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Bureau de la sécurité des transports du Canada

AIR TRANSPORTATION SAFETY ISSUE INVESTIGATION REPORT A15H0001

Raising the Bar on Safety: Reducing the Risks Associated with Air-taxi Operations in Canada

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Canada

ABOUT THIS INVESTIGATION REPORT

This report is the result of an investigation into a class 1 occurrence. For more information, see the Policy on Occurrence Classification at www.tsb.gc.ca

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

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Raising the Bar on Safety: Reducing the Risks Associated with Air-taxi Operations in Canada

Summary

A unique sector in the aviation industry

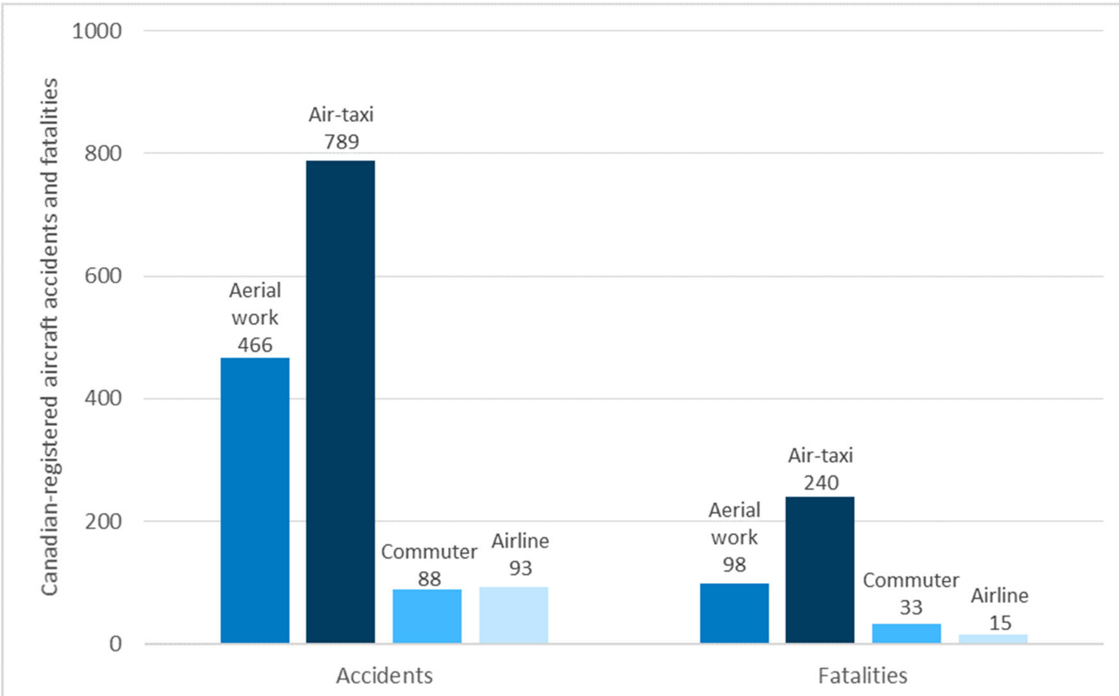
The air-taxi sector provides a diverse array of air services to Canadians. These include helicopters to transport injured or ill patients to hospitals, floatplanes[1] to take commuters from harbour to harbour in coastal cities, and airplanes to bring workers to remote areas, provide search and rescue, or deliver food, equipment, and passengers to communities. These vital air links have helped build Canada and sustain its people.

But air-taxi services operate in a very different context from other sectors of aviation. They often have no set schedule and fly into remote areas in uncontrolled airspace with few aerodromes or navigation aids. What aerodromes there are may be small, with fewer services and less infrastructure. Access to current and forecast weather information or the latest technology may be limited. Operators tend to be smaller. Flight crew have a more direct role in managing many of the operational hazards, and pilots often have direct contact with clients. Pilots may not have operational support from dispatch and other personnel. Flights tend to be shorter, resulting in more takeoffs and landings. Aircraft are exposed to severe weather because they fly at lower altitudes and over rugged, coastal, or northern topography. The aircraft can be small (carrying fewer than 10 passengers, by regulation), in many cases, old (some more than 70 years old), and with less sophisticated technology. Pilots often fly by visual reference to the ground, rather than navigating using instruments alone. Flight crews may have to land on gravel airstrips, on lakes, or on frozen surfaces, especially helicopter crews who often have to land at unprepared sites.

1 "Floatplane" refers to any fixed-wing airplane capable of water-borne operations (including seaplanes).

The air-taxi sector has more accidents and more fatalities than all other sectors of commercial aviation in Canada. The numbers speak for themselves. In the 18-year period from 01 January 2000 to 31 December 2017, there were 789 accidents in the air-taxi sector, resulting in 240 fatalities—representing 55% of all accidents in commercial air services in Canada and 62% of the fatalities in this period (Figure S1).

Figure S1. Total number of accidents and fatalities involving Canadian-registered aircraft by operator type, 2000 to 2017 (Source: TSB)



By contrast, during the same period, airline operations in Canada[2] experienced only 93 accidents (6% of the total) and 15 fatalities (4% of the total).

Air-taxi accidents have significant human and economic costs. The safety issues underlying these accidents are known, and they are persistent: the hazards and risks have been identified and mitigation measures have been recommended in numerous studies and reviews, some of which go back nearly 3 decades. And yet the air-taxi sector continues to experience a high number of accidents and fatalities. Why do these accidents keep happening, and how can safety in the sector be improved?

The safety issue investigation

To answer these questions, the TSB launched this safety issue investigation (SII). The SII consisted of 2 phases.

[2] Airline operations involve aircraft that are built to carry 20 or more passengers and are generally used for commercial passenger flights.

Phase 1: Review of occurrence data and investigation reports

In Phase 1 of the SII, the investigation team reviewed TSB occurrence data, previous investigation reports, and reports on safety in the air-taxi sector by other organizations.

The investigation team analyzed 716 occurrences in air-taxi operations that were reported to the TSB from 2000 to 2014 (the study period), to determine whether there were any patterns or trends.

Statistical analysis showed a downward trend in the *total* number of air-taxi accidents during the study period. However, there was no similar downward trend in the number of *fatal* accidents or fatalities over this period.

To identify the types of accidents that were happening during the study period, the team first used the system established by the International Civil Aviation Organization (ICAO). However, the ICAO system did not prove sufficiently descriptive, because it was designed for the airline industry, rather than for the air-taxi sector, and the system captures accident outcomes, not the circumstances contributing to the accident, which was important for this analysis.

More insightful was reviewing the TSB investigation reports for 167 of the occurrences from the study period. Using the grounded theory qualitative method, the investigators developed a process to categorize accident types based on the circumstances of the accidents described in the reports. The analysis of data provided an understanding of how these accidents were happening (through precise descriptions).

This analysis revealed that the highest number of fatalities in both airplane and helicopter accidents resulted from flights that started in visual meteorological conditions and continued to a point where the pilot lost visual reference with the ground. The main difference was how the flight ended: in a **loss of control** or a **controlled flight into terrain**.

The pilots involved in these accidents had a combined overall average of **5000** hours of experience. Therefore, it would appear that pilot experience is not mitigating against these types of accidents.

Finally, the analysis of the accident data revealed that the factors contributing to air-taxi accidents that occurred during the study period fell into 2 broad areas:

- **acceptance of unsafe practices** (e.g., flying overweight, flying into forecasted icing, not recording defects in the aircraft log, flying with unserviceable equipment, “pushing the weather,” and flying with inadequate fuel reserves)
- **inadequate management of operational hazards** (e.g., inadequate response to aircraft emergencies, inadequate crew coordination contributing to unstable approach, visual flight rules flight at night, loss of visual reference in marginal weather conditions, scales not available for weight and balance calculations).

The SII could not draw conclusions on the accident rate in the air-taxi sector in Canada by hours flown or by number of movements (takeoffs or landings). These data are currently collected or reported for commercial aviation as a whole, but not for particular sectors (such as air taxi) or aircraft types (such as floatplanes or helicopters). Furthermore, movement data are not captured for locations where air-taxi operators are more likely to go, such as uncontrolled airports, remote locations with unprepared landing sites, or lakes.

Phase 2: Interviews with industry

In Phase 2 of the SII, TSB investigators interviewed 119 people from 32 operators as well as 6 civil aviation inspectors from Transport Canada to get a better understanding of the pressures on the industry and the issues faced in their daily work. Approximately 300 hours of audio recordings provided a rich source of insight into the air-taxi sector.

The information from these consultations was organized into 19 safety themes that emerged from analysis using the grounded theory qualitative method. Further analysis within each theme (using accident data, previous studies, and TSB recommendations) yielded the following conclusions (Table S1).

Table S1. Safety themes from interviews with industry, with corresponding conclusions

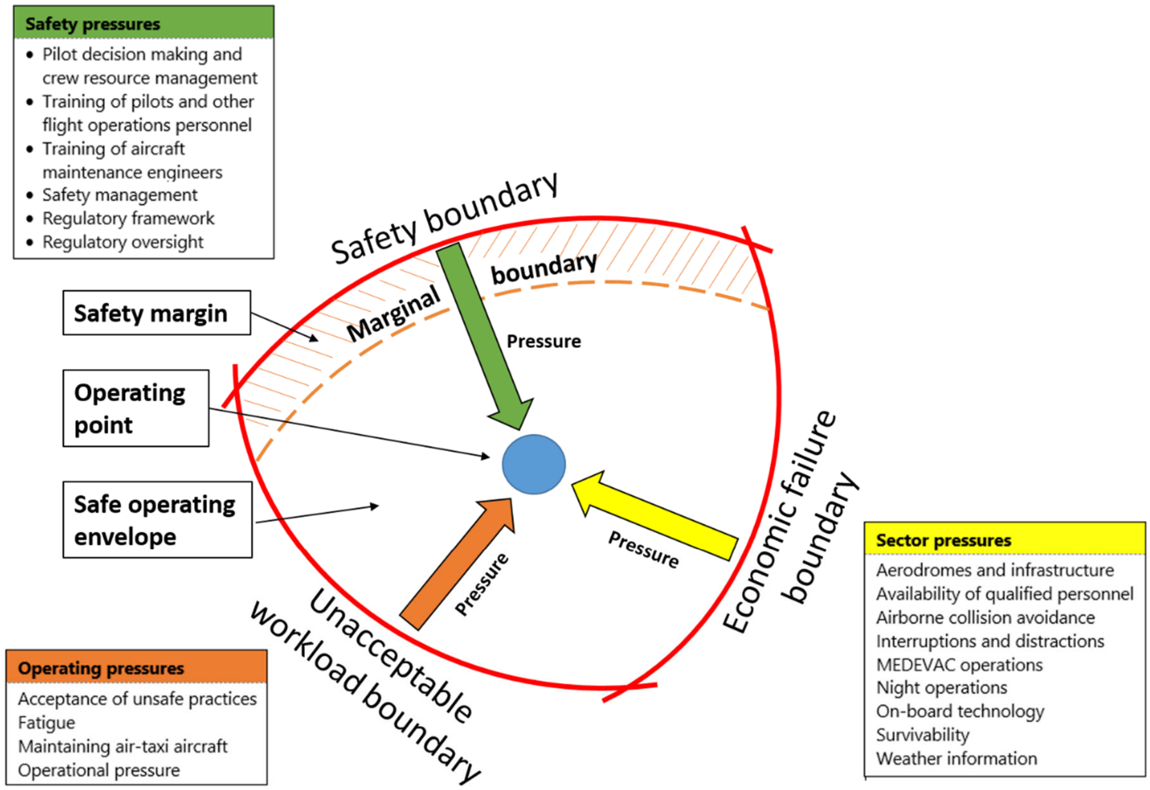
Safety theme	Conclusion
1. Aerodromes and infrastructure	Remote and northern communities of Canada require appropriate aerodrome facilities and infrastructure to ensure that air-taxi operators can provide safe air services for those communities.
2. Availability of qualified personnel	The availability of qualified personnel is critical to safety; competent personnel are a key component in managing risk.
3. Airborne collision avoidance	Traffic avoidance services and procedures are critical elements to mitigate the risk of collision.
4. Interruptions and distractions	Well-developed company policies and standard operating procedures are critical to reduce the likelihood and effects of personnel being interrupted and/or distracted.
5. MEDEVAC operations	The unique nature of conducting MEDEVAC operations can place a great deal of stress on pilots, which may have a negative influence on their decision making.
6. Night operations	Adequate visual references during night operations are critical to ensuring the safety of the flight.
7. On-board technology	Improved technology, if incorporated into an operation, has significant potential to enhance safety in air-taxi operations.
8. Survivability	Aircraft crashworthiness, safety information, and safety equipment are key components to improve occupant survival in the event of an accident.
9. Weather information	Accurate weather information is a critical component of flight planning and allows pilots to make effective weather-related decisions.
10. Acceptance of unsafe practices	If unsafe practices are not recognized and mitigated, or if they are accepted over time as the “normal” way to conduct business, there is an increased risk of an accident.
11. Fatigue	Fatigue-related impairment has a detrimental effect on aviation safety.
12. Maintaining air-taxi aircraft	Maintaining aircraft in a serviceable condition is fundamental to ensuring the safety of flight.
13. Operational pressure	Internal and external pressures, including pressure to get the job done, can negatively impact safety.

Safety theme	Conclusion
14. Pilot decision making (PDM) and crew resource management (CRM)	PDM and CRM are critical competencies that help flight crew manage the risks associated with aircraft operations.
15. Training of pilots and other flight operations personnel	Providing training for pilots and other flight operations personnel is essential for them to develop the skills and knowledge they need to effectively manage the diverse risks associated with air-taxi operations.
16. Training of aircraft maintenance engineers	Aircraft maintenance engineers working in air-taxi operations require extensive technical knowledge to ensure that the wide variety of aircraft types and models used in this sector are maintained in airworthy condition.
17. Safety management	Effective safety management is important for operators to be able to proactively identify hazards and mitigate risks to a level as low as reasonably practicable.
18. Regulatory framework	Regulations must keep pace with advances in the aviation industry to help achieve an acceptable level of safety.
19. Regulatory oversight	A robust system of regulatory oversight that includes safety promotion, monitoring, and enforcement is critical to ensuring that operators are provided with the support they need to effectively manage the risks associated with their operation and that they are complying with the regulations.

Raising the bar on safety

To understand how these safety issues interact, the investigation team analyzed the safety themes within a model called the **safe operating envelope** (Figure S2).

Figure S2. The safe operating envelope model adapted for this SII (Source: TSB)



In this model, the air-taxi sector (or an individual operator) is represented by the operating point (the blue circle), and its position is determined by how hazards and risks are managed. As a result, the operating point is constantly moving. If it crosses any of the boundaries of the safe operating envelope, the system breaks down. The boundaries are

- economic factors (the financial costs become unsustainable),
- workload factors (there is not enough time or resources available), and
- safety factors (there may be harm to workers, passengers, or the public).[3]

The marginal boundary depicts the depth of the safety margin: the fewer or weaker the defences in place, the thinner the safety margin. As the operating point crosses over the marginal boundary, the safety of the operation diminishes until the operating point crosses the safety boundary, where a failure (an accident or incident) occurs.

These multiple pressures affect the dynamics of the system and are influenced by many stakeholders in the air-taxi sector (Figure S3).

3 Adapted from Cook and Rasmussen (2005) in D. Woods, J. Schenk, and T. T. Allen, "An initial comparison of selected models of system resilience," in: C.P. Nemeth, E. Hollnagel and S. Dekker (eds.), *Resilience Engineering Perspectives, Volume 2: Preparation and Restoration* (Boca Raton, FL: CRC Press, 2009), p. 78.

