrived to assist the QFI and SP within minutes of landing in their parachutes. Both crewmembers were subsequently taken to hospital for a medical assessment and toxicology. [2.12.3]

3.1.24. A rescue vehicle operated in close proximity to personnel at an unnecessarily fast pace. [2.12.2]

3.1.25. The chase plane was vulnerable to FOD from the accident aircraft while flying below and behind it to inspect and take photographs. [2.13.1; 2.13.2]

3.1.26. IDAR Data was lost during the download process; specifically, the ASIP and ENSIP files. [2.14.1]

3.1.27. IDAR latitude and longitude resolution is not useful for flight path reconstruction and therefore not helpful to accident investigations. [2.14.2]3.1.28. 2 CFFTS likely had an unhealthy culture at the time of the accident which included the insufficient prioritization of QFI proficiency, such as in this case where a student mission was prioritized over an SCT mission which had been arranged to improve pilot proficiency. [2.15]

3.1.29. Although not representative of the 2 CFFTS population, the FS Culture & Climate Survey conducted by DFS and completed in Feb 2015 indicated an improved culture but raised concerns of fatigue and the use of substances hazardous to aviation. [2.15.11]

### 3.2. CAUSE FACTORS

#### Active Cause Factors

3.2.1. The QFI lacked proficiency to fly the maneuver being taught in strong wind conditions and did not, IAW the SMM, instruct the SP to apply the correct technique to be used when flying a PFL pattern in such winds. [2.4.3; 2.6.3]

3.2.2. Due to the late alignment with the runway and being focused on the aim point, the QFI did not recognize the high rate of descent soon enough to be able to take control in a timely manner and prevent the hard landing. [2.4.4; 2.4.5]

**Latent Cause Factors**

3.2.3. Flapless PFLs were being flown at 2 CFFTS while there was no specific documentation or training regarding the termination of PFLs in this configuration. [2.5.1]

3.2.4. The reduction in the number of flying missions where PFLs could be practiced in the 2012 Phase II & III TPs likely resulted in reducing the experience and proficiency of some NWG QFIs to fly these manoeuvres with no mitigating strategies implemented to offset the resultant increased risk. [2.3.2; 2.3.3]

3.2.5. The culture within 2 CFFTS was such that QFIs believed that missions to maintain or improve pilot proficiency were a lower priority than student missions. [2.15.2]

3.2.6. The pressure from the senior leadership of the RCAF to produce 125 NWGs per year was at the root of the cultural issues and the associated pressing mindset within 2 CFFTS. [2.16]

Return to top of page

## 4. PREVENTIVE MEASURES

### 4.1. PREVENTIVE MEASURES TAKEN

4.1.1. 2 CFFTS issued Standards Bulletin (#140, dated 28 Feb 2014) notifying Harvard II aircrew of new PFL Decision Point Criteria that was adopted to prevent crews from trying to land from a poorly flown PFL pattern:

*While conducting a PFL, the following requirements shall be met by 200ft AGL. If any of these requirements are not met, a Go Around SHALL be initiated:*

*a. minimum airspeed 120 KIAS,*

*b. landing gear down,*

*c. flaps selected to minimum T/O position (can be travelling), and*

*d. angle of bank less than 45 degrees.*

*It is NOT the intent of this bulletin for Harvard pilots to verbalize all criteria by the decision point. Assuming all criteria are met by the decision point, it is sufficient for Harvard pilots to state "parameters met" or "criteria met" by 200ft AGL.* [3.1.11; 3.2.3]

4.1.2. 15 Wing and AETE added a caution in their Emergency Response and Recovery documents regarding the presence of unexploded MDC on canopy fragments following an airborne Harvard II rear seat ejection and the importance of recovering all the MDC. [3.1.22]

4.1.3. The NRC has acquired the capability to download data from the Harvard II IDAR. [3.1.26]

### 4.2. PREVENTIVE MEASURES RECOMMENDED

4.2.1. 2 CFFTS should amend Standards Bulletin #140 to add runway alignment criterion to be met by 200 feet AGL; specifically, that the aircraft must be aligned within a defined number of degrees to the runway heading. [2.4.6; 3.1.14; 3.2.2]

4.2.2. 2 CFFTS should incorporate the amended Standards Bulletin #140 into the Harvard II SMM. [3.2.3; 3.2.4]

4.2.3. 2 Cdn Air Div / Dir AF Trg should add QFI personal limits to the FIC syllabus. The addition of personal limits as a QS task on the instructional technique flying missions, including the addition of personal limits as a scored task on mission grade sheets may respond to this deficiency. [3.1.7]

4.2.4. D Air Sim & Trg should ensure that future projects for pilot training include simulators that emulate the actual training aircraft with two seats that can be utilized for personal limits training during the FIC. [3.1.8]

4.2.5. DAEPM(FT) 6 should determine a way to rectify the disconnect problem of the Nexus U-79A/U connector for all helmets in use within the RCAF, or direct that new procedures be adopted. [3.1.20]

