Transport Canada Transports Canada

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Issue 4/2018

AVIATION SAFETY LETTER

In this issue...

Learn from the mistakes of others;

You'll not live long enough to make them all yourself…

Canada

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Table of Contents

Managing Diversions: the Cognitive Connection

by Kathleen Van Benthem, Ph.D., ACE Lab, Visualization and Simulation Centre, Carleton University, Ottawa, Canada

This article is the third in a series of reports from the Advanced Cognitive Engineering (ACE) Laboratory at Carleton University, Ottawa, Ont. We are pleased to share the results of our studies on human cognition and pilot risk. Each topic will follow this format: we will introduce aspects of cognition integral to flight safety, and interwoven into the narrative will be opportunities for you to contemplate what this information means for you. Before examining the management of diversions during cross-country flights, I would like to thank readers for their responses to the first report in the series, "Prospective Memory in the Cockpit".

Follow-up on the topic of prospective memory

The topic of prospective memory resonated with our readership as a risk factor that was personally relevant. We received feedback from *Aviation Safety Letter* (ASL) readers who had useful strategies for optimizing prospective memory during high workload periods of flight. Thank you for your responses!

Below are some of your ideas:

- Make your cues physical. For example, instead of having your fingers curled around the yoke, hold out straight the number of fingers corresponding to the number of items you want to remember in the future. As you complete the tasks, you can place your fingers back in their natural position around the yoke.
    - This is a nice strategy because the awkward feeling of holding the yoke differently will send frequent reminders to your short-term memory that there is something important you need to do in the future. And while sticky notes and other aids can be misplaced, you can't lose your fingers!
- If you are worried that you might forget something special, such as an item during your walk-around, you can complete a checklist backwards (starting with the last item on your list and ending with the first item). This will ensure that you don't skip anything on your list. It's possible that after many years of completing the same tasks repeatedly, you could fall into an "auto-pilot" mode and limit the mental resources you put towards these important tasks.
    - Changing the order of something (where order does not matter, of course) can force you to think about the actions you have to do in the future and thereby hone your prospective memory skills.

Why are cognitive factors important when managing diversions?

It is known that many serious general aviation (GA) accidents are directly associated with visual meteorological conditions (VMC) flight into instrument meteorological conditions (IMC).[1] Often, the alternative to continuing into questionable weather is either re-routing to an alternate aerodrome or returning to the departure aerodrome. While diversions are unfortunate, a pilot prepares for this eventuality before starting his or her flight and has several potential alternate aerodromes selected for the planned route. Why is it that statistics show us that pilots will choose to continue down a high-risk path to their own (and their passengers') detriment rather than initiate and manage a diversion? This is an important question, as VMC into IMC is the largest single cause of weather-related accidents and has one of the highest lethality rates of any type of GA accident.[2]

Your turn: Take a minute and think about how you plan for weather-related diversions. On a scale of 1 to 10, how prepared for diversions are you before you begin a cross-country flight? Have you ever had to undertake an unplanned diversion during a cross-country route?

Research that examines VMC flight into IMC (also called visual flight rules (VFR) into IMC) suggests that there are usually multiple factors that lead to a series of ill-fated decisions. One factor is called *plan continuation bias*. This cognitive bias shapes our behaviour by encouraging the decision to continue on the track we are on, rather than diverting to a new track. This bias becomes stronger the closer a pilot is to the destination, particularly when it's observed that other aircraft ahead are "making it" safely. Other reasons for *purposely* continuing into IMC may include pressure to arrive at the destination, poor pre-flight planning, or over-confidence in piloting skills. Causes of *inadvertent* VMC into IMC (in which the pilot is unaware of the weather risks) include poor situation awareness and an underestimation of the weather effects. A common thread in all of these causes is pilot cognition.

Your turn: Which causes of VMC into IMC might you be most vulnerable to? Are you more likely to purposefully or accidentally fly VMC into IMC?

In 2016, the ACE Lab at Carleton University conducted a VFR flight simulation study with licensed pilots (42 to 69 years of age). A primary objective of this study was to investigate whether pilot experience and cognition were associated with diversion management. After flying for some time and on their way to their final destination, pilots encountered unexpected diversions from their planned route. Pilots were given a series of surprise ATC (air traffic control) (terminal) instructions, which resulted in a two-part weather-related diversion: first to an alternate aerodrome where they had to orbit over the field, then back to base.[3] Pilots were informed of where they were to divert to, but they were responsible for determining their vectors. Only paper maps and flight supplement documents were used in this study (i.e. no electronic navigational aids were used).

The outcome measures that indexed diversion management were as follows:

- initial mapping and orientation skills (including the speed at which a new vector was calculated and then taken up);
- local situation awareness for own-ship position in relation to the alternate aerodrome, measured five minutes following the diversion instruction;
- estimated time en route to the alternate aerodrome;
- global situation awareness Level 1 (detecting information from the environment) while en route back to base;
- global situation awareness Level 2 (own-ship position and position of other relevant aircraft); and
- communication with ATC and air-to-air during the diversion.

In keeping with our objective, we also used a variety of measures to index pilot expertise and cognition. We also investigated whether poor diversion management was associated with a greater likelihood of a critical incident (from pilot causes) during other segments of the simulated flight (e.g., becoming lost, airspace infringements, or other serious piloting errors).

Your turn: Have you ever continued into a flight, for any reason, but later wondered why you did not turn back, plan a diversion, or find an alternate aerodrome? If you have initiated a weather-related diversion, what helped you make that important decision to change your route during flight?

Pilot expertise and diversion management

Because expertise is a combination of several factors, we created a single index of pilot expertise using total years licensed, hours flown, and level of license and ratings. **The relationship between expertise and diversion management was most evident in pilots' initial responses to the diversion instruction, such as their speed and**

accuracy in planning the new vector to the alternate aerodrome. We also looked at the individual aspects of expertise. For instance, as shown in Figure 1, a higher total of licensed had a positive effect on initial responses to the diversion instruction. There was also a significant relationship between communication ability during the diversion and pilot expertise. The importance of remembering to make air-to-air calls for other traffic and responding to ATC messages is discussed further in the final section on diversion management and critical incidents en route.