In order to raise the bar on safety in air-taxi operations, **all** stakeholders together need to change to a culture where unsafe practices are unacceptable. Operating safely has to become the norm.

The 22 active TSB recommendations that apply to the air-taxi sector need to be addressed. In addition, stakeholders must work together to

- change the safety culture by using modern safety management to support pilot decision making (PDM) and crew resource management (CRM);
- invest in measures to increase the **safety pressures** within air-taxi operations: PDM/CRM; training of pilots, other flight operations personnel and aircraft maintenance engineers; safety management; and regulatory framework and oversight;
- invest in measures to decrease the **sector pressures** (e.g., better weather information) and **operating pressures** (e.g., manage fatigue); and
- improve how rate data are obtained to better evaluate how well safety measures are working

Figure S3. Stakeholders that have a role to play in the air-taxi sector (Source: TSB)

The TSB has issued 4 new recommendations as a result of this SII, which are discussed below.

Eliminating the acceptance of unsafe practices

An important step in raising the bar on safety in air-taxi operations is getting clients, passengers, crews, and operators not to accept unsafe practices even when there seems to be a sufficient safety margin, and to speak up to prevent them from happening. This requires strategies, promotion, and education tailored to the sector to change values, attitudes, and behaviours and create a culture where unsafe practices are considered unacceptable.

Therefore, the Board recommends that

> the Department of Transport collaborate with industry associations to develop strategies, education products, and tools to help air-taxi operators and their clients eliminate the acceptance of unsafe practices.
>
> **TSB Recommendation A19-02**

Promoting proactive safety management processes and a positive safety culture

Many operators belong to a variety of associations, such as the Air Transport Association of Canada (ATAC), the Helicopter Association of Canada (HAC), the Association Québécoise du Transport Aérien (AQTA), the Floatplane Operators Association (FOA), and the Northern Air Transport Association (NATA). Such associations are well positioned to influence safety within the sector and can provide a venue for sharing best practices, tools, and safety data specific to air-taxi operations. They can also provide assistance and training in implementing proactive safety management that incorporates a positive safety culture.

Therefore, the Board recommends that

> industry associations (e.g., ATAC, HAC, AQTA, FOA, NATA) promote proactive safety management processes and safety culture with air-taxi operators to address the safety deficiencies identified in this safety issue investigation through training and sharing of best practices, tools, and safety data specific to air-taxi operations.
>
> **TSB Recommendation A19-03**

Closing gaps in the air-taxi regulatory framework

Some operators interviewed for this SII identified gaps in the existing regulations and standards, and some operators recommended practices that go beyond the current regulatory requirements or that include concepts that are not yet addressed by regulations. For example, some operators carry out all flights under instrument flight rules, use 2 pilots for all operations, or establish their own minimum requirements for pilot flight experience.

However, in the face of competing pressures, operators may choose to simply comply with the existing regulations even though going beyond the regulations would increase safety pressure. For example, they may limit training expenses by providing only the training required by regulation, even when specialized mountain or survivability training would mitigate risks associated with the operation.

As long as gaps, such as the ones identified in the SII, exist in the regulatory framework, there will be an uneven level of safety in the air-taxi sector.

Therefore, the Board recommends that

> the Department of Transport review the gaps identified in this safety issue investigation regarding Subpart 703 of the *Canadian Aviation Regulations* and associated standards, and update the relevant regulations and standards.
>
> **TSB Recommendation A19-04**

Collecting activity data specific to the air-taxi sector

Activity data (e.g., the number of hours flown or the number of takeoffs and landings) are used to calculate accident rates in Canada. However, activity data are collected or reported for commercial aviation as a whole, but not for particular sectors (such as air taxi) or aircraft types (such as floatplanes or helicopters). Without hours-flown and movement data that are categorized by CARs subpart and aircraft type, it will be more difficult for stakeholders in the air-taxi sector to assess risks and determine if mitigation strategies being carried out to improve safety are actually working.

Therefore, the Board recommends that

> the Department of Transport require all commercial operators to collect and report hours flown and movement data for their aircraft by *Canadian Aviation Regulations* subpart and aircraft type, and that the Department of Transport publish those data.
>
> **TSB Recommendation A19-05**

Next steps for the TSB

The TSB, for its part, plans to follow up on this SII by

- communicating the highlights and conclusions of this SII to Transport Canada, air-taxi operators, industry associations, clients, passengers, and the general public;
- conducting outreach to the air-taxi sector to convey the key safety messages from this SII and help stakeholders understand their responsibility in creating a culture where unsafe practices are unacceptable and operational hazards are adequately managed; and
- monitoring air-taxi accident investigations and trends for the next 5 years and communicating these to the stakeholders through our outreach activities.

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1.0 INTRODUCTION

Air-taxi operations provide a diverse array of air services to Canadians. Helicopters transport injured or ill patients to hospitals. Floatplanes[4] take commuters from harbour to harbour in coastal cities and fly adventurers to remote lakes for hunting and fishing. Air-taxi services take workers to mines, oil-and-gas extraction sites, or hydroelectric power plants in regions without roads. They transport workers in forestry, resource exploration, construction, and power-line installation. They provide search-and-rescue services. They support commercial airline operations by bringing passengers from remote communities to larger airports for the next leg of their journey. In many remote and northern parts of Canada, air-taxi services are the only way to reach communities, with small airplanes delivering food, equipment, and passengers. These vital air links have helped build Canada and sustain its people.

1.1 Operating context

Air-taxi services operate in a wide variety of environments, and their operating context is very different from the one that is familiar to most Canadians travelling on scheduled airline operations.

Airlines offer scheduled services from airport to airport, and conduct their flights mainly in controlled airspace (i.e., airspace that is managed by air traffic control). These operations are more structured and predictable, with little variability in day-to-day operations. They have accurate weather information, sophisticated technology, and aerodromes with runways, and they receive support from dispatch and other personnel. The infrastructure and predictability of airline operations control risk to a high degree.

4 In this report, the term “floatplane” refers to any fixed-wing airplane capable of water-borne operations (this includes seaplanes).

In contrast, air-taxi services do not always operate on a set schedule, and often fly into remote areas in uncontrolled airspace with no aerodromes, runways, or navigation aids. They may not have access to current and forecast weather information or the latest technology. Pilots may not have support from dispatch (they may have to provide their own dispatch services) and other personnel.

Air-taxi operations and airline operations are both regulated under subparts of the *Canadian Aviation Regulations* (CARs), along with aerial work and commuter operations. Each type of operation is defined in the sidebar. The regulatory requirements for air-taxi operations—in areas such as training, standard operating procedures (SOPs), and on-board equipment—are less stringent than for commuter or airline operations.

At July 2018, there were approximately 500 approved air-taxi operators, 87 approved commuter operators, and 38 approved

Commercial air operations regulated under the CARs

Although air-taxi operations are diverse, they are all covered under the same regulations: Subpart 703 of the Canadian Aviation Regulations (CARs). The CARs were drafted to recognize the differences among segments of the industry, with smaller aircraft (defined by certified seating capacity) being subject to less stringent regulation. The technical definition of air-taxi operations in the CARs is as follows:

> **703.01** This Subpart applies in respect of the operation by a Canadian air operator, in an air transport service or in aerial work involving sightseeing operations, of any of the following aircraft:
>
> **(a)** a single-engined aircraft;
>
> **(b)** a multi-engined aircraft, other than a turbo-jet-powered aeroplane, that has a MCTOW [maximum certified take-off weight] of 8 618 kg (19,000 pounds) or less and a seating configuration, excluding pilot seats, of nine or less;
>
> **(b.1)** a multi-engined helicopter certified for operation by one pilot and operated under VFR [visual flight rules]; and
>
> **(c)** any aircraft that is authorized by the Minister to be operated under this Subpart.

Other commercial operations regulated under the CARs and discussed in this report are

- airline operations (Subpart 705), involving aircraft built to carry 20 or more passengers, generally used for commercial passenger flights;
- commuter operations (Subpart 704), involving aircraft built to carry 10 to 19 passengers, generally used for commercial passenger flights and on-demand charter flights; and
- aerial work (Subpart 702), involving aircraft used to perform jobs such as fighting forest fires or spraying pesticides on crops.

airline operators in Canada.[5] Operators in these three sectors operate a combined total of more than 6000 commercially registered aircraft.[6]

Air-taxi operations are exposed to more and different hazards than other types of commercial aviation operations, and their operating context has an impact on what mitigations can be put in place to manage risks at the flight, airport, and company levels.

Individual **flights** tend to be shorter, resulting in more takeoffs and landings. Aircraft are exposed to more challenging weather because they fly at lower altitudes and over rugged, coastal, or northern topography. Many flights are made under visual flight rules (VFR), flying by visual reference with the ground rather than navigating using instruments alone.

The **airports** at which these aircraft land are smaller than major airports and are often located in remote areas, with fewer services and less infrastructure. Pilots may therefore have to land at unprepared sites (especially in helicopters), on gravel airstrips, on lakes, or on frozen surfaces.

Air-taxi **operators** tend to be smaller, with fewer staff, than commuter and airline operators. Flight crews also have a more direct role in managing many of the operational risks than in other sectors: most operators use self-dispatch, and pilots often have direct contact with clients. Aircraft are smaller than those used for commuter or airline operations (seating up to 9 passengers) and, in many cases, older (some are more than 70 years old).

The nature of air-taxi operations also means that operators are subject to other pressures unique to the sector. For example:

- A company offering fly-in fishing may need to work quickly after spring ice breakup to prepare outpost camps for the opening of fishing season.
- An operator that flies passengers to and from hunting and fishing outpost camps by floatplane must watch temperatures carefully in the fall, to ensure that hunters and their game are flown out before lakes start to freeze up. Operators must also close up the outpost camps and in some cases shut down their operations for winter.
- Pilots on medical evacuation operations may feel pressure to conduct flights, which may affect their judgment. Even if pilots are not informed of the severity of patients' illness or injuries, they may draw conclusions from, for example, trauma equipment being loaded onto the aircraft.
- Companies and pilots may feel pressure to pick up a survey crew from a site before a severe storm comes in and strands the surveyors for days.

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5 Transport Canada, "Operator List Search," at https://wwwapps.tc.gc.ca/saf-sec-sur/2/CAS-SAC/olsrles.aspx?lang=eng (last accessed on 01 October 2019).

6 Transport Canada, "Canadian Civil Aircraft Register: Number of Aircraft by Category Result," at http://wwwapps.tc.gc.ca/Saf-Sec-Sur/2/CCARCS-RIACC/smACtRes.aspx?ym=201712 (last accessed on 01 October 2019).

- Pilots may pick up and drop off workers at multiple sites over the course of a day, requiring them to continually adjust their operations in light of the weather, winds, geography, schedules, equipment, and different aircraft configurations.

In addition to these challenges, companies, personnel, and aircraft involved in air-taxi operations often work in operations covered by other subparts of the CARs: aerial work, commuter operations, or airline operations. As a result, the companies must adhere to specific regulations for multiple subparts, which may create additional logistical and planning complexity.

1.2 Aircraft accident rates and numbers in Canadian aviation

A key indicator of aviation safety is the aircraft accident rate, calculated as the number of accidents per hours flown or per number of movements (takeoff or landing[7]). This rate gives an estimate of the accident risk. In the absence of rate data, the SII had access only to frequency data (for example, the number of accidents, the number of fatalities).

1.2.1 Accident rate for all Canadian-registered aircraft from 2000 to 2017

The accident rate can be calculated for all Canadian-registered aircraft, which includes commercial and privately registered aircraft, but excludes ultralight aircraft.[8] This overall accident rate provides an indication of the accident trends in Canada for all commercial and privately registered aircraft and can be calculated based on hours flown or the number of movements. This calculation was done for the years 2000–2017.

At the end of this period, in 2017, the Transportation Safety Board of Canada (TSB) recorded 198 accidents involving Canadian-registered airplanes or helicopters in Canada and abroad. This number was within 2% of the previous year's count of 194, 9% below the previous 5-year average of 217, and 14% below the previous 10-year average of 231.

Hours-flown data are collected annually for all Canadian-registered aircraft. Based on these data, Transport Canada provides an estimate of total hours flown by Canadian–registered aircraft each year in Canada and abroad. The estimate for 2017 was 4 565 000 hours, which was about 2% higher than the previous year's estimate, yielding an accident rate of **4.3 accidents per 100 000 hours flown in 2017.** Over the 18-year period between 2000 and 2017, the accident rate per 100 000 hours flown has steadily declined (Figure 1).[9]

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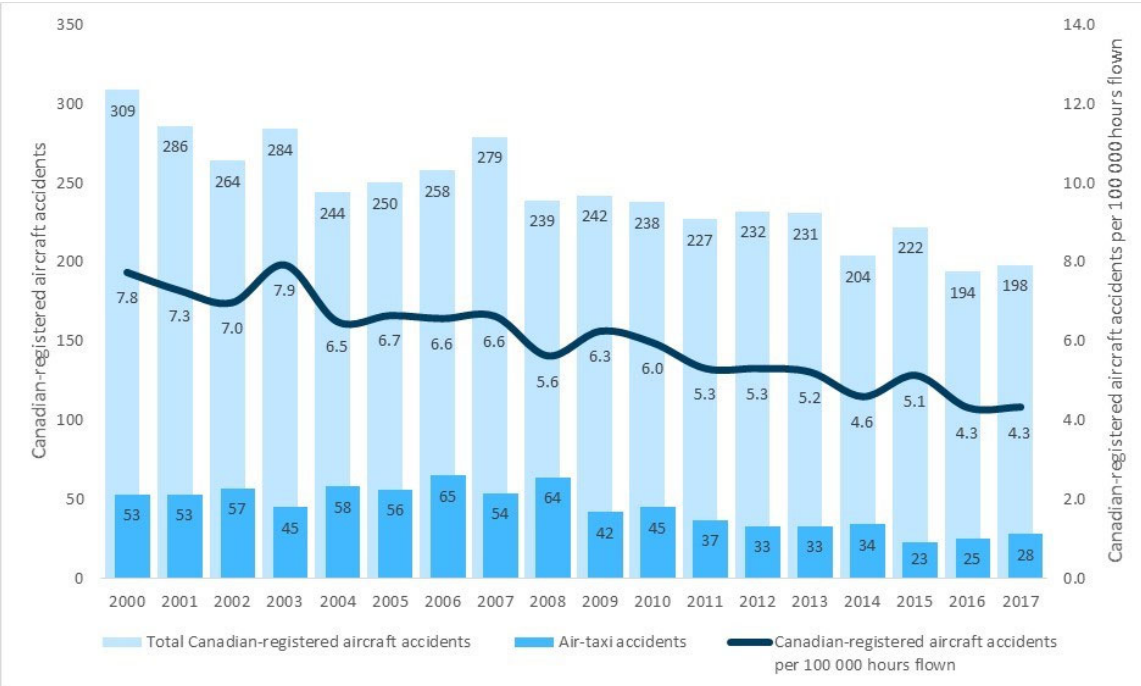
7 The International Civil Aviation Organization (ICAO) defines an aircraft movement as "an aircraft take-off or landing at an airport. For airport traffic purposes one arrival and one departure is counted as two movements." (Source: ICAO, "Glossary," at https://www.icao.int/dataplus_archive/Documents/GLOSSARY.docx [last accessed on 01 October 2019]).

8 All data in this report are for civilian aircraft only. Ultralights are excluded from all subsequent discussion in this report.