4.2.6. 2 Cdn Air Div / Dir AF Trg should enhance parachute training for all ejection seat aircrew. Employment and periodic use of modern parachute training simulators may be an effective method of responding to this deficiency. [3.1.21]

### 4.3. OTHER SAFETY MEASURES RECOMMENDED

**Emergency Response Plan**

4.3.1. 2 Cdn Air Div / Dir AF Trg should ensure that On-scene Commander (OSCER) courses and all Wing emergency response training highlights the importance of vigilance and caution when operating around a crash scene to ensure responder actions do not contribute to injuries. [3.1.24]

**Chase Plane Procedures**

4.3.2. 1 Cdn Air Div should develop chase plane procedures to be included in the FOM. SOPs should address standard duties and procedures for chase pilots and include appropriate cautions. Such procedures should be in line with the fighter community's already established battle damage checks, thereby ensuring continuity and consistency between fleets. These procedures should be included within the 2 CFFTS ground training program. [3.1.25]

### IDAR Data

4.3.3. D Air Sim & Trg 2-3 should liaise with the NRC and CAE MAT to modify the resolution of latitude and longitude so that the IDAR records the smallest value figures possible. [3.1.27]

**Culture**

4.3.4. 2 CFFTS should amend their Orders to remove ambiguity regarding currencies, proficiency and SCT missions, and to better highlight the importance of QFI skill development and proficiency. Further, SCT missions should be made a compulsory quarterly requirements in these Orders, requiring that a report be submitted with justification for any failures to complete the requirements. [3.1.3; 3.1.4; 3.2.1; 3.2.5]

4.3.5. DRDC Toronto Research Centre should study the effects of workload on the 2 CFFTS QFI cadre and provide findings and recommendations to the AIA and the 15 Wing CoC. [3.1.29]

### 4.4. DFS COMMENTS

Training the future pilots of the RCAF is a daunting task, particularly when RCAF pilot manning levels are low and there exists limited experience within the cadre of qualified instructor pilots. 15 Wing has maintained an excellent safety record overall while achieving this aim since the introduction of NFTC. The entire staff who have contributed to the force generation of RCAF and expatriate pilots over the course of this training program are to be commended for a job well done.

There exists a delicate balance between quantity and quality when setting course standards, and that balance has cycled in both directions over the many years that the RCAF's pilot training system has existed. Attempts to do more with less in the current context of continuous operational and financial optimum efficiencies have routinely been made, in the RCAF as well as throughout society. However, there will typically always be some level of compromise in quality if or when quantity becomes the focus.

In an effort to graduate more pilots, a revised TP reduced the overall number of flying missions and thereby reduced the overall airborne experience level of NWGs from that of previous graduates. Possibly due to the somewhat hasty implementation of the new TP, the effect of doing this was not fully considered and/or understood in the 2012 re-design of the Phase II and Phase III pilot courses. Performance standards were maintained despite the reduction in training and mitigating initiatives were not fully considered.

Though surely not done intentionally, the QFI was essentially set up for this sort of occurrence to take place due to a lack of consideration for the possible effects of the reduction in PFL training during the 2012 redesign of the Harvard Phase II & III courses, exacerbated by the culture within 2 CFFTS to prioritize student missions over QFI proficiency. This culture shift was likely very insidious and most probably not intentional. This is where the leadership, at all levels, need to be careful in the messaging of their intent as it can have undesired effects (e.g. a culture shift) and potentially introduce safety risks.

Manning and experience levels of aircrew within the RCAF are likely to continue to be low in coming years, or at the very least less than what we were used to seeing some years ago. It is imperative that the leadership consider the potential impact this may have. RCAF commanders across each fleet of aircraft need to assess the performance of NWGs arriving at their units and address any concerns they may have with 2 Cdn Air Div. This will be particularly important in the future when pilot training transitions towards the use of even more simulation which will likely further reduce the amount of airborne flying training. The RCAF's ability to maintain the same level of operational capabilities as when there existed a higher level of experience should continually be reassessed.

S. Charpentier

Colonel

Director of Flight Safety

Return to top of page

### Notes

[1] There are four instructional categories: A1, A2, B and C. A1 is the highest category instructor and C is the lowest. The B category QFI is recognized as having the ability to deliver instruction in accordance with the course training plan and also having the necessary skills and experience to provide more in depth instruction to students who may require additional instruction.

[2] SCT missions are designated staff training missions to allow the maintenance of proficiency in flying the aircraft. Minimum SCT mission hours are defined in 1 Cdn Air Div Orders Vol 5, 5-506 and expanded upon in 2 CFFTS Orders, Section 3, 4.10. Scheduling of SCT missions is at the discretion of Flight Commanders.

[3] RCAF pilot training is divided into 4 phases: Phase I at 3 CFFTS in Portage la Prairie, MB; Phase II & III at 2 CFFTS in Moose Jaw, SK, and; Phase IV at 4 Wing in Cold Lake, AB.