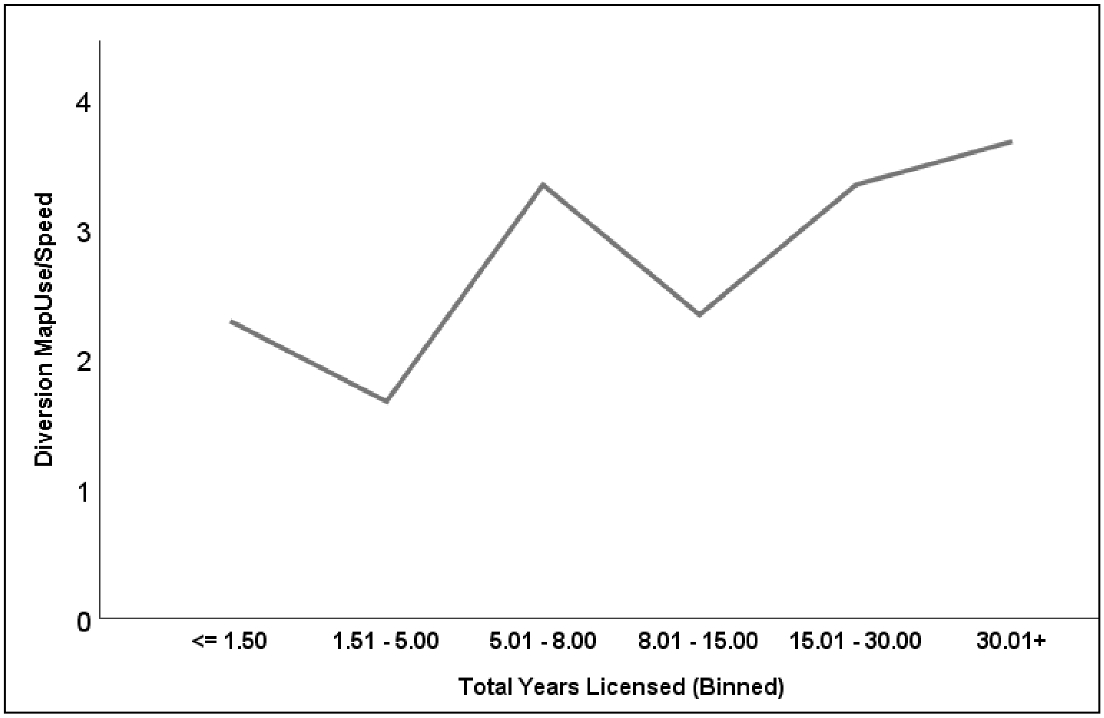

Figure 1. The relationship of "initial mapping and orientation skills" to total years flown (unpublished findings, Van Benthem & Herdman, 2018)

Pilot cognition and diversion management

In light of diversion management's reliance on mapping, orientation, reasoning, and decision-making we examined similar types of items from a well-known cognitive test for pilots called CogScreen-AE (Kay, 1995) in this analysis. Indeed, the strongest and most consistent relationships were found between the test items for pathfinding, visual sequencing, and mental flexibility (the ability to shift attention and apply new rules) and the diversion management factors. Scores for initial mapping and orientation and for communication were difficult to predict using cognitive factors. However, **estimated time en route (an efficiency variable) and situation awareness while flying the new vector back to home base were predicted by five or more of the cognitive variables.** The importance of this relationship between cognition and situation awareness will become apparent in the final section below.

Your turn: Have you considered how developing your piloting expertise might positively affect your ability to prepare for and manage diversions?
Do you believe there is anything that can optimize cognition for management of unexpected events?

Diversion management and critical incidents

As hinted above, lower scores for two diversion management factors were associated with greater likelihood of a critical incident during other segments of the simulated flight. The two diversion factors relevant to critical incidents were situation awareness and communication. The relationship between these two aspects of diversion management and critical incidents is important as it suggests that **poor diversion management might also reflect a higher risk for serious incidents during other (non-diversion-related) segments of flight.**

We also looked at predictors of critical incidents *during* the diversion segments of flight. These diversions included not hearing, or ignoring, the ATC diversion instructions; incorrect orbiting altitudes; incorrect procedures at the alternate aerodrome; and not finding the alternate aerodrome. Once again, we found a significant trend where greater expertise was associated with fewer diversion-related critical incidents.

In summary, weather-related diversions can arise without notice and require basic pilotage and communication abilities to be accessed during a period of high mental workload. Investigating the factors associated with diversion management is important, as VMC into IMC decisions are associated with one of the highest accident fatality rates in GA. **The pivotal point during flight, when pilots must decide whether or not to divert from their intended route, may be influenced by their skills, confidence, and preparations made for managing diversions.**

Optimizing diversion management skills might include maintaining and upgrading skills for the diversion factors we explored, as well as others. Some of these skills include:

- initial mapping and orientation skills;
- local situation awareness for own-ship position in relation to the alternate aerodrome;
- global situation awareness Level 1: detecting information from the environment while en route;
- global situation awareness Level 2: own-ship position and position and intent of other relevant aircraft; and
- communication with ATC and air-to-air during the diversion.

Other suggestions include:

- Upgrading expertise factors, such as maintaining regular flight hours, and obtaining additional ratings;
- Boosting abilities and confidence in abilities to manage diversions, so that when the option presents itself, the pilot is ready and prepared to manage the additional tasks that occur with diversions. Regular flight simulation experiences that include diversion practice are one method for safely developing these skills.
- Critically evaluating your cognitive skills, remembering that fatigue, injuries, and even normal aging can influence your cognition on a day-to-day basis. Our work shows that cognition related to pathfinding, visual sequencing, and mental flexibility were the most relevant for diversion management. Deliberately practising these types of cognitive skills in everyday life—for instance, by playing table tennis or card games where rules change frequently (The Five Crowns card game is one example of this type of game)—may promote this cognition in other areas. One reason why the more experienced pilots in our study showed better performance during the diversion activity may be that flying several years without the use of navigational aids could have honed those basic piloting skills so that they were readily accessible when needed.

We would appreciate hearing your thoughts on diversion management and risk for GA pilots. Please send your comments to kathy.vanbenthem@carleton.ca. We hope you have enjoyed this series from the ACE Lab at Carleton University. △

References

1. AOPA. (2018). VFR into IMC Accidents 07/15/2017 to 0/17/2018. https://www.aopa.org/asf/ntsb/vfrintoimc.cfm
2. Geske, R. (2018). AOPA Air Safety Institute 27th Joseph T. Nall Report. General Aviation Accidents in 2015. Publisher, Richard G. McSpadden Jr.
3. Van Benthem, K. & Herdman, C.M. (2017). Individual factors predict diversion management during a simulated cross-country VFR flight. In Proceedings of the 19th International Symposium on Aviation Psychology (pp. 262 - 269). Dayton, OH.

Cannabis Legalization

Further to the article published in the Aviation Safety Letter (ASL), Issue 3/2018, please find below additional information about the legalization of cannabis as it relates to Canadian aviation.

Transport Canada is responsible for dealing with fitness for duty considerations such as medical state and impairment as they relate to safety in air, marine, rail and motor vehicle modes of transport by federally-regulated employers. Transport Canada is aware that the Canadian aviation community may be concerned about the upcoming legalization of cannabis and are seeking guidance.

Cannabis use can cause immediate impairment but also causes longer-lasting impairment that may not be obvious to the user or to the people around them. Cannabis, like many other substances such as narcotics, muscle relaxants, anti-depressants, etc., causes impairment that can affect the judgement and actions of members of a flight crew, including pilots. There is scientific consensus regarding the long-lasting effects of cannabis on individuals, even after impairment is no longer felt. However, current tests for the psychoactive chemical in cannabis do not correspond with impairment levels. As a result, in the interest of aviation safety, Transport Canada does not intend to ease restrictions on the use of cannabis or other substances that cause impairment.