9 A Kendall's Tau-b (τ_b) correlation coefficient was calculated to determine the degree of association between year and accident rate per 100 000 hours flown over the 18-year period. There was a strong negative correlation between the variables (τ_b = -0.856, $p < 0.0001$), indicating a decrease in rate over time.

This accident rate is based on activity by all Canadian-registered aircraft, including activity outside of Canada. Because there is no activity estimate available for air-taxi operations specifically, it is not possible to determine an accident rate by hours flown for just this sector.

Figure 1. Number of accidents and accident rate for Canadian-registered aircraft per 100 000 hours flown from 2000 to 2017



Movement data are collected on all Canadian- and foreign-registered civilian aircraft operating in Canada. Based on these data, Statistics Canada estimates a total of 6 122 671 civil aircraft movements in Canada for the year 2017. (Movements of Canadian-registered aircraft outside of Canada are not included in this number.) The 2017 estimate was slightly higher than the 2016 estimate, and it lay between the averages for the previous 5 years (6 006 231) and the previous 10 years (6 217 814).

There were 195 airplane and helicopter accidents in Canada (including ones involving foreign-registered aircraft) in 2017. This number was close to the previous year's count of 196, was 11% below the 5-year average of 219, and was 17% less than the 10-year average of 234. This yielded a civil aviation accident rate for airplanes and helicopters in Canada of **3.2 accidents per 100 000 movements**.

A steady downward trend in accident rate by movements was evident over the 18-year period from 2000 to 2017 (Figure 2).[10] However, the estimates and data used to calculate the rate by movements apply to the entire commercial aviation sector; it is not possible to calculate this rate for just the air-taxi sector.

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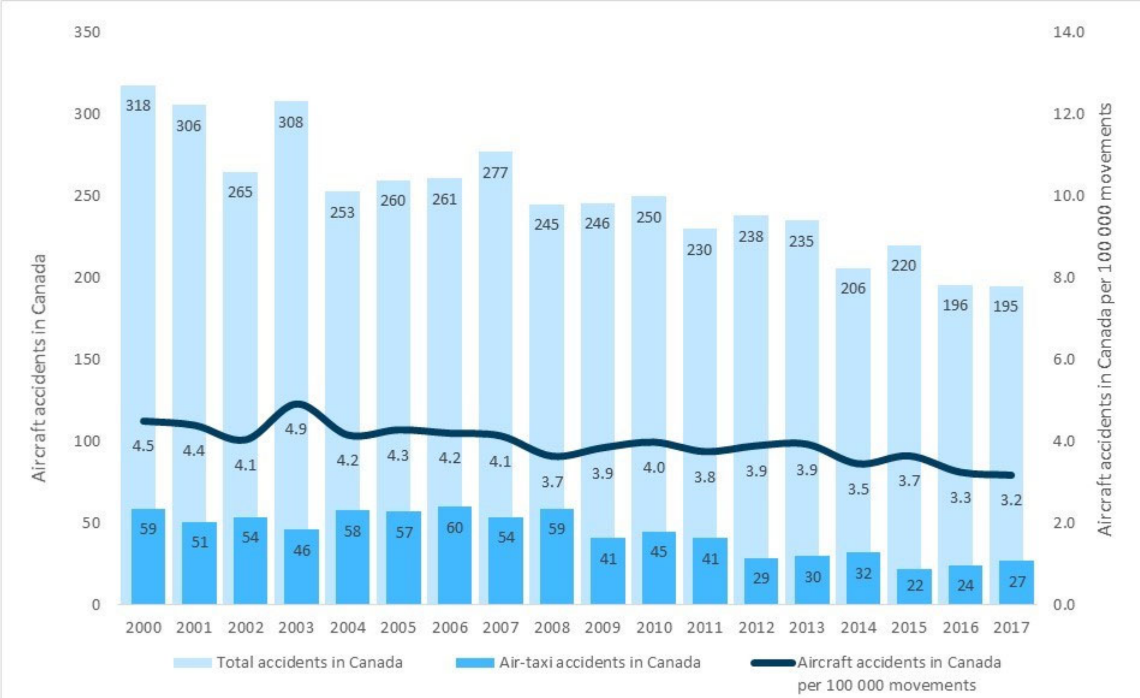
10 A Kendall's τ_b correlation coefficient was calculated to determine the degree of association between year and accident rate per 100 000 movements over the 18-year period. There was a strong, negative correlation between the variables (τ_b = -0.712, p < 0.0001), indicating a decrease in rate over time.

Figure 2. Number of accidents and accident rate for Canadian-registered and foreign aircraft in Canada per 100 000 movements from 2000 to 2017



Whether rates are calculated for Canadian-registered aircraft operating inside and outside Canada in terms of hours flown, or Canadian- and foreign-registered aircraft operating in Canada in terms of movements, in both cases there has been a steady decline in accident rates over the last 18 years.

1.2.2 Accident numbers for the air-taxi sector from 2000 to 2017

The accident rate cannot be calculated for just the air-taxi sector, whether by hours flown or by number of movements, because this information is not collected by CARs subpart.[11]

Although activity data are not available to determine the accident rate for just the air-taxi sector, there has been a downward trend in the total *number* of air-taxi accidents over the 18-year period from 2000 to 2017,[12] particularly after 2008. This is consistent with the decline observed for all Canadian-registered aircraft (see **Section 1.2.1 Accident rate for all Canadian-registered aircraft from 2000 to 2017**).

However, in spite of the downward trend in the *total* number of accidents, the numbers of *fatal* accidents and fatalities have not shown significant downward trends[13,14] (Figure 3).

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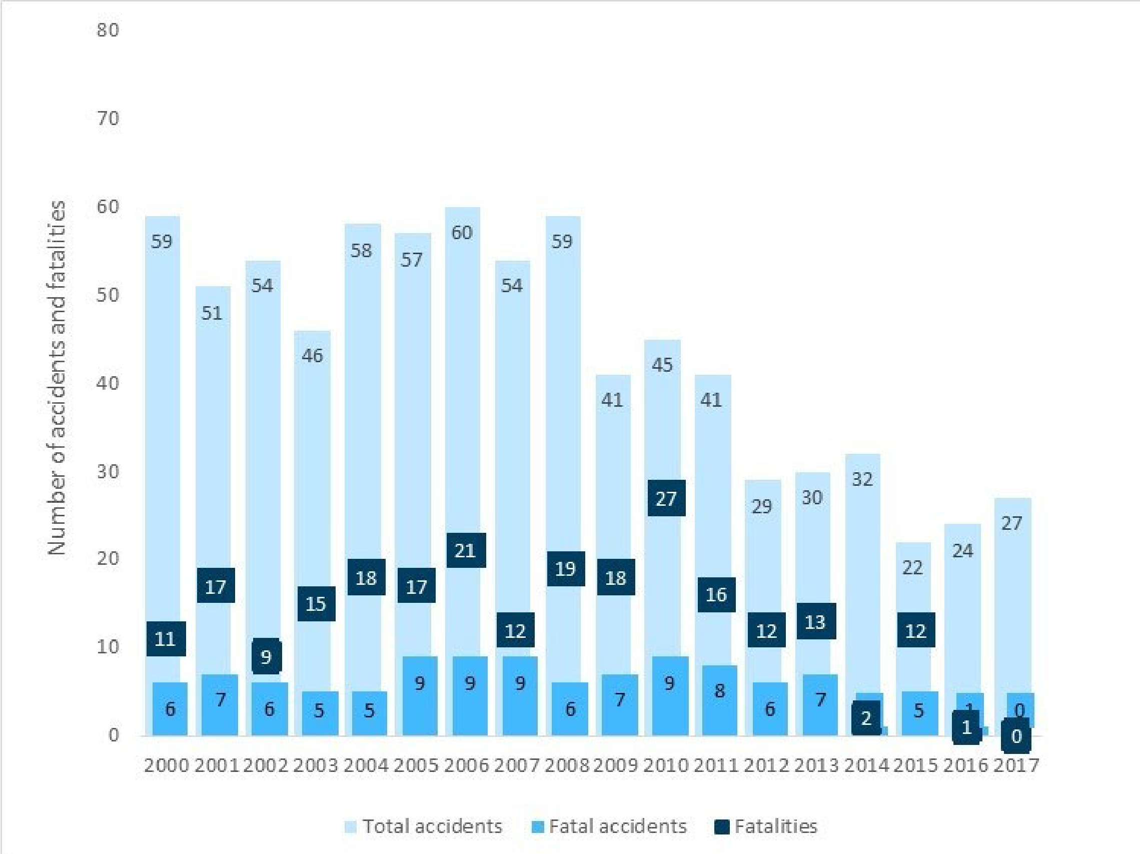
11 Under existing Transport Canada reporting requirements, operators submit the hours flown per aircraft on an annual basis. Some operators hold multiple air operator certificates and use the same aircraft to operate under various CARs subparts. Therefore, the SII could not use hours flown by a specific aircraft to determine the type of operation performed.

12 For the total number of air-taxi accidents in Canada from 2000 to 2017, the Kendall's τ_b is -0.620, and p is 0.0004.

13 For the count of fatal accidents over the period from 2000 to 2017, the Kendall's τ_b is -0.293, and p is 0.1050.

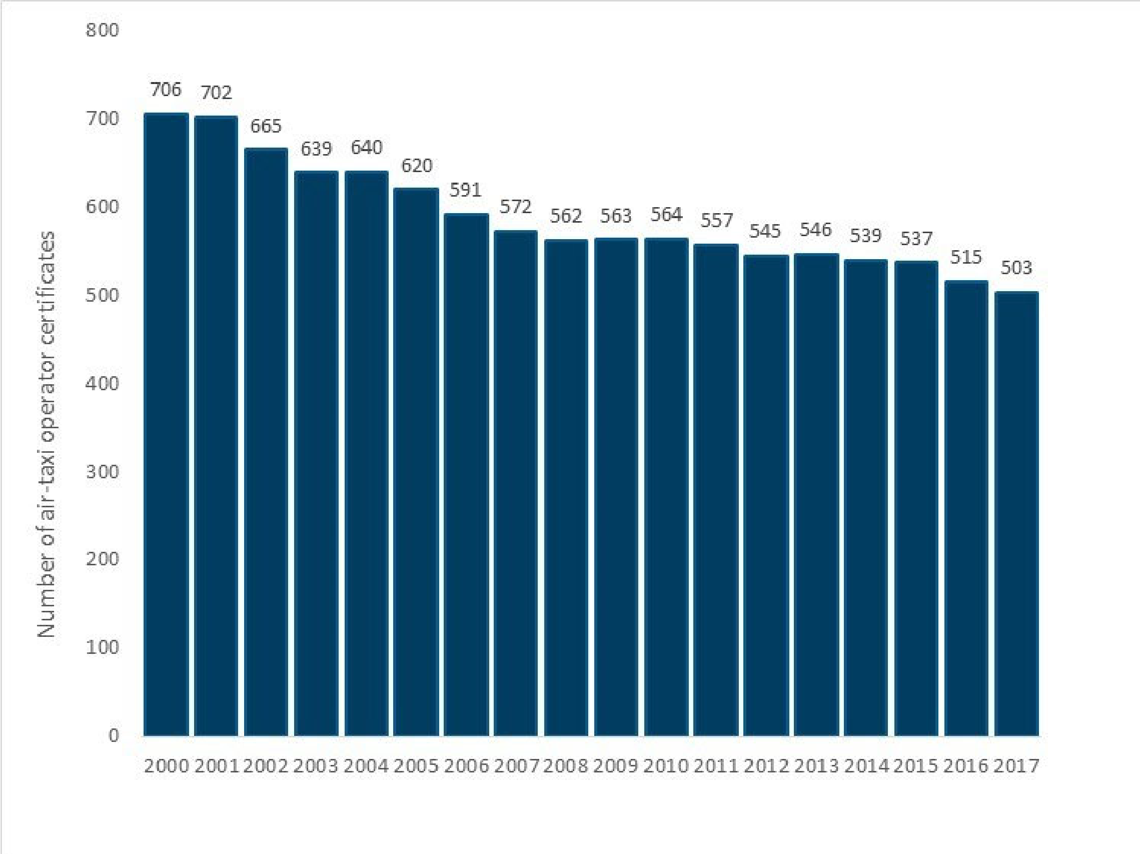
14 For the count of fatalities over the period from 2000 to 2017, the Kendall's τ_b is -0.266, and p is 0.1282.

Figure 3. Total accidents, fatal accidents, and fatalities in air-taxi operations, 2000 to 2017



A decline in the number of air-taxi air operator certificates over the period 2000–2017 was also observed (Figure 4). The number of air operator certificates can be interpreted as an indication of activity in the sector, showing that the number of air-taxi operators has been decreasing over time. However, without air-taxi–specific hours flown or movement data, it is not possible to understand what factors are contributing statistically to the overall decline observed.

Figure 4. Air operator certificates for air-taxi operators in Canada, 2000 to 2017

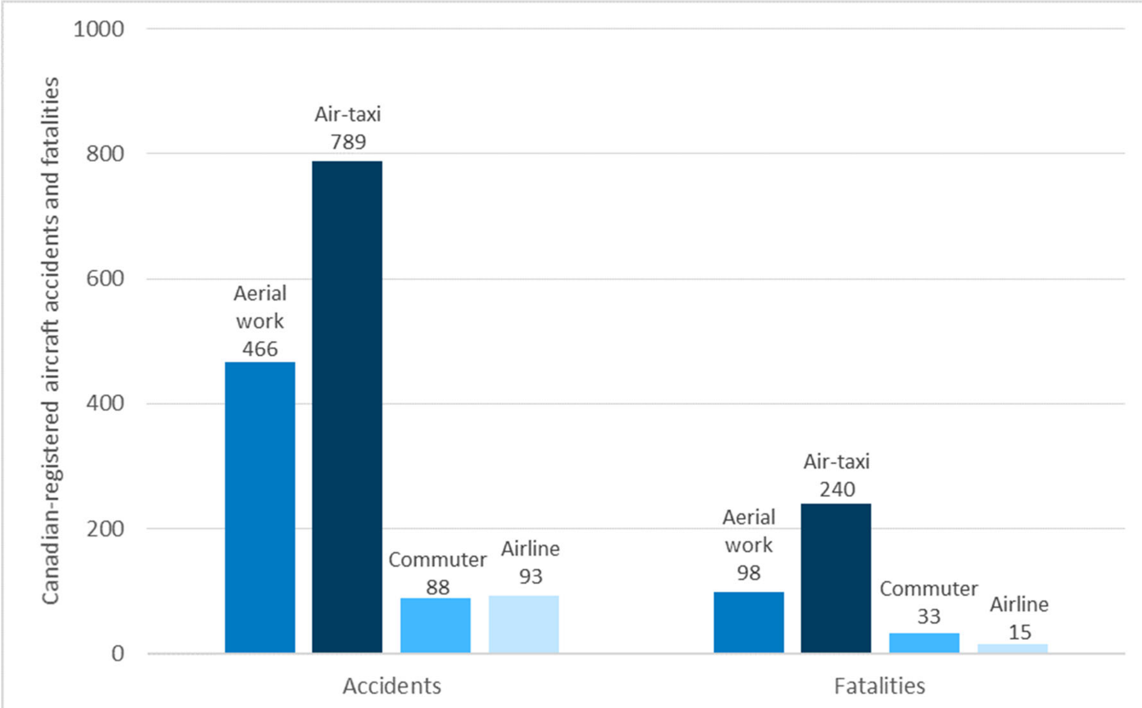


1.3 A sector of concern

Safety in the air-taxi sector has been the subject of concern, as well as numerous studies and reviews (Appendix A), for over 27 years. It is a challenging sector of commercial aviation, given its operating context, and it experiences a high number of accidents, especially fatal accidents.