[4] Definition of Level 4: The candidate completed the task without assistance, making only minor errors. The trainee was able to self-analyze and correct errors. Minor errors detract from the ideal, but which do not jeopardize safety or the successful completion of the task.

[5] The Harvard II is fitted with a gas operated Interseat Sequencing System (ISS) which, when selected, allows either crew member to initiate the ejection of both seats; the rear seat ejecting first and the front seat ejecting 0.37 seconds afterwards, thereby ensuring the seats and parachutes don't interfere with one another.

[6] A-P1-183-RAA/PC-D01 – Version 1.00 – RCAF Pilot Wings Standard – ADLN ADMR 102197,valid to 30 Dec 14

[7] CFS no longer exists. Its responsibilities have been divided between a new 15 Wing Standards organization and an Air Operations Training Standards and Evaluation Team within the Directorate of Air Force Training at 2 Cdn Air Div.

[8] DRDC-RDDC-2015-L136: Director Flight Safety (DFS) Flight Safety Culture & Climate Survey Results Summary: 2 Canadian Forces Flying Training School (2 CFFTS), 2015-05-05

### ANNEX A – ABBREVIATIONS

ABBREVIATION - MEANING

ACH - Advanced Clearhood

AETE - Aerospace Engineering Test Establishment

AFTEMS - Air Force Training and Education Management System

AGL - Above ground level

AIA - Airworthiness Investigating Authority

ALSE - Aviation Life Support Equipment

AOT - Air Operations Training

APC - Annual Proficiency Check

ASL - Above sea level

ASIP - Aircraft Structural Integrity Program

ATC - Air Traffic Control

BMAT - Bombardier Military Aviation Training

C - Celsius (ºC = Degrees Celsius)

CAE MAT - CAE [the company] Military Aviation Training

Cdn Air Div - Canadian Air Division

CFAFM - Canadian Forces Approved Flight Manual

CFFTS - Canadian Forces Flying Training School

CFITES - Canadian Forces Individual Training and Education System

CFS - Central Flying School

Cmdt - Commandant

CoC - Chain of Command

CYMJ - Canadian Forces Base Moose Jaw Airport Designator

DFS - Director of Flight Safety / Directorate of Flight Safety

DGMPRA - Director General Military Personnel Research & Analysis

Dir AF Trg - Director Air Force Training

DND - Department of National Defence

DRDC - Defence Research and Development Canada

DROOD - Director Research Operational and Organizational Dynamics

DTAES - Director of Technical Airworthiness and Engineering Support

ELE - Estimated Life Expectancy

ELEV - Elevation

ENSIP - Engine Structural Integrity Program

EOD - Explosive Ordnance Disposal

FIC - Flight Instructor Course

FIS - Flying Instructor School

FOD - Foreign Object Debris / Damage

FS - Flight Safety

FTD - Flight Training Device

FK - Final Key

Flt Comd - Flight Commander

ft - Feet

G - Acceleration in multiples of gravitational acceleration

HHQ - Higher Headquarters

HK - High Key

HPMA - Human Performance in Military Aviation

IAW - In accordance with

IDAR - Integrated Data Acquisition Recorder

ISS - Interseat Sequencing System

IT&E - Individual Training and Education

KIAS - Knots Indicated Airspeed

kms - Kilometres

kts - Knots

L - Local Time

LG - Landing Gear

LK - Low Key

LMLG - Left main landing gear

M - Magnetic (ºM = Degrees Magnetic)

MDC - Mild Detonating Cord

MLG - Main landing gear

MND - Minister of National Defence

MSL - (height above) Mean Sea Level

NCM - Non-commissioned members

NM - Nautical mile

NFTC - NATO Flying Training in Canada

NRC - National Research Council

NG - Nose gear

NWG - New Wings Graduates

OEM - Original Equipment Manufacturer

OSCER - On-Scene Commander

OTU - Operational Training Unit

PDI - Parties of Direct Interest

PFL - Practice / Precautionary Forced Landing

PM - Preventive Measure

QETE - Quality Engineering Test Establishment

QFI - Qualified Flying Instructor

QS - Qualification Standard

RCAF - Royal Canadian Air Force

RDPS II - Radar Display Playback System

RMLG - Right main landing gear

Rwy - Runway

SCT - Staff Continuation Training

SK - Saskatchewan

SME - Subject Matter Expert

SMM - Standard Manoeuvre Manual

SNIC - Snow and Ice Control

SOW - Statement of Work

SP - Student pilot

T - True (ºT = Degrees True)

T-6A-1 - CT156 Harvard II

TDO - Training Development Officer

TP - Training plan

TRGSET - Training and Standards Evaluation Team

TWR - (Control) Tower

VAR - Variation

VMC - Visual Meteorological Conditions

W Comd - Wing Commander

## ANNEX B – LIST OF TABLES AND FIGURES

### TABLES



### FIGURES