Impairment caused by cannabis use is a serious issue for Transport Canada given its potential to threaten aviation safety. Despite the impending legalization of cannabis, Transport Canada has an existing regulatory framework in place concerning impairment. Pursuant to the *Aeronautics Act* and the *Canadian Aviation Regulations* (CARs), regulations and medical standards address the consumption of drugs and alcohol by certificate holders, such as pilots. The CARs, under section 602.03, set out the rules governing alcohol and drug use by crew members:

> *Canadian Aviation Regulations (SOR/96-433)*
> *Section 602.03*
> *No person shall act as a crew member of an aircraft:*
> *(a)* *Within eight hours after consuming an alcoholic beverage;*
> *(b)* *While under the influence of alcohol; or*
> *(c)* ***While using any drug that impairs the person's faculties to the extent that the safety of the aircraft or of persons on board the aircraft is endangered in any way.***

Currently, the use of cannabis is a disqualifying factor for obtaining a medical certificate to fly or control aircraft. The CARs currently provide that all members of a flight crew, such as pilots, are prohibited from working while using any drug (legal or illegal) that impairs faculties to the extent that the safety of the aircraft or people on board is endangered in any way. The definition of a drug includes cannabis and, therefore, these regulations will continue to apply once the *Cannabis Act* comes into force.

Transport Canada has a robust medical protocol and testing regime in place in order to address substance abuse disorders. Canadian medical certificate holders with a known diagnosis of substance abuse may be subject to no-notice drug and alcohol testing to ensure compliance with the abstinence provisions of their certificate.

Taking cannabis, and products containing it, across any international border is illegal and can result in serious criminal penalties in Canada and in other countries, including the United States. The import and export of cannabis will remain illegal after the legalization of cannabis in Canada, and also when travelling to or returning from jurisdictions with legalized or decriminalized cannabis. This includes cannabis for medical purposes.

Each country or territory decides who can enter or exit through its borders. The Government of Canada cannot intervene on your behalf if you do not meet your destination's entry or exit requirements. During state control procedures, pilots or other crew members may be denied entry to a foreign country, including the United States, if they have previously used cannabis products, even if these products were used legally in Canada. △

General Aviation Safety Campaign: One-Year Update

by Heather Schacker, Manager, Aviation Safety Promotion and Education, Technical Program Evaluation and Coordination, Civil Aviation, Transport Canada

The General Aviation Safety Campaign (GASC) has now been in full swing for over a year, and we have some exciting developments to share with you. Thanks to all of our partners for being instrumental in helping us reach our goals and continuing to support the safety campaign.

If you haven't yet seen the GASC website, check it out! Here you will find the latest safety information, including safety tips, articles, and videos. There is always new information being added, so check back often. Have you seen our latest video? How to remain proficient, as well as current as a pilot has some great information about what it means to stay current and the extra things you should do to stay proficient.

In June 2018, Transport Canada (TC) attended the Canadian Owners and Pilots Association (COPA) convention. As the GASC was launched in partnership with COPA, the COPA convention was the perfect place to launch the first GASC National Safety Seminar. Attending one of these free safety seminars helps you keep your skills current and meet the two-year recurrent training requirement in *Canadian Aviation Regulations*, Standard 421.05(2). Look for an aviation safety seminar near you!

Working Groups

- Maintenance
- Stabilized Approach and Landing
- Angle of Attack Indicators
- Single-Pilot Resource Management
- Pilot Decision Making
- Voluntary Reporting Systems
- Flight Risk Assessment Tool
- Safety Equipment

In addition to the creation of the national safety seminar, we have also launched eight new working groups! These working groups will address specific safety concerns, review existing information and resources, and make suggestions on recommendations, mitigation, and implementation strategies related to their safety topic.

If you were at AirVenture Oshkosh, the Ultralight Pilots Association of Canada (UPAC) Annual Convention, or the Aviation Insurance Association Regional Convention, you might have seen TC or the GASC booth! At these events we were able to engage with the aviation community and learn more about the safety concerns facing general aviation pilots. We are excited to have opened the door to working with the insurance sector. This partnership will allow us to increase safety and decrease accidents through insurance incentives. If you want to talk to us about the safety campaign, look for us at some upcoming aviation events!

We are very passionate about the GASC, and we are looking forward to continuing to improve safety in the general aviation community. Keep an eye out for new information on our website, look for us at upcoming aviation events, and check out a safety seminar! If you would like to reach us, send us an email at TC.GeneralAviation-AviationGenerale.TC@tc.gc.ca. We'd love to hear from you! △

Continued International Engagement for General Aviation

by Heather Schacker, Manager, Aviation Safety Promotion and Education, Technical Program Evaluation and Coordination, Civil Aviation, Transport Canada

Transport Canada Civil Aviation (TCCA) continues to strengthen the connections it made with international authorities thanks tothe formal cooperation initiative that TCCA signed with Australia's Civil Aviation Safety Authority (CASA) and the Civil Aviation Authority of New Zealand (CAA NZ) at the the International Aviation Safety Conference in spring 2018. As a part of this initiative, TCCA recently visited Australia and New Zealand to continue strengthening its partnerships with these two authorities whose organizational structures are similar to that of Canada's, as well as promoting key safety priorities that line up with the General Aviation Safety Campaign's (GASC) key safety topics (chief among them loss of control, weather, and human factors). These organizations share similar priorities when it comes to aviation safety. The cooperation between TCCA, CASA, and CAA NZ focused on identifying priority areas for the coming year, with an emphasis on international engagement and General Aviation (GA) safety. This partnership will provide TCCA with the opportunity to learn from the experience of CASA and CAA NZ's when it comes to issues such as communicating effectively with the GA community, using social media to its full potential, enhancing consultation with industry.

CASA Aviation Safety Advisor, Iain White, presents a safety seminar in Emerald, Australia

All three organizations were able to share results of recent industry engagements with the goal of coordinating efforts and maximizing commitments in the coming years. The increased exchange of information regarding these events and forums gave TCCA the opportunity to identify areas that could be incorporated into the Canadian GA industry over the next few years. Examples of this included the Eurpoean Aviation Safety Agency's (EASA) annual safety conference on GA safety and the Safety Management International Collaboration Group (SMICG).

Another main focus of this visit included communications with and outreach to the GA community. GA is a priority for all three authorities, in spite of the fact that not every country defines it exactly the same way. The overlap in safety issues allowed for productive discussions on the gaps and challenges facing the GA community. Each authority agreed to continue sharing its products and experiences with the goal of improving GA safety across all three countries. CASA and CAA NZ also have a robust online presence and will apply their expertise to assist TCCA in developing more content for the GASC website. Both authorities were particularly interested in how TCCA is beginning to establish relationships with industry, specifically its strong partnership with the Canadian Owners and Pilots Association (COPA) through the GASC, and how this involvement has been key to effective outreach and communication for the GA community.

TCCA also had the privilege of attending a safety seminar, hosted by CASA. This seminar focused on the safety concerns faced by Australian GA pilots, many of which also exist in CanadaThese safety concerns included situational awareness and pilot decision making— both of which are two key topics in the GASC. TCCA will be working with CASA to continue to enhance Canada's GASC safety seminars on an annual basis.

Please check out the Aviation safety seminars page (www.tc.gc.ca/en/services/aviation/licensing-pilots-personnel/staying-current-proficient-pilot/aviation-safety-seminars.html) for further details on the times and locations of the seminars.