In the 18-year period from 01 January 2000 to 31 December 2017, there were 789 air-taxi accidents resulting in 240 fatalities. This total represented 55% of all accidents in commercial air services in Canada and 62% of the fatalities in this period. In contrast, there were 93 accidents in airline operations in Canada (6% of the total) and 15 fatalities (4% of the total) in the same period (Figure 5).

Figure 5. Total number of accidents and fatalities involving Canadian-registered aircraft by operator type, 2000 to 2017



1.4 The human and economic costs of accidents

Apart from the obvious human costs—death and injury to the people involved in an accident (e.g., passengers, crew, bystanders)—the economic costs can be significant and include the following:

- physical damage to the aircraft
- loss of use of the aircraft
- cleanup of contaminated accident sites
- costs associated with flight delay or cancellation
- airport closure or disruption
- loss of baggage and cargo
- search-and-rescue costs
- cost of immediate company response to the accident
- cost of accident investigations by governments, operators, manufacturers, and others
- insurance payments and litigation
- increased cost of insurance
- loss of the operator's, the manufacturer's, or the industry's reputation
- loss of existing contracts or future business for the operator

With the air-taxi sector's high number of fatal accidents, the human and economic costs of such accidents are high. Many accidents and deaths in air-taxi operations are **preventable**, and many accidents occur as the result of **repeated**, **persistent hazards and risks**. These hazards and risks have been the subject of multiple reviews and recommendations calling for mitigation measures, and yet they continue to lead to accidents. Although the number of accidents has generally been reduced, these hazards and risks have continued to exist for decades, in spite of improvements in knowledge, technology, and practices available to mitigate them.

1.5 The safety issue investigation

In light of the accident data and the persistent, repeated hazards and risks present in the air-taxi sector, the TSB began a safety issue investigation (SII) in May 2015. SIIs are conducted when there is

> a series of occurrences with common characteristics that have formed a pattern over a period of time. This pattern is made of one or more significant safety risks previously identified by the TSB or organizations in other jurisdictions in the course of their investigations, or of an issue of interest that has emerged from statistical analysis.[15]

The purpose of this SII was to understand the hazards and risk factors associated with air-taxi operations in Canada, not just factors that were relevant to one specific segment (such as helicopter operations or floatplane operations). It included a review of the literature (previous studies and TSB recommendations), an analysis of TSB occurrence data, and consultation with industry to gather qualitative data.

With information from all of these sources, the aim was to answer the following questions:

- What are the hazards and risk factors associated with air-taxi operations, recognizing that the operating context is contributory to accidents?
- How are hazards and risk factors being managed?
- What additional mitigations are needed to improve the safety of air-taxi operations?

The intent of the SII was to identify any underlying systemic safety issues that need to be addressed, so that action can be taken to reduce the persistent risks in air-taxi operations across Canada.

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15 Transportation Safety Board of Canada, *Policy on Occurrence Classification*, Appendix B, at http://www.tsb.gc.ca/eng/lois-acts/evenements-occurrences.html (last accessed on 01 October 2019).

2.0 A HISTORY OF CONCERN

2.1 Previous studies of safety in air-taxi operations

At least 17 previous studies have sought to identify and provide insight into the hazards and risks affecting the air-taxi sector. Studies have been conducted by organizations such as Transport Canada (TC), the Transportation Safety Board of Canada (TSB), the U.S. Federal Aviation Administration, the Chief Coroner of British Columbia, and several Canadian federal government organizations and bodies. A detailed list of these studies can be found in Appendix A.

Given that each study was carried out by a group or organization with a particular area of concern, the complete list of identified issues is lengthy: there are dozens of issues, ranging from the general (cultures and attitudes within the Canadian air-taxi sector), to the slightly more specific (night visual flight rules flight), to the extremely specific (post-crash survival of civilian work-related aircraft crashes in Alaska from 2004 to 2009). Such a long list is probably to be expected, especially given the varied aircraft, personnel, topography, and operational requirements found in this sector. At the same time, there is commonality: a much smaller list of issues—11 in total—that turn up in multiple studies:

- decision making and human factors
- training
- weather
- limitations in aircraft equipment
- pilot skills
- loss of visual reference
- pilot or occupant survivability
- the transition to safety management systems
- TC oversight
- infrastructure and funding
- operational pressures

2.2 Active TSB recommendations

Of the TSB's 37 active aviation safety recommendations, 22 are applicable to air-taxi operations in Canada (Appendix B).[16] One of these recommendations is more than 20 years old.

Table 1 shows a breakdown of the TSB's active recommendations that apply to air-taxi operations, and how long they have been active.

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[16] This was the number of active recommendations at 26 April 2019.

Table 1. Active TSB recommendations applicable to air-taxi operations in Canada

Length of time active	Number of recommendations
Less than 8 years	21
More than 20 years	1
Total	22

2.3 TSB Watchlist

The TSB Watchlist identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. The issues on the 2018 Watchlist are supported by a combination of findings from investigation reports, Board safety concerns, and Board recommendations. Some of these issues have been on the Watchlist since 2010, and others were added to the list for the first time in 2018. All of these issues, however, require a concerted effort from the regulator and industry stakeholders for improvements to be achieved.

Table 2 lists 5 key safety issues on the 2018 Watchlist that are relevant to all air operations in Canada.

Table 2. Safety issues on the 2018 Watchlist: why they matter and action required

Issue	The situation	Actions required
Risk of collisions from runway incursions	• Runway incursions lead to an ongoing risk of aircraft colliding with vehicles or other aircraft at Canadian airports. • Every year, there are millions of successful takeoffs and landings on Canadian runways. However, an accident can occur when an aircraft or vehicle mistakenly occupies an active runway.	This issue will remain on the TSB Watchlist until: • the rate of runway incursions, particularly the most severe ones, demonstrates a sustained reduction; • TC and all sectors of the aviation industry collaborate and develop tailored solutions to identified hazards at Canadian airports; and • modern technical solutions, such as in-cockpit electronic situational awareness aids, and direct-to-pilot warnings, such as runway status lights, are also implemented.
Runway overruns	• Despite the millions of successful movements on Canadian runways each year, runway overrun accidents sometimes occur during landings or rejected takeoffs. In fact, since 2013, there have been an average of 9 overrun accidents and incidents annually. These can result in aircraft damage, injuries, and even loss of life—and the consequences can be particularly serious when there is no adequate runway end safety area (RESA) or suitable arresting material.	This issue will remain on the TSB Watchlist until: • operators of airports with runways longer than 1800 m conduct formal runway-specific risk assessments and take appropriate action to mitigate risks of overrun to people, property, and the environment; and • TC adopts at least the International Civil Aviation Organization (ICAO) standard for RESAs, or a means of stopping aircraft that provides an equivalent level of safety.

Issue	The situation	Actions required
	• There has been some progress since this issue was first included on the Watchlist in 2010. In 2016, TC published a proposal to introduce measures to address the risk of runway overruns at selected airports. However, the TSB remains concerned that these measures will not fully address the underlying safety deficiency that gave rise to its recommendation on RESAs.	
Safety management and oversight	• Some transportation operators are not managing their safety risks effectively, and many companies are still not required to have formal safety management processes in place. TC's oversight and intervention are not always effective at changing unsafe operating practices. • All transportation companies are responsible for managing safety risks in their operations.	This issue will remain on the Watchlist until: • TC implements regulations requiring all commercial operators in the air and marine industries to have formal safety management processes, and effectively oversees these processes; • transportation operators that do have a safety management system (SMS) demonstrate to Transport Canada that it is working—that hazards are being identified and effective risk-mitigation measures are being implemented; and • TC not only intervenes when operators are unable to manage safety effectively, but does so in a way that succeeds in changing unsafe operating practices.
Slow progress on addressing TSB recommendations	• Actions taken to fix long-standing, high-risk safety deficiencies in the air, marine, and rail modes of transportation have been too few and too slow.	This issue will remain on the Watchlist until: • TC takes the actions needed to reduce the number of active recommendations that are more than 10 years old so that all recommendations that would bring Canada in line with international standards are addressed, and so that there is a marked reduction in the remaining outstanding recommendations for which the regulator has indicated its agreement; • change agents targeted by the existing 28 dormant recommendations demonstrate to the TSB that the residual risk has been reduced to an acceptable level so that these recommendations can be closed; and • the Government of Canada reviews and improves interdepartmental processes for expedited implementation of safety

Issue	The situation	Actions required
		recommendations in the air, rail, and marine modes of transportation.
Fatigue management in rail, marine, and air transportation	• In the transportation industry, crews often work long and irregular schedules—sometimes in challenging conditions or crossing multiple time zones—that are not always conducive to proper restorative sleep. Fatigue poses a risk to the safety of freight-train, marine, and air operations because of its potential to degrade several aspects of human performance. • Fatigue can impact human performance in ways that can lead to accidents. This is why the TSB routinely investigates whether fatigue was present in an occurrence, whether it played a role, and whether the operator had practices in place to effectively manage the associated risks.	This issue will remain on the TSB Watchlist until: • TC publishes revised flight and duty-time limitation regulations;* and • where required, Canadian air operators implement fatigue risk-management systems to address fatigue-related risks specific to their operation.

* Government of Canada, *Canada Gazette,* Part II, Vol. 152, No. 25 (07 December 2018), Regulations Amending the *Canadian Aviation Regulations* (Parts I, VI and VII — Flight Crew Member Hours of Work and Rest Periods).

3.0 METHODS

3.1 Sources of data

Both quantitative and qualitative data were collected and analyzed for this safety issue investigation (SII).

For the purposes of the analysis, the Transportation Safety Board of Canada (TSB) data were restricted to the years 2000 to 2014—referred to as the "study period"—to ensure that only closed investigations and published investigation reports were used. The data provided in **Section 1.2 Aircraft accident rates and numbers in Canadian aviation** of this report were updated to cover the years 2000 to 2017 for the purpose of understanding the overall trends in Canada.

The qualitative analysis was performed using a grounded theory study[17] and the constant comparative method of data analysis.[18]

Table 3 summarizes the data sources, study period, the general analysis procedure, and the qualitative analysis process.

Table 3. Data sources, study period, and procedures and process for analyzing the data

Data description and study period	General analysis procedure and sample size	Qualitative analysis process
Air-taxi accidents reported to the TSB from 2000 to 2014	• Trend analysis of accident and fatal accident frequencies and International Civil Aviation Organization occurrence categories (N = 716) • Qualitative analysis of TSB investigation report content using grounded theory (N = 167)* • Quantitative analysis using accident type categories generated as part of this SII (N = 716)	• Qualitative analysis consisted of a review of published investigation reports. • Published investigation reports were coded by the SII team and information was cross-compared using the constant comparative method of data analysis until accident types with descriptions emerged.**
Data derived from interviews with air-taxi operators and Transport Canada (TC) inspectors	• Qualitative analysis of summary transcripts (N = approximately 300 hours of audio from 125 interviews with 32 operators and the regulator), generating safety themes	• Qualitative analysis consisted of a review of summary transcripts from the interviews. • The summary transcripts were coded by the SII team, and the information was cross-compared using the constant comparative

17 Grounded theory is "a qualitative research design in which the inquirer generates a general explanation (a theory) of a process, action, or interaction shaped by the views of a large number of participants." (Source: J. Corbin and A. Strauss, B*asics of Qualitative Research Techniques and Procedures for Developing Grounded Theory*, 4th Edition [Sage Publications, 2015], p. 6.)

18 In grounded theory research, the constant comparative method of data analysis "refers to the researcher identifying incidents, events, and activities and constantly comparing them to an emerging category to develop and saturate the category." (Source: J. W. Creswell, *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*, 2nd Edition [Sage Publications, 2007], p. 238.)

Data description and study period	General analysis procedure and sample size	Qualitative analysis process
		method of data analysis until safety themes with descriptions emerged.
Both data sets analyzed in an integrated method	• Qualitative analysis integrating accident-type underlying factors and safety-theme underlying factors to identify the best approach for raising the bar on safety and improving the safety of air-taxi operations	• Qualitative analysis consisted of a review of accident types with descriptions, findings and recommendations from published investigation reports, relevant safety studies, relevant safety literature, and the safety themes. • These sources, using the 19 safety themes as the primary source, were cross-compared using the constant comparative method of data analysis until 3 higher-level pressures emerged. • The 3 higher-level pressures were mapped to the safe operating envelope model. The safe operating envelope model is a dynamic risk management model originally described by Rasmussen in 1997 to explain the structure and function of systems like the air taxi sector.***

* All but 5 of the 167 investigation reports were categorized as "accidents"; the 5 "incidents" with published investigation reports were included so that the SII team could understand the causal and contributing factors in risks of collision or mid-air collisions. The 5 incidents were not included in the quantitative analysis, which covered only accidents. The information from the published TSB reports was used to generate the accident-type categories.

** J. W. Creswell, *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*, 2nd Edition (Sage Publications, 2007), pp. 64-68.

*** D. D. Woods, J. Schenk, and T. T. Allen, "An Initial Comparison of Selected Models of System Resilience," in: C.P. Nemeth, E. Hollnagel and S. Dekker (eds.), *Resilience Engineering Perspectives, Volume 2: Preparation and Restoration* (CRC Press, 2009), p. 78; and J. Rasmussen, "Risk Management in a Dynamic Society: A Modelling Problem", *Safety Science*, Vol. 27, No. 2/3 (1997), pp. 183–213.

Sections 3.2, 3.3, and 3.4 of this report provide more details on how the data from each phase of the SII were analyzed.

3.2 TSB occurrence data and published investigation reports

3.2.1 Occurrence data

Phase 1 of this SII consisted of an analysis of data on all accidents that occurred during air-taxi operations and were reported to the TSB from 01 January 2000 to 31 December 2014. This 15-year period was selected to provide a large enough window to show trends and to ensure that any associated investigation reports had been published. The data set, which was extracted from the TSB's Aviation Safety Information System (ASIS), contained 716 accidents. Data from these accidents were tabulated and examined to determine whether there were any trends, anomalies, or areas of interest in relation to the following factors:

- year of occurrence
- fatal versus non-fatal accidents
- number of fatalities
- aircraft type (i.e., airplane or helicopter)
- International Civil Aviation Organization aviation occurrence category (see **Section 4.1.2.1 Airplanes**)

3.2.2 Review of published investigation reports

The TSB published investigation reports for 162 of the 716 air-taxi accidents and for 5 air-taxi incidents in the study period, making a total of 167 reports.[19] These reports were analyzed for common hazards; findings as to cause, contributing factors, and risk; and recommendations. Information from the reports was cross-compared and iteratively sorted into descriptive accident types. The following questions guided the analysis:

- What unsafe acts and conditions[20] caused and contributed to accidents?
- How are these unsafe acts and conditions being managed or mismanaged?
- What mitigations are involved in managing associated hazards and risk factors?
- Are there patterns of factors for given accident types?
- Are there patterns of factors for fatal accidents?