Aviation safety is a priority for everyone, and improving it through this international partnership will benefit the whole aviation community. We are looking forward to continuing to work together to improve aviation safety across all three countries. △

Aircraft Group Number (AGN)

AGN will be published in the CFS commencing early 2019. The purpose of the AGN is to provide a simple method for interrelating the numerous technical specifications concerning the aerodrome and the characteristics of the critical aircraft for which the aerodrome, or part thereof is certified. It is broken down as follows:

Table 1-1: Runway Obstacle Free Environment

Aircraft Group Number	Wing Span
I (for approach speed CAT C or D use AGN IIIB	Less than 14.94 m
II (for approach speed CAT C or D use AGN IIIB)	14.94 m up to but not including 24.10 m
IIIA (for approach speed CAT C or D use AGN IIIB)	24.10 m up to but not including 36.00 m
IIIB (includes groups I – IIIA with C & D approach speeds)	24.10 m up to but not including 36.00 m
IV	36.00 m up to but not including 52.12 m
V	52.12 m up to but not including 65.23 m
VI	65.23 m up to but not including 79.86 m

Note: Table 1-1 includes consideration of the higher approach speeds that occur in the runway environment.

Table 1-2: Taxiway Obstacle Free Environment

Aircraft Group Number	Wing Span
I	Less than 14.94 m
II	14.94 m up to but not including 24.10 m
IIIA/IIIB	24.10 m up to but not including 36.00 m
IV	36.00 m up to but not including 52.12 m
V	52.12 m up to but not inclusing 65.23 m
VI	65.23 m up to but not inclusing 79.86 m

Example on use of the tables: An aircraft has a wingspan of 20 m and a reference landing speed (Vref) of 129 kt. A standard references the use of Column II (wingspan) of Table 1-1 for its application. The aircraft falls into AGN II when referencing across the columns; however, the associated note directs the use of AGN IIIB due to the Vref being in the C category. For Table 1-2, the AGN is read directly across from the column referenced in the appropriate standard. △

TSB Final Report A17Q0050—Collision with Wires

Factual information

History of the flight
On 30 April 2017, the Piper PA-31 was conducting aerial magnetometric survey work in the area of Schefferville Airport (CYKL), Que. The aircraft was accompanied by a 2nd aircraft, which was also performing aerial magnetometric survey work in the same area.

The magnetometric survey work was conducted at low altitude (300 feet [ft] above ground level [AGL]) above an area determined according to a flight profile pre-established by the client. Each aircraft had on board 2 pilots, who took turns as pilot flying during flight segments generally spread over 2 daily flight blocks lasting up to 5 hours (hr) each.

At approximately 1336, the 2 aircraft took off again with the same crews and flew toward the survey area.

At approximately 17:38, having completed the work, the 2 aircraft began their return flight segment to CYKL. At that time, the aircraft in cause was about 10 minutes (min) ahead of the second one and was approximately 53 nautical miles (NM) northwest of CYKL. The aircraft in cause headed for the airport and descended to an altitude of 100 to 40 ft AGL.

At 17:56, while the aircraft was flying over railway tracks, it struck the conductor cables of a power transmission line and crashed on top of a mine tailings deposit located approximately 3.5 NM northwest of CYKL (Figure 1). There was no fire, but the aircraft was completely destroyed by the impact forces, and both pilots were fatally injured.

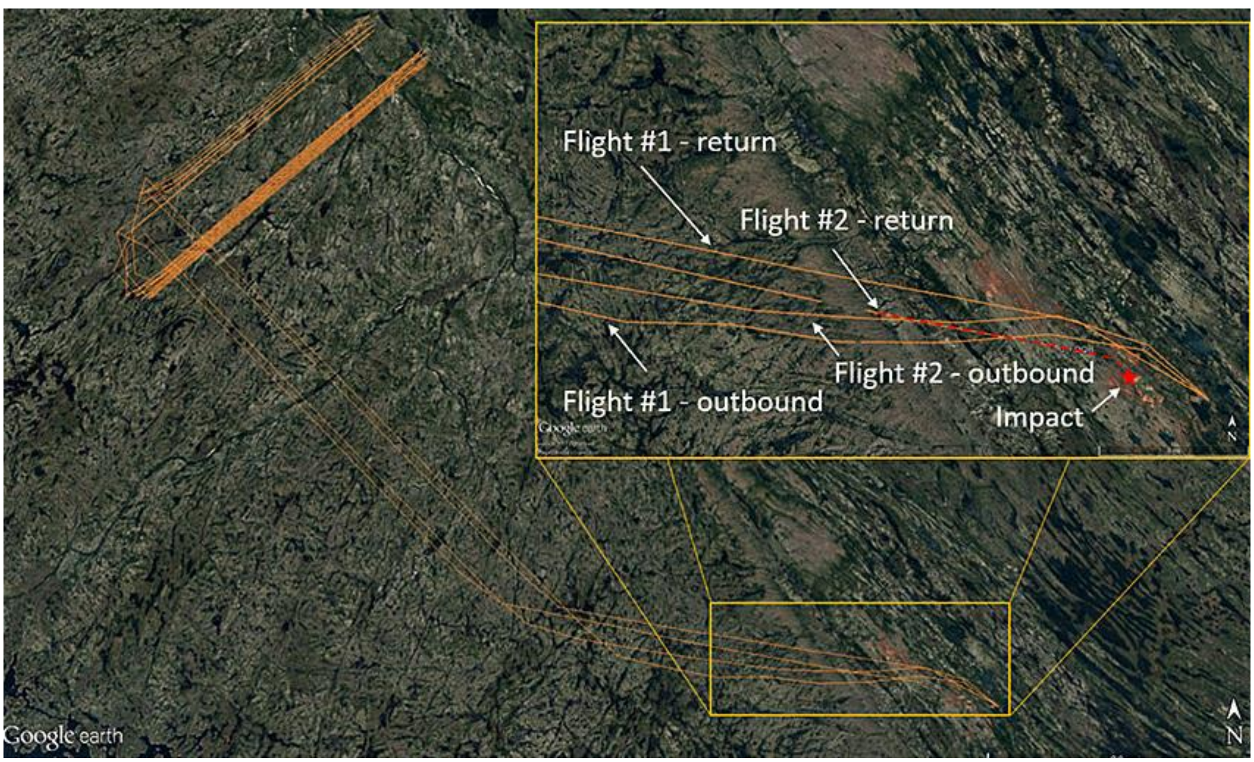

Figure 1. The 2 flights conducted by the aircraft in cause on the day of the accident, with detail showing the very-low-altitude flight segments (Source: Google Earth, with TSB annotations)

Personnel information

General
Records indicate that the flight crew held the necessary licences and qualifications for the flight, in accordance with existing regulations

Flying experience
The pilot-in-command had been employed by the company since March 2016. This was his first magnetometric survey contract, and he had conducted about 16 flights as co-pilot to familiarize himself with this type of aerial work before being assigned to the role of pilot-in-command the week before the accident.

The co-pilot had been employed by the company since September 2014. This was his 4th magnetometric survey contract, and he had trained the occurrence pilot-in-command during the first flights of the contract. At the time of the accident, the co-pilot was the pilot monitoring, seated in the right seat.

Aircraft information

Records show that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures, and had no known anomaly prior to the occurrence flight.

Meteorological information

According to the graphical forecast area (GFA), weather conditions in the area of CYKL were favourable for visual flight, with clear skies and northerly surface winds.

Aids to navigation

Air navigation charts
The applicable chart for the area was the Wabush VFR Navigation Chart (VNC) (AIR 5019). NAV CANADA publishes the VNCs for Canadian airspace in accordance with International Civil Aviation Organization (ICAO) standards.

According to ICAO, all structures over 300 ft (about 90 m) high are considered obstacles and must be shown on a VNC. NAV CANADA considers references to cultural features below that height to be exclusively for navigation purposes rather than for obstacle avoidance. Not all obstacles are shown, because it is impracticable to guarantee that all obstacles have been included, and not all geographical or aeronautical features can be shown.

The power transmission line severed by the occurrence aircraft was not depicted on the Wabush VNC and there was no regulatory requirement for it to be shown

Wreckage and impact information
The accident occurred at the mouth of a small valley created artificially by a former mine tailings deposit located on either side of a railway track (Figure 2). A power transmission line spanned across the tracks just before the mouth of the valley.

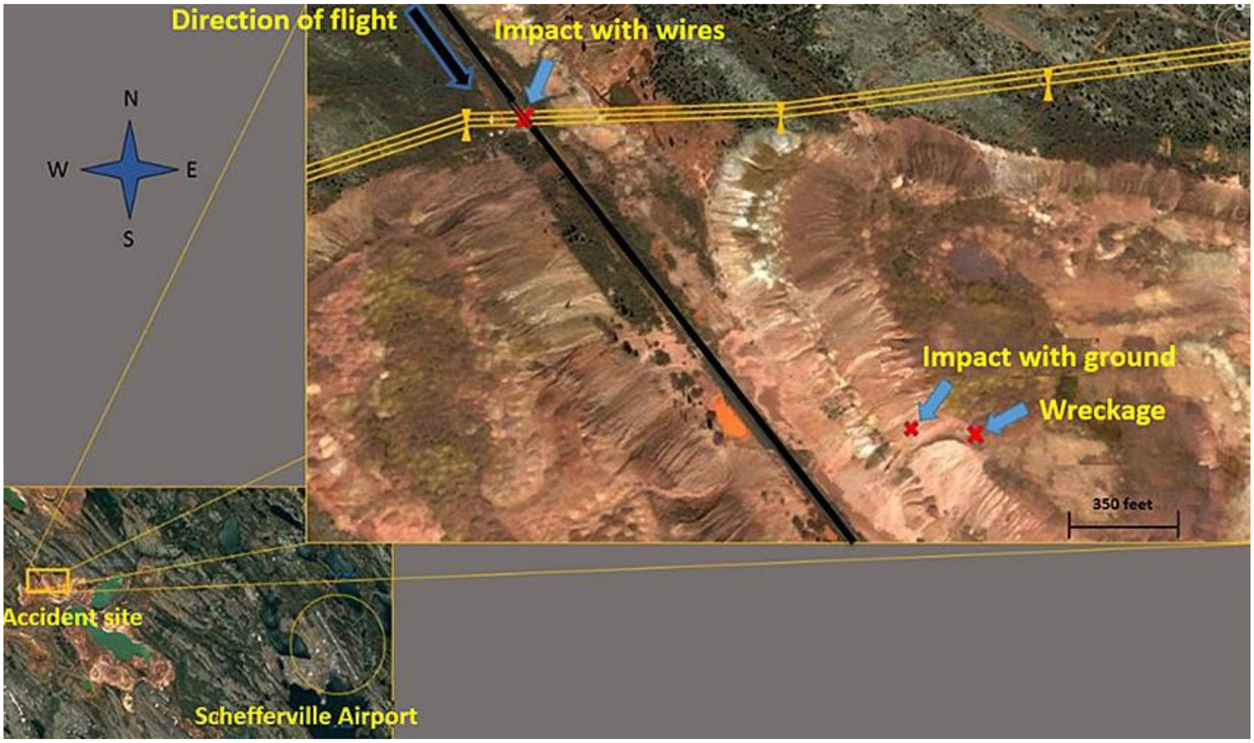

Figure 2. Accident site details

After striking the wires, the aircraft remained airborne and deviated to the left before colliding with the ground, close to the top of the ascending slope of the mine tailings deposit, on the east side, approximately 1400 ft southeast of the impact with the power transmission line.

At the point of impact, the power transmission line crosses the railway tracks at a height of 70 ft and an angle of approximately 45°.

The 3 cables were severed, with 2 remaining hooked to the aircraft's left engine until fully extended, when they were again severed at their anchor point on the aircraft.

The aircraft wreckage was found at the top of the plateau, about 134 ft east of the initial point of impact with the ground (Figure 3). The left engine was separated from the wreckage (Figure 4) and was found slightly farther away, with the propeller. Sections of the conductor cables were wrapped around the left engine propeller drive shaft.

Figure 3. Wreckage

Figure 4. Left engine: the circle shows the severed pieces of cable wrapped around the propeller drive shaft

Medical and pathological information
Toxicology testing of the pilots did not reveal the presence of any substance that could have impeded their performance. TC's examination of the pilots' medical records did not reveal any medical or pathological factor that could have affected their performance.

Low flying
The CARs state, "No person shall operate an aircraft in such a reckless or negligent manner as to endanger or be likely to endanger the life or property of any person." However, when an aircraft is not flying over a person, ship, vehicle, or structure, and is operated for the purposes of aerial work under Subpart 702 of the CARs, there is no minimum altitude requirement above terrain.

Nevertheless, "no person shall operate an aircraft in such a reckless or negligent manner as to endanger or be likely to endanger the life or property of any person."

Risk taking

Sensation seeking
Sensation seeking is the tendency to seek novel, varied, complex, and intense sensations and experiences. Low flying produces intense sensations in pilots by requiring high levels of cognitive and attentional resources in an

unforgiving environment. Men and younger persons typically score higher on sensation-seeking scales than do women and older persons, with peak levels occurring in late adolescence (18 to 20 years of age).

The occurrence pilots were 24 and 25 years old. The investigation determined that the co-pilot had previously expressed his enjoyment of low flying, but there was nothing to indicate that this was the case for the pilot-in-command. However, an analysis of GPS data showed that the pilots had conducted 27 flight segments at very low altitude.

After departing the survey area, while on the return flight, the pilots conducted a very-low-altitude flight (varying between 100 and 40 ft AGL) that lasted 18 min (from 17:38 until the impact at 17:56).

Risk perception
All activities carry a degree of associated risk. It is up to the individual to assess the level of risk associated with an activity when deciding whether or not to engage in it. Because it leaves little margin for error in terms of emergency manoeuvres and navigation, low flying is considered a high-risk activity.

Individuals who repeatedly perform a dangerous activity with no, or few, negative repercussions may become desensitized or habituated to the high level of risk. Problems can arise when perceived risks no longer match the actual risks and dangers associated with an activity.

Visibility of wires
Wires can be difficult to see during flight. According to an article published in *Aviation Week*, "Wires aren't consistently visible all of the time. Changing sunlight patterns can obscure them. [...] A wire that is perfectly visible from one direction may be completely invisible from the opposite."