The descriptions and explanations of each accident type were developed and refined, resulting in an accident type and a description for each category. This approach is called a grounded theory study. The constant comparative method of data analysis was used.[21]

The remaining air-taxi accidents (554 reported accidents for which no investigation report was published) were then sorted into the accident types generated in the SII using the limited information available in the occurrence summaries in ASIS.[22]

The identified patterns of hazards that contributed to certain types of accidents gave weight to the Board's concern about the higher incidence of accidents in air-taxi operations than in

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[19] More than 1000 air transportation occurrences are reported to the TSB each year, in accordance with its mandatory reporting requirements. The primary criterion for classifying an occurrence is the potential for new safety lessons to be learned. For more information, see the TSB *Policy on Occurrence Classification,* at http://www.bst-tsb.gc.ca/eng/lois-acts/evenements-occurrences.html (last accessed on 01 October 2019).

[20] An unsafe condition is a situation or condition that has the potential to initiate, make worse, or otherwise bring about an undesired event. An unsafe act is an error (slip, lapse, or mistake) or deliberate deviation from prescribed operating procedures that, in the presence of a possible unsafe condition, leads to an occurrence or creates the potential for an occurrence to happen.

[21] J. W. Creswell, Qualitative Inquiry and Research Design: Choosing Among Five Approaches, 2nd Edition (Sage Publications, 2007), p. 64.

[22] As shown in **Section 4.1 Information from TSB occurrence data and published investigation reports**, the "Other" category is large. This is because information for the occurrences that were not the subject of a full investigation is limited to what is available in ASIS.

airline, commuter, and aerial work operations. The context of the operation (e.g., helicopter flying under visual flight rules into instrument meteorological conditions, fixed-wing aircraft where coordination was required among crew members, floatplane operating overweight) was the dominant factor that emerged in each accident type. However, more than accident-report information was needed to validate the hazards and risk factors, explain the underlying safety issues, discover the mitigations in place, and identify the mitigations needed. The TSB wanted to find out what was going on in the industry.

3.3 Information from consultations with industry

In Phase 2 of the SII, operators in the air-taxi industry were invited to participate in an email survey and in guided interviews. The survey and the interviews were used to validate the results of the analysis in Phase 1 of the SII, as well as to augment the information on hazards, mitigations currently in place, and mitigations needed in the air-taxi sector.

3.3.1 Survey

When the SII was begun (May 2015), approximately 550 companies held an air operator certificate for air-taxi operations in Canada. In March 2016, a 4-question survey on safety issues was sent to 524 confirmed email addresses representing a large portion of the air operator certificate holders. However, the response rate was low: less than 2%. The reason for such a low response rate could not be determined. The limited information collected through the survey was included in the analysis of interview transcripts as additional information, but did not provide the core data for the study.

3.3.2 Interviews

3.3.2.1 Operator interviews

All 550 air-taxi operators whose email addresses were valid and who were available were invited to participate in the interviews. The operators interviewed were selected following a stratified, purposeful sampling strategy,[23] which also included maximum-variation[24] and theory-based[25] strategies.

Purposeful sampling strategies are used in qualitative research to inform an understanding of the research problem or phenomenon being investigated (in this case, the hazards and risks present in air-taxi operations in Canada). Such a strategy is used not only to select the sample but also in the analysis.

The factors used in the sampling strategy were derived from the analysis of the TSB investigation reports:

- geographic distribution across Canada

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[23] The purposeful sampling strategy selects subgroups and facilitates comparisons.

[24] The maximum variation strategy documents diverse variations and identifies important common patterns.

[25] A theory-based strategy finds examples of a theoretical construct and thereby elaborates on and examines the construct.

- fixed-wing (airplane) and rotary-wing (helicopter) operations
- single-pilot and multi-crew operations
- specialty operations (floatplane, medical evacuation [MEDEVAC])

The purposeful sampling strategy was used to achieve "saturation" in the areas identified as important and contributory from this analysis. Saturation of description or explanation is considered reached when similar instances are seen over and over again, and no new information that would yield new properties is found. Such saturation is a "stop rule" in qualitative analysis; that is, when saturation is reached, data gathering and analysis stops.[26]

A total of 119 people from 32 operators were interviewed. Individuals within an operator were invited to participate.

The participating operators had fleets ranging in size from 1 to more than 40 aircraft. Some operators held air operating certificates under only Subpart 703 of the *Canadian Aviation Regulations* (CARs), while others held air operating certificates under more than one subpart (702, 703, 704, or 705).

Interviews were conducted with personnel working at all levels of the companies in various capacities and in various kinds of operations:

- single-pilot and multi-crew
- airplane, floatplane, and helicopter
- visual flight rules and instrument flight rules
- MEDEVAC

3.3.2.2 Regulator interviews

In addition to personnel from the operators, 6 civil aviation inspectors from Transport Canada (TC) headquarters and regional offices were interviewed. The list of inspectors was supplied by TC.

3.3.2.3 Interview questions and summary

A standard interview questionnaire guided the interviews and covered

- the type of operational flying carried out by the company;
- the factors posing the highest risk to safety;
- the key accident types identified in Phase 1 of the SII;
- mitigations in place; and
- mitigations needed.

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26 J. W. Creswell, *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*, 2nd Edition (Sage Publications, 2007), pp. 126–127.

The interviews yielded approximately 300 recorded hours of interview data. Summary transcripts were made of each interview and analyzed for common hazards, accident types, mitigations in place, and mitigations needed. Information from the interview transcripts was cross-compared and iteratively sorted into safety issues.[27]

The summary transcripts were analyzed using a grounded theory study using the constant comparative method of data analysis.[28] First, the summary transcripts were analyzed using exploratory coding.[29] As the description or explanation began to develop, the remaining summary transcripts were analyzed until the safety themes "matured," and it appeared that saturation (or near saturation) had been reached. At this point, the safety themes were written up and presented to subject-matter experts, who refined the safety theme descriptions given their experience in the sector. The process was time-consuming and thorough, and it yielded deeper understanding of complex phenomena in which interrelationships among factors typically prevent traditional numerical analysis.

3.4 Making sense of the data

The safety themes that emerged from this process (19 in total) were selected as the primary source of information for cross-comparison. The results of the literature review and findings and recommendations from published accident investigation reports, as well as previous safety studies, were added to these safety themes. The augmented safety themes were further cross-compared using the constant comparative method of data analysis.

From this cross-comparative analysis, 3 groups of themes, which were labelled "pressures," emerged.

These pressures were then mapped to the safe operating envelope model, which is a theoretical explanation for how systems like the air-taxi sector are structured and how they function. This model made it possible to further refine a theory to explain the hazards and risk factors persisting in air taxi operations in Canada.

Section 4.1 Information from TSB occurrence data and published investigation reports of this report describes the results of the analysis of the TSB data. **Section 4.2 Information from consultations with industry** summarizes the qualitative data gathered from interviews with air-taxi operators. **Section 5.0 Discussion** discusses the results of the data analysis from **Section 4.0 Information gathered during the investigation**. The

27 The TSB defines "safety issue" as "an issue encompassing one event or linked events that has or have the potential to lead to the identification of safety deficiencies." (Source: Transportation Safety Board of Canada, *ISIM Reference Manual – Air*, section 4.4: Substantiation of Safety Issues).

28 J. W. Creswell, Qualitative Inquiry and Research Design: Choosing Among Five Approaches, 2nd Edition (Sage Publications, 2007), p. 64.

29 Exploratory coding is a process that makes use of the constant comparison method of the grounded theory (see **Appendix C – Grounded theory procedure**).

results are discussed in **Section 5.3 Information from Phase 1 and Phase 2**, in which the synthesized data are used to model operations in the air taxi sector as a whole using an adaptation of the Cook and Rasmussen safe operating envelope model.[30] **Section 6.0 Conclusion** summarizes what was learned in this SII and highlights the actions required to improve safety in the air-taxi sector.

30 Adapted from Cook and Rasmussen (2005) in D. Woods, J. Schenk, and T. T. Allen, "An initial comparison of selected models of system resilience," in: C.P. Nemeth, E. Hollnagel and S. Dekker (eds.), *Resilience Engineering Perspectives, Volume 2: Preparation and Restoration* (Boca Raton, FL: CRC Press, 2009), p. 78.

4.0 INFORMATION GATHERED DURING THE INVESTIGATION

4.1 Information from TSB occurrence data and published investigation reports

4.1.1 Data for the study period 2000–2014

From 2000 to 2014, there were 716 accidents involving air-taxi operations.[31] Of these 716 accidents, 100 were fatal, resulting in the deaths of 227 people (93 crew members, 133 passengers, and 1 person on the ground) and serious injuries to another 150 people (47 crew members, 99 passengers, and 4 people on the ground).

There was a downward trend in the *total* number of air-taxi accidents during the study period (Figure 6).[32,33] However, unlike the *total* number of accidents, there was no declining trend in the number of *fatal* accidents or fatalities over the study period.[34]

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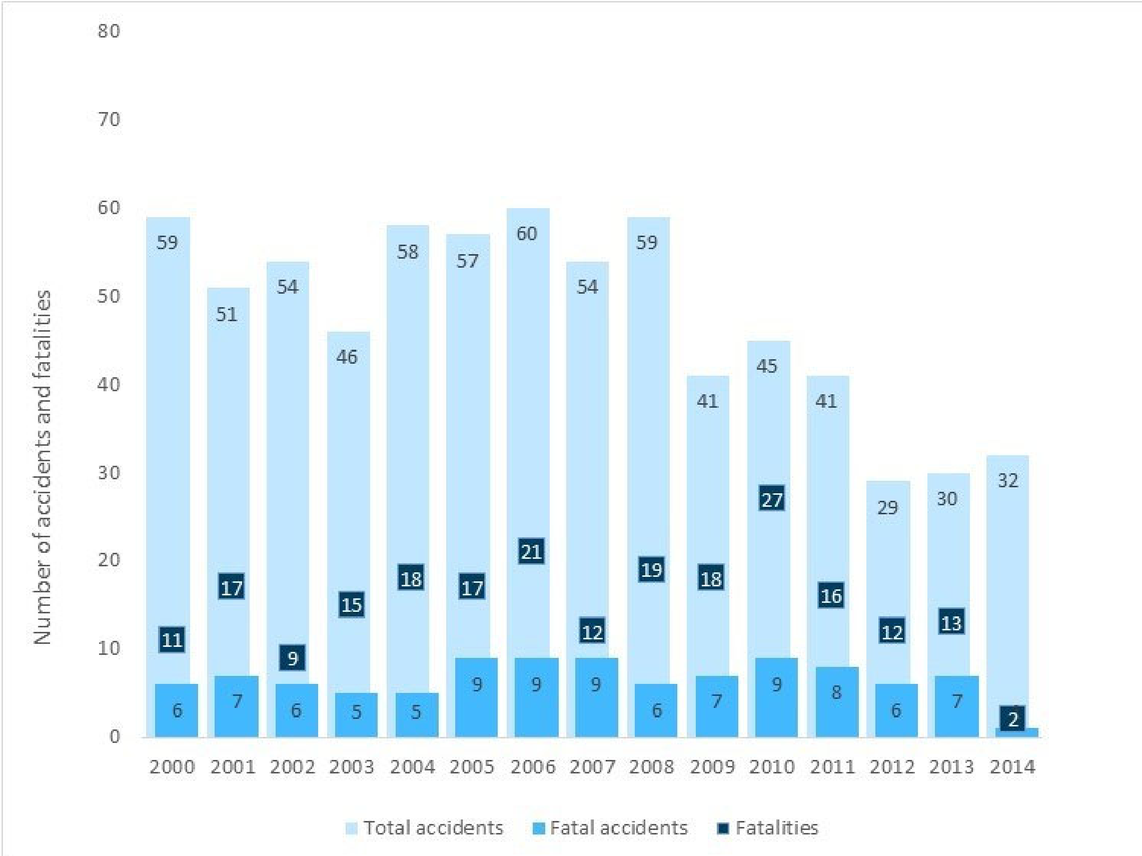
31 Canadian-registered aircraft only.

32 A Kendall's Tau-b (τ_b) correlation coefficient was calculated to determine the relationship between year and number of accidents over the 15-year period. There was a negative correlation between the variables (τ_b = -0.502, p = 0.0098), indicating a decrease in rate over time.

33 An accident rate (i.e., accidents per 100 000 hours flown) could not be calculated for this sector specifically, because data on hours flown are not broken down by CARs subpart.

34 For the number of fatal accidents by year from 2000 to 2014, Kendall's τ_b = 0.010, p = 0.9594; for the number of fatalities by year from 2000 to 2014, Kendall's τ_b = 0.000, p = 1.0000.

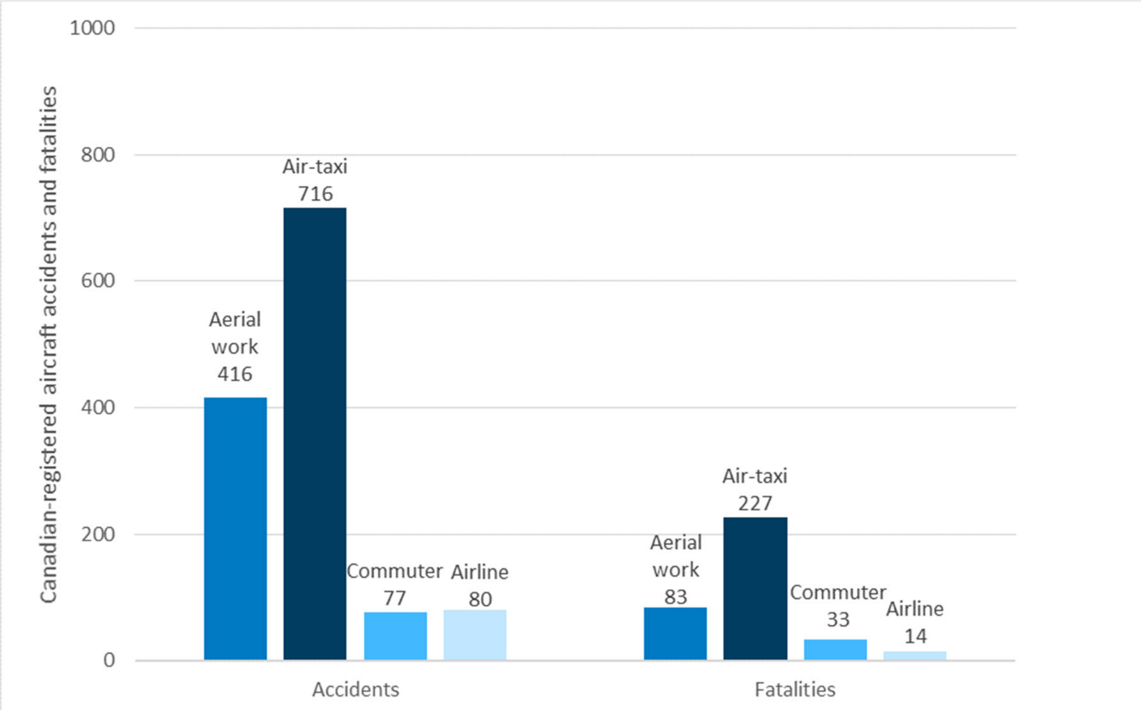
Figure 6. Total number of accidents, fatal accidents, and fatalities in the air-taxi sector over the study period, 2000–2014



The Transportation Safety Board of Canada (TSB) recorded an average of 6.7 fatal air-taxi accidents per year in this 15-year study period, with an average of 15.1 fatalities per year.

Accidents in the air-taxi sector represented 56% of all commercial air services accidents in Canada and 64% of the fatalities in the 15-year study period. By comparison, airline operations in Canada experienced few accidents (80 or 28% of the total) or fatalities (14 or 4%) in the same period (Figure 7).