Reaction time to avoid wires
In the context of a collision between 2 aircraft in flight, the average time required to detect the potential collision, make a decision, and take evasive action is 12.5 seconds. However, in the context of a pilot who has decided to fly at very low altitude (less than 100 ft AGL), situational awareness means certain elements are removed from this reaction time. In this particular context, the time to become aware of the trajectory (5 seconds) and the time to decide to deviate to the left or to the right (4 seconds) do not need to be included when the pilot is very close to the ground.

Therefore, when the pilot, already at very low altitude, sees and recognizes the wires, the 12.5-second reaction time needed to avoid a collision between 2 aircraft can be reduced by 9 seconds. Consequently, in the very-low-altitude occurrence flight, the reaction time to avoid the wires was estimated at 3.5 seconds

Marking of obstacles to air navigation
The conductor cables were not marked, and were not required by regulation to be marked.

Identification of power transmission lines
Before conducting low-level navigation, a pilot should consult a current VNC to identify the location of obstacles along the planned route of flight.

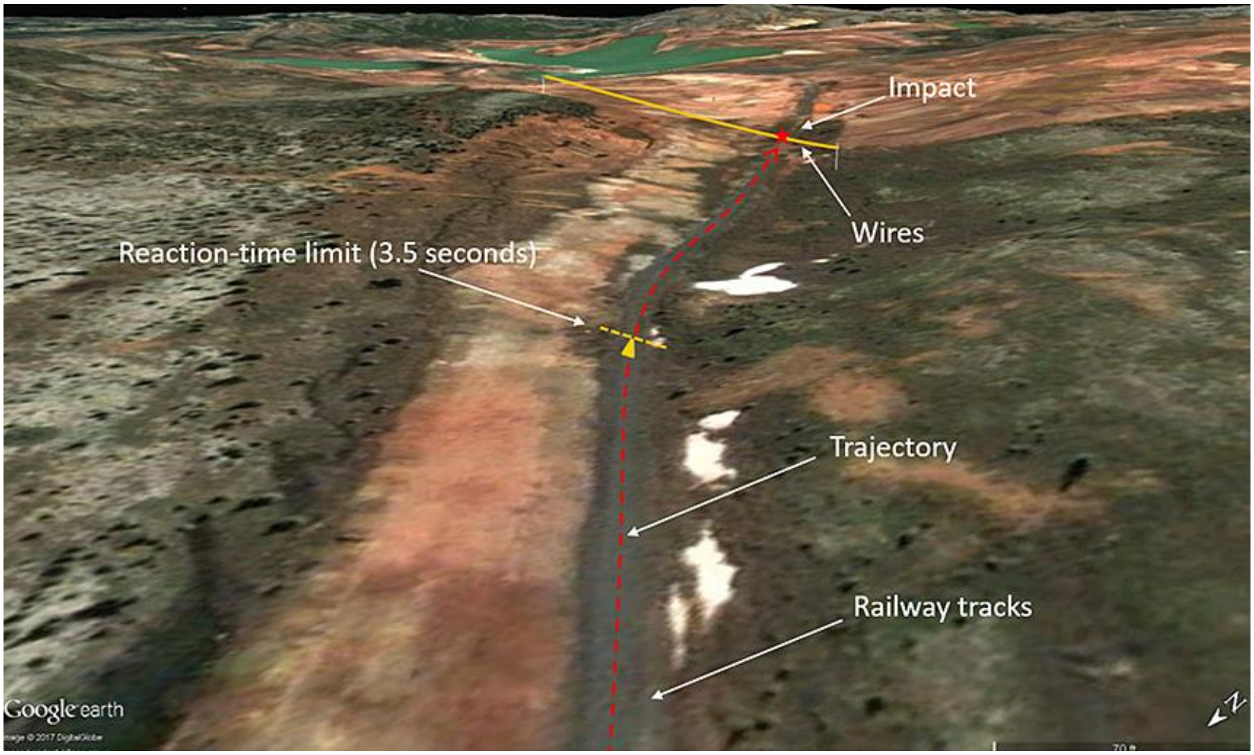

Figure 5. Trajectory prior to impact (Source: Google Earth, with TSB annotations)

If operations near obstacles such as power transmission lines are required, a reconnaissance flight conducted at a higher altitude is the first step in positively identifying their location.

The aircraft was flying at very low altitude above the railway tracks, the pilot flying did not detect the power transmission line in time to avoid it, and the aircraft collided with the wires, which were 70 ft above the ground.

Findings as to causes and contributing factors

1. Sensation seeking, mental fatigue, and an altered risk perception very likely contributed to the fact that, immediately after completing the magnetometric survey work, the pilot flying descended to an altitude varying between 100 and 40 ft AGL and maintained this altitude until the aircraft collided with the wires.
2. It is highly likely that the pilots were unaware that there was a power transmission line in their path.
3. The pilot flying did not detect the power transmission line in time to avoid it, and the aircraft collided with the wires, which were 70 ft above the ground.
4. Despite the warning regarding low-altitude flying in the *Transport Canada Aeronautical Information Manual*, and in the absence of minimum-altitude restrictions imposed by the company, the pilot chose to descend to a very low altitude on the return flight; as a result, this flight segment carried an unacceptable level of risk.

TSB Final Report A18W0025—Collision with Terrain

History of the flight
At 09:39 on 15 February 2018, the Airbus Helicopters AS 350 B2 departed Norman Wells Airport (CYVQ), N.W.T., with the pilot and 1 passenger on board. The purpose of the flight was to transport the passenger to a telecommunications tower on Bear Rock, N.W.T., which is located 35 nautical miles (NM) southeast of Norman Wells, and 3 NM west-northwest of Tulita, N.W.T.

At 09:58, the helicopter landed on a helipad near the telecommunications tower and was shut down. The helipad, measuring 16 feet (ft) by 16 ft, is made of treated timber. At the time of the occurrence, the helipad was mostly bare wood; however, there were several patches of ice (Figure 1).

Approximately 30 minutes (min) after landing, given the temperature at the time, the pilot conducted a first engine run. On start-up, the pilot felt vibrations consistent with those felt over the previous 3 days, both on the ground and during flight.

Figure 1. Helipad on Bear Rock

At 11:08, the pilot initiated the engine-start sequence for another engine run. The engine started and accelerated normally to 70% gas generator speed (nanograms [Ng]). The pilot increased the fuel flow control to the flight position. As the throttle was increased, the helicopter began bucking fore and aft on the landing gear skids.

In response, the pilot decreased the fuel flow control, which increased the bucking. The pilot then decided to lift off in order to stop what he perceived to be ground resonance. The fuel flow control was quickly increased and the collective raised; however, the fuel flow control was not fully advanced and locked into the flight gate. Neither the main rotor revolutions per minute (rpm) nor the engine rpm accelerated to the flight-governing range before the helicopter became airborne.

Figure 2. Front side of the occurrence helicopter, looking to the east

The helicopter lifted several ft off the helipad, rotated to the left, and drifted approximately 30 metres (m) to the southeast. Given that the engine rpm had not accelerated into the flight-governing range, the rotor rpm subsequently drooped, and the pilot was unable to maintain control of the helicopter.

At approximately 11:10, the helicopter descended, collided with terrain, and came to rest 50 m downslope of the helipad (Figure 2).