Figure 7. Number of accidents and fatalities in aerial work, air-taxi operations, commuter operations, and airline operations, during the study period 2000–2014



4.1.2 Accidents by aircraft type and operations

The accidents in this data set were segregated into airplane, helicopter, floatplane, and medical evacuation (MEDEVAC) accidents, and into their International Civil Aviation Organization (ICAO) occurrence categories.

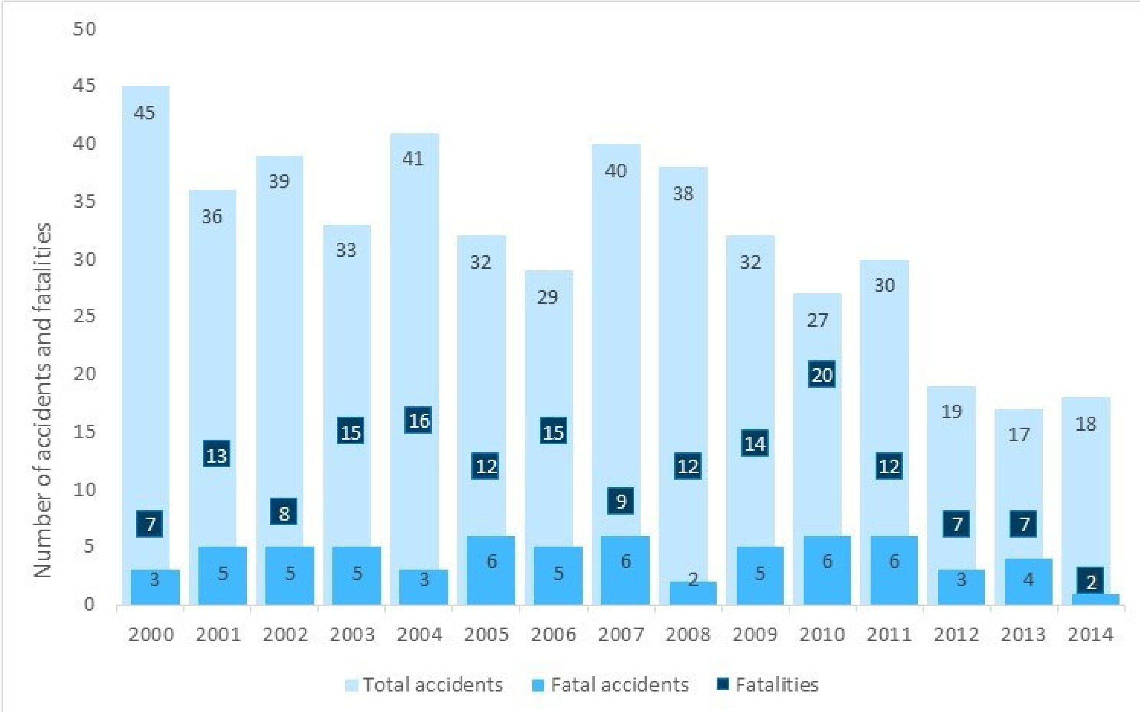
4.1.2.1 Airplanes

From 2000 to 2014, there were 476 airplane accidents in the air-taxi sector, of which 65 (14%) were fatal. In this period, there was a downward trend in the *total* number of airplane accidents in the sector, but no clear trend for the number of *fatal* accidents and fatalities (Figure 8).[35]

Consistent with the decreasing trend in *total* accidents, in the last year of the study period (2014), there were only 18 accidents, and only 1 was fatal (with 2 fatalities). These numbers are much lower than the average of 30.5 accidents, 4.6 fatal accidents, and 12.4 fatalities per year over the previous 10 years.

35 For the number of airplane accidents by year from 2000 to 2014, Kendall's τ_b = -0.670, p = 0.0005; for the number of fatal airplane accidents by year, Kendall's τ_b = -0.063, p = 0.7580; for the number of airplane fatalities by year, Kendall's τ_b = -0.197, p = 0.3173.

Figure 8. Air-taxi accidents and fatalities involving airplanes, 2000–2014



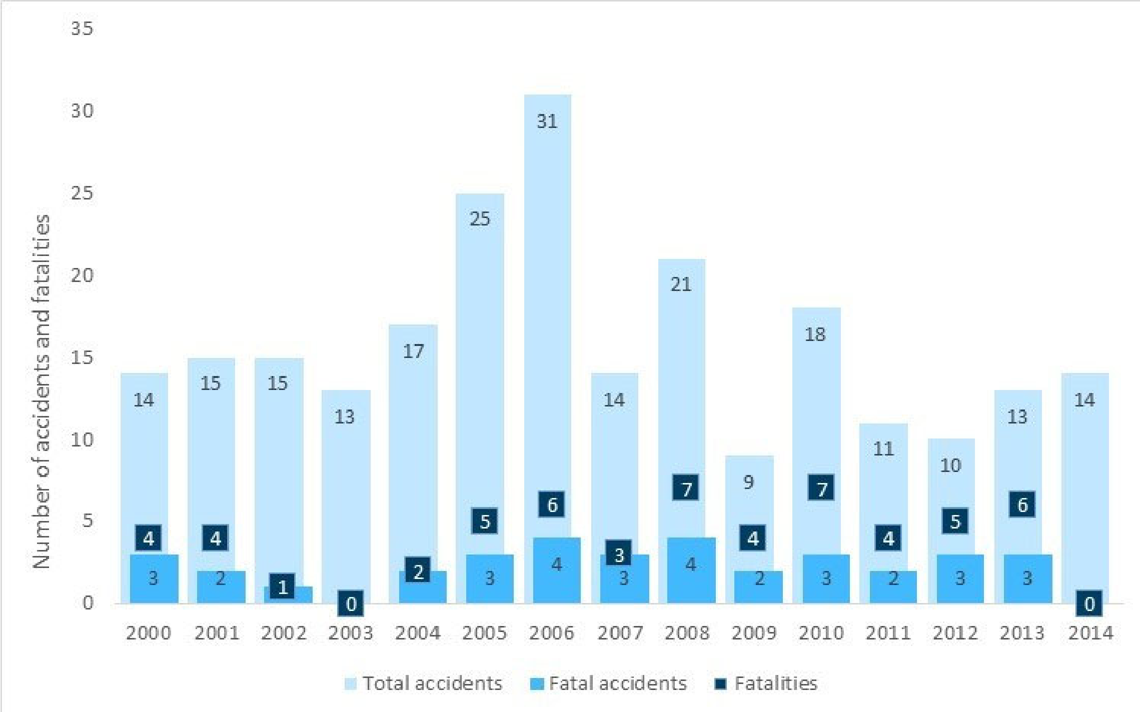
4.1.2.2 Helicopters

Over the study period, 35 of the 240 helicopter accidents in the air-taxi sector (15%) were fatal. Helicopter accidents averaged 16 per year (16.9 in the 10 years before 2014) and peaked at 31 accidents in 2006 (Figure 9). Unlike for airplanes, there was no clear decrease in the number of helicopter accidents.[36]

In the last year of the study period, there were 14 helicopter accidents, none of which were fatal.

[36] For the number of helicopter accidents by year from 2000 to 2014, Kendall's τ_b = -0.176, p = 0.3697.

Figure 9. Air-taxi accidents and fatalities involving helicopters, 2000–2014



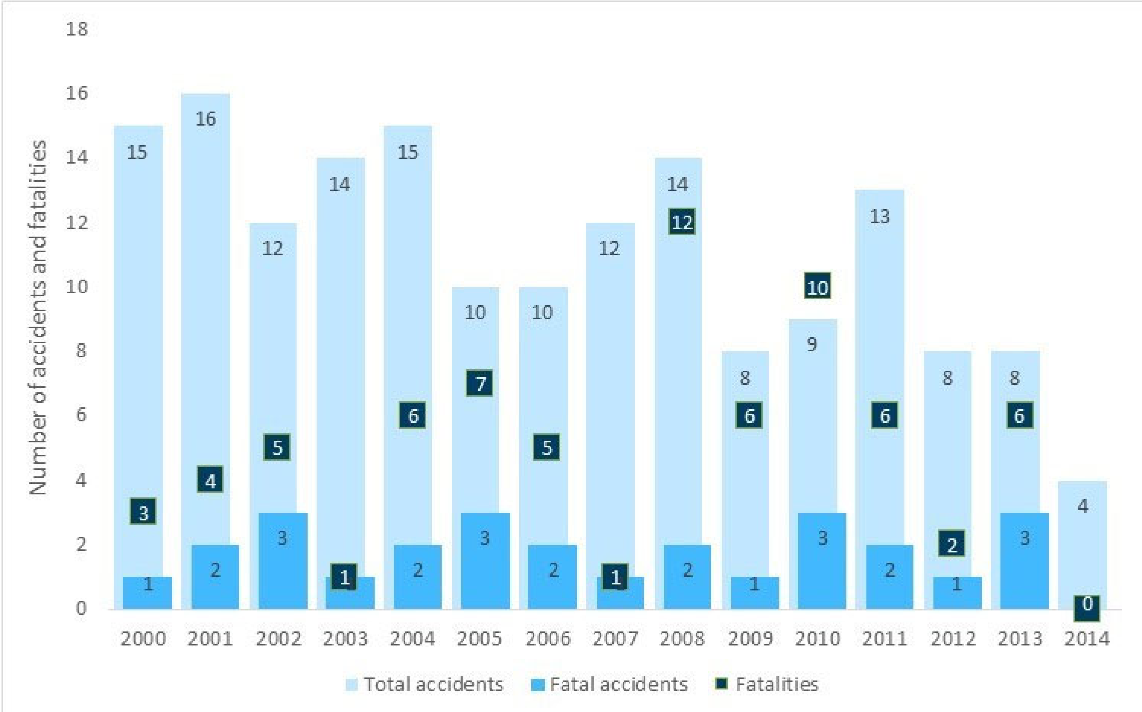
4.1.2.3 Floatplanes

Of the 476 airplane accidents during the study period, 168 (35%) involved floatplanes. Similar to the findings for all airplane accidents, the *total* number of floatplane accidents showed a gradual downward trend during the study period, but the number of *fatal* accidents and fatalities did not show any trend (Figure 10).[37]

In 2014, there were 4 floatplane accidents, down from 8 in each of the preceding 2 years, and lower than the 10-year average of 10.7. None of the floatplane accidents in 2014 were fatal, whereas the previous 10 years saw 2.0 fatal accidents resulting in 6.1 fatalities per year, on average.

[37] For the number of floatplane accidents by year from 2000 to 2014, Kendall's τ_b = -0.631, p = 0.0014; for the number of fatal floatplane accidents by year, Kendall's τ_b = -0.077, p = 0.7146; for the number of floatplane fatalities by year, Kendall's τ_b = 0.089, p = 0.6518.

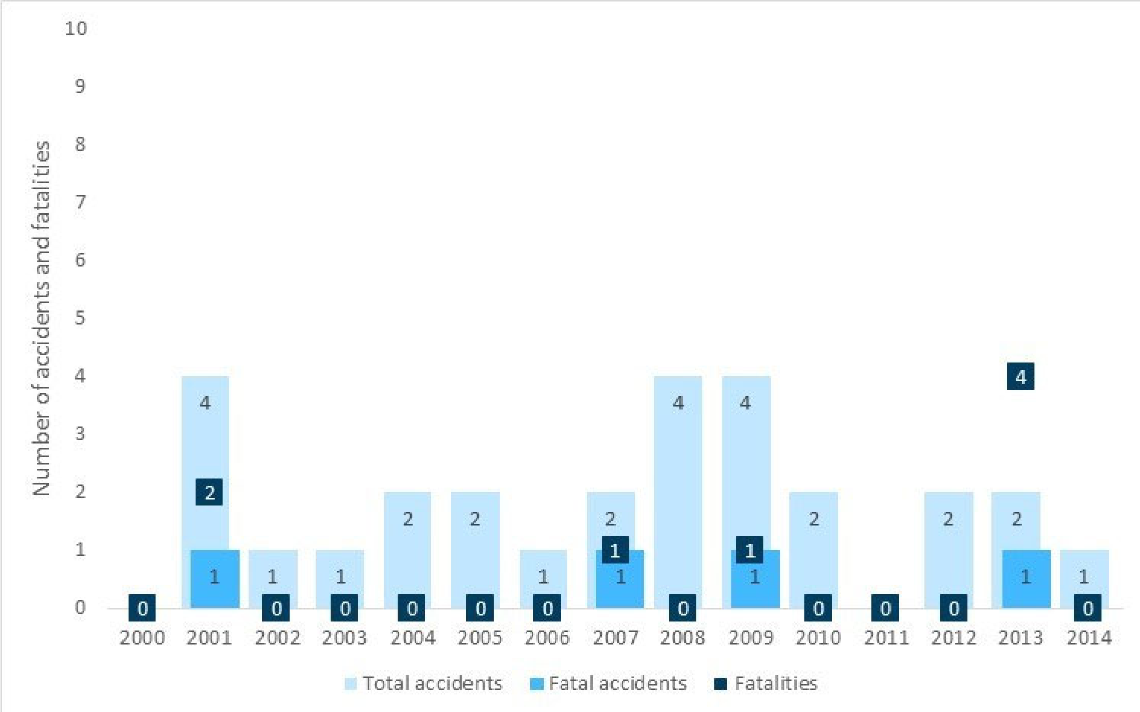
Figure 10. Air-taxi accidents and fatalities involving floatplanes, 2000–2014



4.1.2.4 Medical evacuation operations

MEDEVAC operations conducted by air-taxi operators involve both airplanes and helicopters. There were 28 accidents involving MEDEVAC operations during the study period, of which 4 were fatal, resulting in 8 fatalities. In the 10-year period before 2014, there were on average 2.1 accidents per year, including 0.3 fatal accidents and 0.6 fatalities per year (Figure 11).

Figure 11. Air-taxi accidents and fatalities involving MEDEVAC operations, 2000–2014



4.1.3 Accidents by International Civil Aviation Organization occurrence category

Accidents can be analyzed in more detail by examining the events that contributed to them or were involved in them. This safety issue investigation (SII) analyzed accidents and risks of collision to fit them into the occurrence categories established by ICAO. The ICAO taxonomy allows occurrences to be categorized under multiple occurrence categories. For example, if an engine failure occurred and a loss of control followed, the occurrence would be categorized under both categories.[38]

Figure 12 and Figure 13 provide a breakdown of the most common ICAO occurrence categories for airplane and helicopter accidents, respectively. In both airplane and helicopter accidents, the most common ICAO occurrence category was **in-flight loss of control**. Nearly as common in both types of aircraft was **collision with obstacles during takeoff or landing**. **Controlled flight into terrain** (CFIT) was the third most common category of helicopter accidents; in airplane accidents, CFIT ranked fifth. **System/component failure or malfunction (powerplant)** was the fourth most common occurrence category for both airplanes and helicopters.

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38 International Civil Aviation Organization (ICAO), *Aviation Occurrence Categories: Definitions and Usage Notes*, version 4.2 (October 2011.