The pilot was wearing the 4-point lap and shoulder harness, but was not wearing a helmet. He received serious injuries, but managed to egress the helicopter, return to the telecommunications tower service building, and contact the company to report the accident. A company helicopter was dispatched from Fort Simpson, N.W.T., and arrived at approximately 15:00 to transport the pilot to medical facilities in Yellowknife, N.W.T.

Weather
The Tulita hourly weather observation taken at 11:00 (10 min prior to the accident) reported calm winds (at 3 knots [kt]), visibility greater than 25 statute miles (SM) with light snow, and a temperature of −27 °C.

Pilot
Records indicate that the pilot was certified and qualified for the flight in accordance with existing regulations.

Aircraft
The AS 350 B2 is equipped with a single engine and has a maximum take-off weight of 2250 kilograms (kg) (4960 pounds [lbs]). The helicopter was being operated within its weight-and-balance and centre-of-gravity (C of G) limits.

Ground resonance
Ground resonance (oscillation divergence) is a self-excited vibration on helicopters with articulated rotor systems. It generally occurs on the ground during landing or rotor-starting phases. As described in the U.S. Federal Aviation Administration (FAA) *Helicopter Flying Handbook*, "Ground resonance is a mechanical design issue that results from the helicopter's airframe having a natural frequency that can be intensified by an out-of-balance rotor. The unbalanced rotor system vibrates at the same frequency or multiple of the airframe's resonant frequency and the harmonic oscillation increases because the engine is adding power to the system, increasing the magnitude (or amplitude) of the vibrations [...].

If left uncorrected, it can become severe and damage the airframe structure."

According to guidance in the FAA's *Helicopter Flying Handbook*, when ground resonance is experienced during low engine rpm,

"the only corrective action [...] is to close the throttle immediately and fully lower the collective to place the blades in low pitch. If the rpm is in the normal operating range, fly the helicopter off the ground, and allow the blades to rephase themselves automatically."

The AS 350 B2 flight manual does not contain ground resonance handling procedures.

Main rotor head
Ground resonance does not normally occur in rigid or semi-rigid rotor systems because there is no drag hinge. The AS 350 series of helicopters is equipped with a Starflex rotor head, which consists of many composite components and elastomeric parts (thrust bearings). The Starflex rotor head is known as an articulated rotor head.

During the impact sequence in this occurrence, the main rotor head was significantly damaged. Two of the 3 frequency adapters were recovered from the accident site. Examination of the rotor head components did not identify any indications of pre-impact failure.

Landing gear
AS 350 series helicopters are equipped with 2 systems on the landing gear skid assembly that absorb vibrations:

- Flexible steel strips: The steel strips increase the landing gear skid flexibility and position the natural frequency of the landing gear skid in such a way as to reduce ground resonance.
- Damper assemblies: The dampers are intended to absorb the vibration energy and reduce oscillation divergence.

The occurrence aircraft was equipped with both of these systems.

Following the accident, on 24 February 2018, the operator removed the landing gear damper assemblies for inspection and testing, which were conducted by the maintenance organization's in-house component shop.

The damper assemblies were functionally tested. The left damper passed the test but the right damper did not. The right damper was disassembled, cleaned, and reassembled with new packings, seals, and washer valves. Following reassembly, the right damper was re-tested and was found to be serviceable.

Main rotor blade removal and installation
On 11 February 2018, 4 days before the accident, the helicopter was placed in the hangar overnight. An aircraft maintenance engineer had removed the main rotor blades with the assistance of the occurrence pilot and placed them on a wheeled storage rack.

After reinstalling the main rotor blades on the morning of 12 February 2018, the occurrence pilot conducted an engine run, during which vibrations were noted. The vibration levels were not verified using vibration analysis equipment, which was available at the maintenance hangar. The blade tip tracking and dynamic balancing were not checked, as prescribed in the aircraft maintenance manual.

When this type of work is carried out, the *Canadian Aviation Regulations* and company policies require that an entry be made in the aircraft journey log; however, no entry was made in the aircraft journey log for either the removal or the installation of the rotor blades. The investigation found that it was the maintenance provider's routine practice to do this type of work without making entries in the aircraft journey log.

The pilot subsequently flew the helicopter for 6 hours (hr) before the occurrence and the vibration continued. During this time, no action was taken to verify or rectify the vibration and no aircraft journey log entries were made.

Information on the pre-accident tracking and balance condition of the rotor system was not available (because it was not recorded by maintenance) and was impossible to obtain post-accident.

Key safety messages
The investigation highlighted the following safety messages:

- The success of recovery when encountering possible ground resonance depends on appropriate action relevant to the main rotor speed.
- It is important to record maintenance activities in the aircraft journey log and follow maintenance procedures, for example when removing and installing main rotor blades.
- Wearing the available lap and shoulder harnesses and a helmet is key to preventing injury in rollover accidents in which the potential for head injury is high.

Safety action taken
Following this accident, the following safety actions were taken:

- On 26 June 2018, management sent an email to all company pilots and aircraft maintenance engineers, reminding them of the requirement to enter blade removal and installation in the aircraft journey log.
- An audit cycle was added to monitor the blade removal and installation events.
- Company pilots were reminded, in recent training classes, of the requirement to record any sudden changes in vibration levels in the aircraft journey log.

TSB Final Report A18W0054—Engine PowerLoss and Forced Landing

History of the flight
At 04:44 on 25 April 2018, the Piper PA-31-350 Navajo Chieftain departed Medicine Hat Airport (CYXH), Alta. with 2 flight crew members and 4 passengers on board for a scheduled charter flight to Calgary International Airport (CYYC), Alta. The aircraft had been fuelled with 50.1 U.S. gallons (gal.) of 100LL aviation gasoline (AVGAS) and the operational flight plan showed a final fuel load of 144 U.S. gal. (864 pounds [lbs]). This resulted in full inboard fuel cells (56 U.S. gal. in each) and approximately ⅓ full outboard cells (16 U.S. gal. in each).

After departure, the aircraft climbed to a cruising altitude of 8000 feet (ft) above sea level (ASL). The crew completed the cruise checklist, which included switching the fuel selectors from inboard to outboard fuel cells.

A descent was initiated at 05:35 MDT, when the aircraft was approximately 20 nautical miles (NM) southeast of the threshold for Runway 35R at CYYC. Prior to the descent, the crew completed the normal descent checklist. At 05:36 MDT, the arrival controller offered the aircraft a landing option for Runway 35L, which the crew accepted. At 05:38 MDT, when the aircraft was approximately 12 NM south of Runway 35R, the right engine began to surge. The captain then requested that the first officer run the engine failure in-flight checklist. The items on the checklist were performed, with the exception of the cause check and feathering the propeller. The cause check directs the crew to check fuel flow, fuel quantity, fuel selector position, oil pressure and temperature, and magneto switches.

Shortly thereafter, the flight crew contacted the arrival controller and requested to land on Runway 35R, because it was a more direct flight path. The arrival controller cleared the aircraft for the visual approach to Runway 35R. At 05:39, the crew contacted the arrival controller and stated that they had lost the right fuel pump. The arrival controller asked if they wanted to place aircraft rescue and firefighting on standby; the flight crew declined. At approximately 05:40, the left engine began to surge.