Figure 12. Events in airplane air-taxi accidents by ICAO occurrence category, 2000–2014

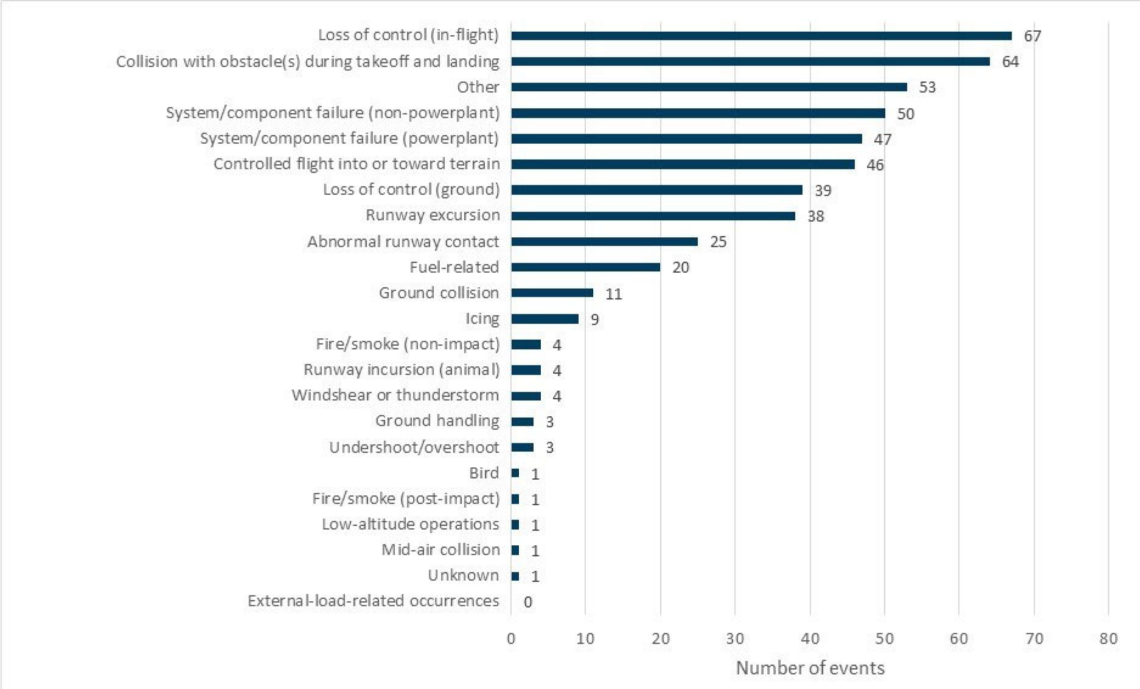
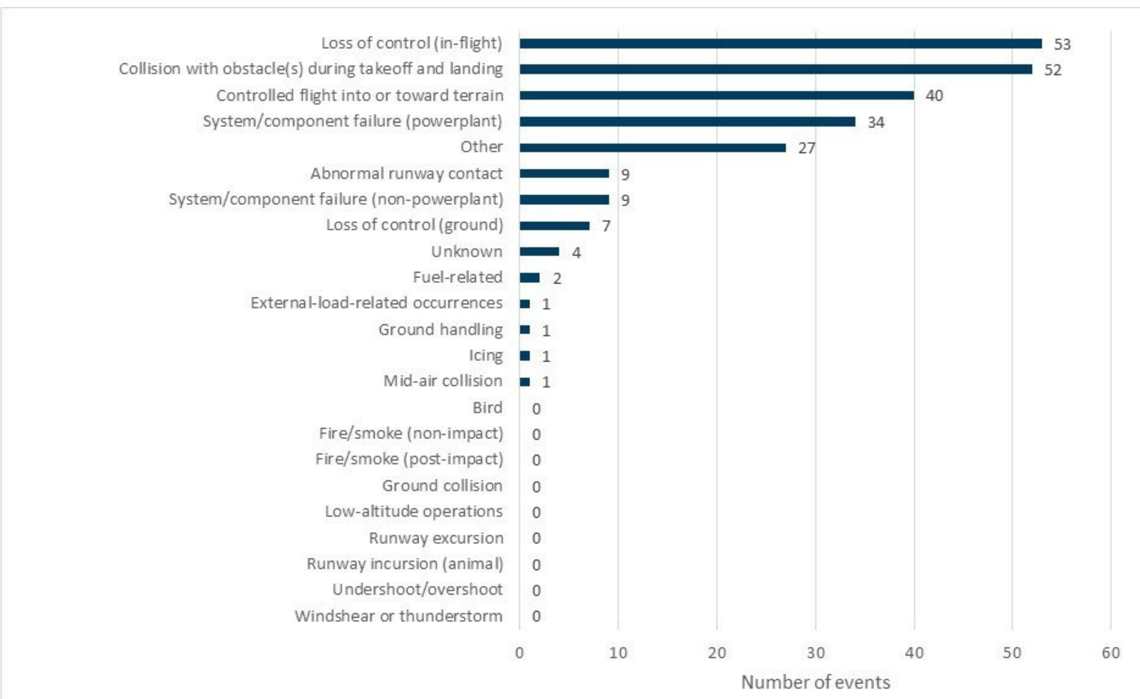


Figure 13. Events in helicopter air-taxi accidents by ICAO occurrence category, 2000–2014



4.1.4 What kinds of accidents are happening in the air-taxi sector?

4.1.4.1 Identifying precise accident types using data from published TSB investigation reports

Over the course of the study period, the TSB published 167 investigation reports (relating to 162 accidents and 5 incidents) into air-taxi occurrences. Of these occurrences, 110 involved airplanes and 57 involved helicopters.

When each occurrence was assigned to one or more ICAO categories, it was found that the ICAO categories, which had been developed particularly for airline operations, did not usefully describe accident types in air-taxi operations in Canada. To address this, the SII team applied grounded theory (Appendix C) to create descriptive accident types—in other words, types of accidents that described the circumstances of the accident as well as the outcome. The accident types developed in this investigation are not discrete categories and do not create a new taxonomy. The categories were used to help the SII team understand how accidents were unfolding and why, rather than simply counting the number of accidents.

The following information was captured for each occurrence:

- accident type
- information about the equipment and weather
- pilot, operator, and aircraft information
- information about causal and contributing factors
- risk factors
- information about safety action taken or recommendations

This analysis yielded 14 airplane-related accident types and 9 helicopter-related accident types (23 in total).[39]

The data were then examined to identify the differences or commonalities in the 23 accident types. Six types were common to both airplane and helicopter accidents:

- visual flight rules (VFR) + loss of visual reference + loss of control + collision with terrain or water
- VFR + loss of visual reference + CFIT
- risk of collision or mid-air collision
- maintenance issues
- manufacturing issues
- exceptions

Despite these commonalities, the reports revealed that the underlying contributing factors and risks in the airplane and helicopter accidents were quite different. As a result, separate analyses were conducted for airplanes and helicopters for this part of the SII.

4.1.4.2 What contributed to these accidents?

Sorting the data into the 23 accident types provided a snapshot of the kinds of accidents that occurred during the study period. The published TSB investigation reports provided an

[39] Some accidents did not fit well into one of the newly created categories. As a consequence, categories for "Other" and "Exception" for both aeroplane and helicopter accidents were created. Accidents were categorized as "Other" if the summary information in ASIS did not provide enough information to categorize the accident at all. Accidents were categorized as "Exceptions" if they were extraordinary and did not fit any of the named categories (these were generally "one-offs" or outliers).

understanding of how these accidents happened (description) and why they happened (hazards and risk factors), and stated the experience of the pilots involved (pilots' average total flight time).

The tables and sections that follow summarize the accident types observed in the 167 published investigation reports, the commonly associated accident characteristics, and the hazard and risk factors most commonly identified in the findings in each.

Table 4. Airplane accident types, common accident characteristics, pilots' average total flight time, and hazards and risk factors among 110 accidents, 2000–2014

Accident type	Characteristics of flights commonly associated with this type of accident	Pilot-in-command average total flight time	Hazards and risk factors most commonly included as findings in published TSB investigation reports
Approach and landing + single pilot No. of accidents: 7	• Passenger-carrying flight • Departed under instrument flight rules (IFR) • Difficulty during approach (i.e., unapproved area navigation [RNAV] and localizer approach, circling approach, missed approach, approach below minimum descent altitude [MDA]) • CFIT	5122 hours	• Descent below MDA • No ground proximity warning system • Limited visibility during approach or illusion during approach • Aerodrome lighting • Standard operating procedures (SOPs) lacking detail or not used / not followed
Approach and landing + multi-crew No. of accidents: 13	• Passenger-carrying flight, departed IFR or night visual flight rules, difficulty in the approach (i.e., unapproved RNAV, non-directional beacon [NDB], instrument landing system) • Missed approach, crashed on second approach • Descent below MDA, crashed on approach • Continued flight, runway excursion • No explanation for the unstable approach	3416 hours	• SOPs lacking detail or not used / not followed • Crew coordination and communication breakdowns • Landed too far down the runway • Poor management of speed and altitude • Errors with global positioning system • Distraction
Maintenance-related No. of accidents: 5	• In-flight warning or failure (e.g., gear indicator, engine power loss) • Unsafe condition or emergency	8657 hours	• Compromised fuel system + electrical arcing • No aircraft pre-flight inspection • Engine failed; asymmetric thrust not well managed • Incorrect or absent installation • Aircraft maintenance engineer not qualified • Component failure due to lack of maintenance • Fuel contamination • Multi-engine aircraft flight manuals and training programs lacked critical cautions and minimum control speeds re: loss of control of the aircraft.

Accident type	Characteristics of flights commonly associated with this type of accident	Pilot-in-command average total flight time	Hazards and risk factors most commonly included as findings in published TSB investigation reports
Manufacturing-related No. of accidents: 11	• In-flight warning or failure (component or system) • Unsafe condition or emergency	3249 hours	• Component failure in-flight due to manufacturing defect or design • Response to component failure in flight contributed (i.e., crew did not feather propeller of failed engine or retract flaps, increasing drag); engine failure with single-engine instrument flight rules flight in mountains while manoeuvring to avoid instrument meteorological conditions (IMC) • Company operations, reduced power takeoff procedure, not reaching best single engine rate of climb • Crew coordination, SOPs poor for abnormal or emergency situations • Emergency training weak • Survivability concerns due to deformation of cabin and adequacy of safety harnesses
Takeoff condition No. of accidents: 4	• Runway condition preventing aircraft from obtaining sufficient take-off speed • Ice on aircraft preventing aircraft from obtaining sufficient lift	3311 hours	• Combination of overweight and contaminated airframe • In aircraft with ice or snow adhering to the airframe, aerodynamic stall is prevalent • No or inadequate passenger safety briefing, no or partial safety harness use • Transport Canada (TC) oversight concerns (e.g., 3-year timespan between audits)
Floatplane + loss of control No. of accidents: 16	• After takeoff, visual illusion/manoeuvring/wind conditions encountered • Stall • Loss of control • Difficulty egressing the aircraft following collision with ground or water •	2061 hours	• Aerodynamic stall on approach or when manoeuvring • Egress-related, including time to egress exceeded, door operation, ability to locate and/or exits jammed • No or inadequate passenger safety briefing • Partial restraint use by pilots and passengers • No stall warning in the DHC-2 MK I (Beaver)
Floatplane + weight and balance No. of accidents: 6	• Aircraft loaded overweight and/or out of centre-of-gravity limits (not usually recognized) • Unusual attitude • Aerodynamic stall • Collision with ground or water • Egress difficulty	4212 hours	• Aircraft beyond centre-of-gravity limits and/or overweight • Aerodynamic stall • Weight-and-balance calculation not completed before departure • No stall warning in the DHC-2 MK I (Beaver)

Accident type	Characteristics of flights commonly associated with this type of accident	Pilot-in-command average total flight time	Hazards and risk factors most commonly included as findings in published TSB investigation reports
Fuel-related No. of accidents: 10	• Fuel problem or fuel starvation in flight • Forced landing	912 hours	• Pilot experienced task saturation in emergency • Operators' training program did not include fuel system operation • Aircraft fuel gauges inaccurate
VFR+ loss of visual reference + CFIT No. of accidents: 11	• Weather was forecasted to deteriorate • Flight departed in visual meteorological conditions (VMC) • Darkness, cloud, or precipitation in flight (some flights over water or near mountains) • Lost visual reference to surface, resulting in CFIT	6219 hours	• IMC were encountered • Flying in low-visibility conditions • Departed with weather forecasted to deteriorate, with plan to evaluate en route • Black-hole illusion
VFR + loss of visual reference + loss of control No. of accidents: 6	• Flight departed in VMC conditions • Encountered dark/cloud/precipitation in flight • Lost visual reference with the ground • Lost control in-flight • Collided with the ground or water	4170 hours	• Marginal VFR into IMC encountered en route • Lack of instrument flying experience (cited as a causal and contributing factor despite 4 of 6 of the pilots involved holding an instrument rating)
Icing No. of accidents: 5	• Icing forecasted • Single-pilot passenger-carrying flight • Encountered icing in-flight • Unable to maintain altitude •	2920 hours	• Continued flight into forecasted icing • Marginal weather operations • Aircraft not certified for flight into known icing conditions • Aerodynamic stall • Operational control self-dispatch
Risk of collision / mid-air collision No. of accidents: 6	• Two or more aircraft • At airport • Air traffic control involved • Takeoff and/or landing • Risk of collision	No pilot flight hours included in reports	• Procedures for land and hold-short operations inadequate • Pilot communications (, no statement of runway position, believed cleared, different radio frequencies) • Coordination between controllers for tasks and information inadequate
Exceptions No. of accidents: 10	• No general scenarios	3708 hours	Not applicable

Table 5. Helicopter accident types, with common accident characteristics, pilots' average total flight time, and hazards and risk factors among 57 accidents, 2000–2014

Accident type	Characteristics of flights commonly associated with this type of accident	Pilot-in-command average total flight time	Hazards and risk factors most commonly included as findings
Aerodynamic effects on control + loss of control No. of accidents: 11	• Flight departed and remained under VMC • Encountered conditions in which aerodynamic situations affected control of the helicopter (thin air, flowing air, mountains, low-speed flight, close to ground) • Lost control of helicopter • Collided with terrain	5792 hours	• Strong updrafts or downdrafts at maximum gross weight, settling with power, subsiding air, downwind (heli-skiing) • Loss of tail-rotor effectiveness
Maintenance-related No. of accidents: 10	• In-flight warning or failure • Unsafe condition or emergency	1800 hours	• Unapproved part (screw on fuel control unit) failed • Tail rotor disengaged • AS350 hydraulic test—locking mechanism and test procedure • Airworthiness directive not followed • Contaminated fuel • Non-compliance with optional service bulletin
Manufacturing-related No. of accidents: 10	• In-flight warning or failure encountered (i.e., component or main system) • Unsafe condition or emergency	6185 hours	• On-condition part (coupling) failed • Fuel cell system partially modified, partial collapse • Mechanical failure of forward coupling sleeve and stub shaft, incorrect heat of part at manufacturer • Third-stage compressor wheel fatigue crack not detected • Weakness in No. 2 bearing balls—specific part numbers • Maintenance instructions incomplete or difficult • Maintenance engineers made assumptions about the procedure • Symptoms of failure not recognized by manufacturer
VFR + loss of visual reference + CFIT No. of accidents: 10	• Flight departed in VMC • Encountered cloud, precipitation, whiteout, illusion, darkness, or smoke • Pilot lost visual reference to ground • Collided with terrain	6837 hours	• VFR into IMC at slow speed • No instrument rating
VFR + loss of visual reference + loss of control No. of accidents: 7	• Flight departed in VMC, encountered cloud, precipitation, or whiteout • On takeoff or approach • In-flight • Visual reference to ground lost, loss of control of helicopter, collision with terrain	2617 hours	• Climbing turn, whiteout, loose snow, and loss of control • No horizon

Accident type	Characteristics of flights commonly associated with this type of accident	Pilot-in-command average total flight time	Hazards and risk factors most commonly included as findings
Training-related No. of accidents: 3	• Training flight where simulated conditions become actual conditions • Training and/or familiarization flight where an unexpected event occurs • Helicopter lands hard or crashes on terrain unsuitable for occurrence-recovery training	4683 hours	• Practice autorotations, inappropriate environment for training
Risk of collision or risk of mid-air collision No. of accidents: 2	• Two or more aircraft • Takeoff and landing, mid-air • In-flight risk of collision	1800 hours and 6650 hours*	• See-and-avoid principle has limitations • No traffic alert and collision avoidance system • No traffic advisory • No broadcast of intentions; controllers' tasks divided
Exceptions No. of accidents: 4	• Not applicable	5325 hours	• Pilot behaviour • Cover on engine / routine interrupted • Confined-area manoeuvring • Servo transparency hazard

* Total flight time for the pilots involved in the mid-air collision.