At 05:42, the aircraft was transferred to the tower controller. Moments later, the flight crew transmitted a Mayday call. The tower controller cleared the aircraft for landing on Runway 35R. Recognizing that the aircraft was not going to make it to the airfield, the flight crew selected a suitable road (36 Street N.E.) to attempt an emergency landing.

At 05:43, the flight crew made a second Mayday call, informing the tower controller that they would be landing on a road because they would not be able to make it to the airfield.

The aircraft touched down in the northbound lanes of 36 Street N.E., just north of the intersection with Marlborough Drive N.E. Shortly after the aircraft touched down, its right wing contacted a light standard on the right side of the road, shearing off the outer 4 ft of the wing. The aircraft continued north, through the intersection with Marbank Drive N.E., and came to a stop just south of the on-ramp for eastbound 16 Avenue N.E., which is part of the Trans-Canada Highway (Figure 1).

Figure 1. The occurrence aircraft after coming to a stop on 36 Street N.E., Calgary, Alta.

Checklist
The air operator created a standard operating procedures (SOPs) document containing a normal procedures checklist for the PA-31-350. This checklist was compared to the one in the *Pilots Operating Handbook* (POH), which is published by the aircraft manufacturer. The investigation found differences between the 2 documents. Of note, in the POH descent checklist, there is a step to check that the fuel selectors are set to inboard. However, the air operator's normal procedures descent checklist did not include this item. Instead, the step to check that the fuel selectors are set to inboard was included in the before landing checklist.

The manufacturer's POH contains a caution note between the before takeoff and normal takeoff procedures that states, in part, "Outboard tanks are for coordinated level flight only and may never be used for takeoff."

In the description of cruise flight, the POH contains the following statement: "If outboard cells are used during climbs, descents or prolonged uncoordinated level flight, power loss may result even if there is appreciable fuel remaining." Neither statement was reproduced in the air operator normal procedures checklist document.

Quick reference handbook
The air operator's SOPs for the Piper Navajo state the following:

These SOPs are structured on SOPs commonly used on larger aircraft. As the air operator is primarily an industry entry-level organization, the complexity of the SOPs is meant as an introduction and learning tool to the type of SOPs Super T employees may find at organizations using larger aircraft.

The quick reference handbook (QRH) forms part of the SOPs document (Chapter 10). The physical format and layout of the QRH were compared with those of QRHs commonly found in the industry. The following observations were made:

- The QRH pages lacked tabs to help the flight crew quickly identify the pertinent section to use.
- The table of contents at the front of the QRH indicates where corrective action for specific operating conditions can be found. However, the page numbers on the actual pages of the QRH are small and are located on the bottom left side of the page, which can make them difficult to find in an emergency.

The air operator fuel management standard operating procedure
The air operator's SOPs do not include any guidance information on fuel monitoring or management, and the investigation found that the captain and first officer used different methods to manage and monitor fuel consumption throughout the flight. The captain referenced the global positioning system (GPS), which provides basic fuel-planning data based on a fuel load and fuel consumption rate input by the user. The GPS did not have any data input with respect to the actual fuel burn, nor did it have any data input with respect to how much fuel was actually on board the aircraft at a specific time, or in which fuel cell. In addition, the captain relied on memory to determine how much fuel was on board and in which fuel cell, and when to switch cells.

The first officer leaned the engines out to 22 gal. per hour (hr) (per engine) based on the digital fuel flow meter and incorporated an observation of the fuel quantity gauges in his routine instrument scan.

The flight crew members did not discuss fuel management strategies during the pre-flight briefing.

Aircraft
The Navajo Chieftain fuel is stored in flexible fuel cells (2 in each wing panel). The outboard cells hold 40 U.S. gal. each, and the inboard cells hold 56 U.S. gal. each, for a total of 192 U.S. gal. Of this amount, 182 U.S. gal. is useable. The fuel management controls include the fuel cell selectors, fuel shutoffs, and fuel crossfeed controls. During normal operation, each engine is supplied by fuel from its respective fuel system.

Two electric fuel-quantity gauges are mounted in the overhead switch panel. The right fuel quantity gauge indicates the quantity of fuel in the selected right fuel system cell (inboard or outboard), and the left fuel quantity gauge indicates the quantity of fuel in the selected left fuel system cell (inboard or outboard). When a fuel cell is selected, its corresponding fuel level is shown.

The aircraft is equipped with 2 (left and right) red "FUEL BOOST INOP" lights in an annunciator panel mounted at the top of the centre instrument panel. These warning lights illuminate when the fuel boost pressure is sensed at less than 3 pounds per square inch (psi). There are also 2 (left and right) electrically powered emergency fuel pumps for use in case of an engine-driven fuel pump failure.

Meteorological information
Weather was not considered a factor in this occurrence.

Personnel information
Records indicate that the captain and first officer were certified and qualified for the flight in accordance with existing regulations.

Aircraft examination
The aircraft was towed back to the airport property and placed in a hangar for post-accident examination.

Electrical power was applied to the aircraft using the battery, and the fuel quantity readings from the fuel gauges were noted. Both the left and right inboard fuel cells were indicating that they were approximately ¾ full. This corresponds to a useable fuel quantity of approximately 40 U.S. gal. in each inboard fuel cell.

With the fuel selector valves in the outboard position, the left outboard cell was indicating empty and the right outboard cell was showing a full gauge deflection—past the full mark. Mechanical damage to the outboard fuel quantity–sending unit of that cell was observed through the fuel filler opening. The outboard fuel cells were drained of fuel. The left outboard fuel cell contained 0.09 U.S. gal., and the right cell contained 0.05 U.S. gal. The POH specifies that the unusable fuel for the outboard fuel cells is 2 U.S. gal. per cell.

Safety messages
As shown in this occurrence, when fuel management SOPs are not in place, fuel starvation can occur even if there is sufficient fuel remaining on board the aircraft to complete the planned flight. In addition, if flight crews do not complete checklist procedures in their entirety, opportunities to rectify emergency situations can be lost. However, in this occurrence, when the flight crew decided that the aircraft could not make it to the airport, their prioritization of selecting a suitable alternate landing area and managing the energy state of the aircraft contributed to the success of the emergency landing.

Safety action taken
Following this occurrence, the air operator made several changes to its Piper Navajo SOPs, QRH, and normal procedures checklist for the aircraft, and submitted them to Transport Canada. These changes included the following:

- A step has been added to set a timer when the outboard tanks are selected.
- The step to switch from the outboard tanks to the inboard tanks has been moved from the before landing checklist to the descent checklist on the company-generated normal procedures checklist.
- Guidance on procedures for accepting runway changes has been added to the company SOPs.
- More detail on aircraft evacuation procedures has been added to the SOPs.
- Enhanced procedures on preparing passengers for an emergency landing have been added to the SOPs.
- Tabs have been added to the QRH pages to facilitate quick procedure identification.
- More detail on procedures for rough-running engines has been added to the SOPs and a rough-running engine checklist has been added to the QRH.

Additionally, the training syllabus for new crew members and the company's emergency response plan have been amended, and an industry-supplied course on fatigue management and human factors has been scheduled.