4.1.4.3 Looking at all accidents reported to the TSB through the lens of the accident types

To put the data from the completed TSB reports in context, all 716 air-taxi accidents (476 airplane, 240 helicopter) were analyzed and categorized into the newly created accident types—19 named categories plus 1 "exception" and 1 "other" each for airplanes and helicopters. This yielded a total of 23 accident types that were used to analyze the published TSB investigation reports.

4.1.4.3.1 Airplane occurrences

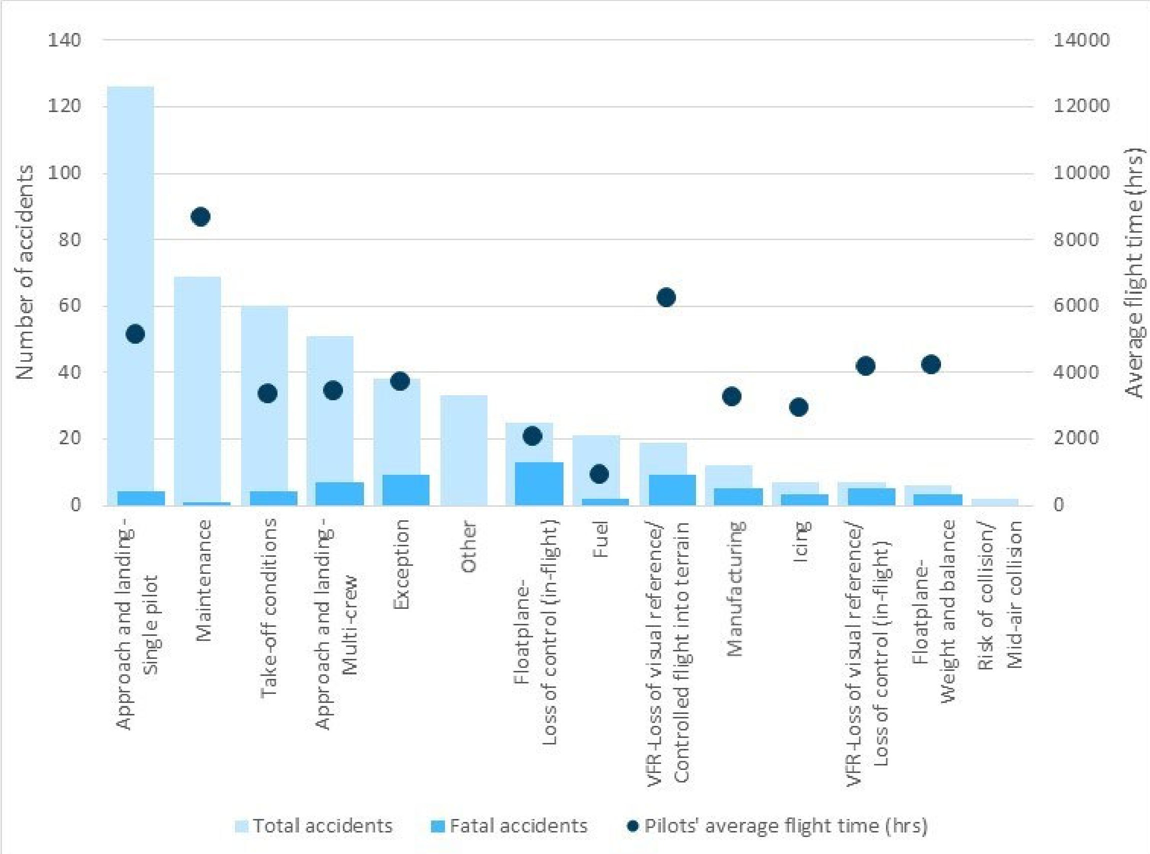
Figure 14 shows summary statistics for accident types for airplane occurrences. Of the 476 airplane accidents, the most common accident types were

- single-pilot approach-and-landing (26%),
- maintenance-related (14%),
- takeoff-condition–related (13%),
- multi-crew approach-and-landing (11%), and
- floatplane loss-of-control (5%).

The highest number of fatalities occurred as a result of floatplane accidents involving loss of control (34 deaths), followed in frequency by VFR + loss of visual reference + CFIT accidents (26 deaths).

Pilots involved in maintenance-related accidents had an average total flight time of 8657 hours, the highest flight-time average. The lowest flight-time average was held by pilots involved in fuel-related accidents; they had an average total flight time of 912 hours.

Figure 14. Average flight time for pilots involved in airplane air-taxi accidents, compared to the total number of airplane accidents and fatal accidents during the study period, 2000–2014



4.1.4.3.2 Helicopter occurrences

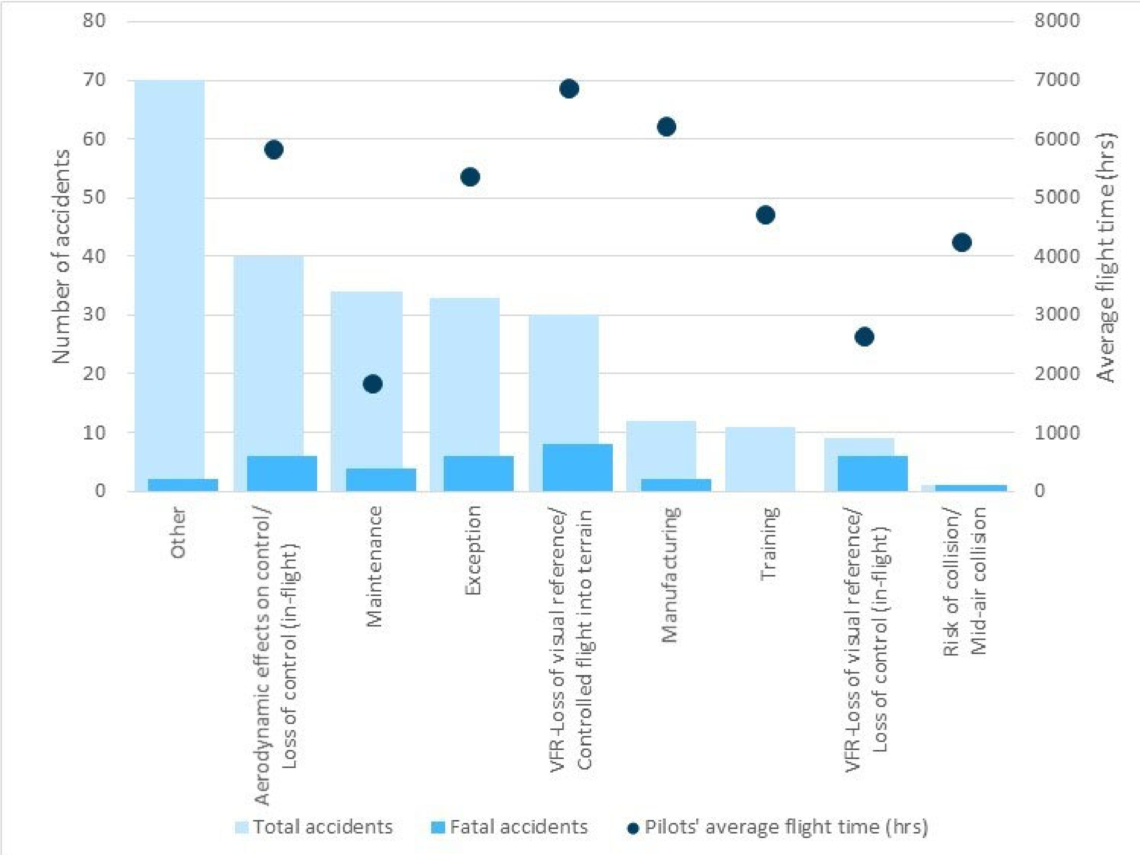
Figure 15 shows summary statistics for accident type for helicopter occurrences. Of the 240 helicopter accidents, the most common accident types were

- aerodynamic effects on control with loss of control (17%),
- maintenance-related issues (14%),
- VFR + loss of visual reference + CFIT (12%),
- manufacturing-related issues (5%), and
- training (5%).

The highest number of fatalities occurred as a result of accidents involving VFR + loss of visual reference + CFIT (14 deaths), followed by VFR + loss of visual reference + loss of control (13 deaths).

Pilots involved in VFR + loss of visual reference + CFIT accidents had the highest average total flight time (6837 hours). Pilots involved in maintenance-related accidents had the lowest average total flight time (1800 hours).

Figure 15. Average flight time for pilots involved in helicopter air-taxi accidents, compared to the total number of helicopter accidents (240) and fatal accidents during the study period, 2000–2014



The analysis of the TSB accident data over 15 years showed similarities to results of previous studies identified through the literature review. This suggests that the hazards s have not changed in many years.

This TSB accident data illustrated the types of accidents that have been happening in this sector. The next step was to validate these results by consulting operators in the industry: asking them what they considered to be the greatest risks to safety in their day-to-day operations and how they managed these risks.

4.2 Information from consultations with industry

The industry consultations carried out in 2016 as part of this SII provided information about what operators perceived to be their most significant risks, what they were doing to lessen those risks, and what more they believed needs to be done. It should be noted that this information represents the views of those who participated in the SII, and these views have not been independently validated by the TSB. Nor do these observations reflect ongoing initiatives by service providers or the regulator.

The information collected from these consultations was organized into 19 safety themes that emerged from the grounded theory method:

1. Aerodromes and infrastructure

2. Availability of qualified personnel
3. Airborne collision avoidance
4. Interruptions and distractions
5. MEDEVAC operations
6. Night operations
7. On-board technology
8. Survivability
9. Weather information
10. Acceptance of unsafe practices
11. Fatigue
12. Maintaining air-taxi aircraft
13. Operational pressure
14. Pilot decision making (PDM) and crew resource management (CRM)
15. Training of pilots and other flight operations personnel
16. Training of aircraft maintenance engineers (AMEs)
17. Safety management
18. Regulatory framework
19. Regulatory oversight

This section summarizes what operators said about each safety theme and the associated safety issues, as well as what operators are doing to manage these issues and what more they think could be done. Additional context is provided for each theme in the form of TSB findings from investigation reports published during the study period (2000 to 2014), TSB recommendations, and findings and recommendations from previous studies of safety in the air-taxi sector (for more information about these studies, see **Section 2.0 A history of concern**).

Section 5.0 Discussion discusses the information presented in **Section 3.0 Methodology** and **Section 4.0 Information gathered during the investigation**, following the structure and order of safety themes presented in this section.

4.2.1 Safety theme: Aerodromes and infrastructure

4.2.1.1 Background

In remote and northern communities, air transportation is often the only reliable year-round mode of transportation. These communities rely on air services to supply fresh food, medicine, and other goods; deliver health-care services; provide emergency medical evacuations; support exploration and economic development work; and support tourism and travel outside of the community.

The north, in particular, presents inherent challenges and risks to air transportation. Its population is spread out in small communities over vast stretches of inhospitable terrain.

Air operations are subject to extreme weather, including cold temperatures, and to extended periods of darkness. Low and sporadic passenger volumes, along with these harsh operating conditions, create a difficult and costly operating environment for the air-taxi industry.

Because of the importance of air transportation in remote and northern communities, civil aviation infrastructure in the north was recently the subject of an audit by the Auditor General of Canada.[40] This infrastructure includes proper lighting, navigational aids, runways, and information on weather and runway conditions, all of which are critical components for safety and accessibility at these aerodromes.

The responsibility for the state of this infrastructure is shared. Transport Canada (TC) sets regulations for air transportation infrastructure and oversees compliance. Airport operators ensure that airports comply with regulations. These operators may include municipalities; federal, provincial, and territorial governments; local authorities; and private entities. NAV CANADA, in its role as the air navigation service provider, is responsible for providing instrument approaches and navigation aids.

4.2.1.2 What operators told us about this theme

4.2.1.2.1 Safety issues associated with this theme

Among the issues operators identified as posing a high risk to safety were aspects of remote, northern, and small aerodromes.

Many operators raised concerns about poor runway conditions and short runways. These included the absence of runway-condition reports at some aerodromes, and the absence of aircraft performance limitations for taking off from and landing on short, soft, or gravel runways.

Limitations of other infrastructure were also mentioned, including insufficient lighting, inadequate maintenance of the infrastructure in some locations, and absence of and inadequate de-icing facilities.[41]

4.2.1.2.2 How operators are managing these issues

Some operators are providing enhanced training on aircraft performance for short-runway operations.

Some operators have developed standard operating procedures (SOPs) to help crews cope with infrastructure limitations for their specific operations. These SOPs include a requirement to perform a pre-flight briefing that includes infrastructure limitations.

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40 Office of the Auditor-General of Canada, *Report 6—Civil Aviation Infrastructure in the North—Transport Canada* (2017) (Ottawa, ON: Parliament of Canada), at http://www.oag-bvg.gc.ca/internet/English/parl_oag_201705_06_e_42228.html (last accessed on 01 October 2019).

41 Since the industry consultations, the TSB has issued Recommendation A18-02.

Other SOPs include direction not to depart if icing conditions are forecast and de-icing equipment is not available at the destination. When flying to a location without de-icing equipment, some operators have equipped their aircraft with portable de-icing sprayers where there is a risk of icing while on the ground. As well, some operators are using aircraft covers when necessary.

Some operators require all landings and takeoffs at remote airstrips to be conducted by senior pilots or the captain. Operators also said they require flight crews to obtain information on the current runway conditions at the destination before departure.

One company conducts a risk assessment before all flight departures to mitigate changing runway conditions. Operators mentioned that they employ knowledgeable local people to work at remote aerodromes: such personnel can pass along first-hand knowledge of the runway conditions or local weather, and operators find it beneficial for crews to know the local topography surrounding remote aerodromes.

4.2.1.2.3 What operators said could be done

Multiple operators requested more area navigation (RNAV) approaches and approaches with vertical guidance at remote airports.

Operators said they need more weather reporting from remote aerodromes, through automated weather observation system (AWOS) stations and weather cameras (see also **Section 4.2.9 Safety theme: Weather information**).

Operators also expressed the need for more accurate reporting of runway conditions and for better maintenance of runways at remote and northern aerodromes. Some operators said de-icing equipment should be required at away bases.

Finally, operators said it is essential to provide training in pilot decision making (PDM) to mitigate infrastructure issues (see also **Section 4.2.14 Safety theme: Pilot decision making and crew resource management**).

4.2.1.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period revealed 6 findings related to infrastructure:

- In a 2004 occurrence involving a loss of control related to airframe icing, the investigation found that there was a lack of equipment at the airport to adequately inspect aircraft for ice and to adequately de-ice aircraft.[42]
- In runway overrun occurrences in 2006 and 2011, obstacles and topography beyond the runway overrun area were causal or contributing factors.[43]

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[42] TSB Aviation Investigation Report A04H0001.

[43] TSB aviation investigation reports A06P0036 and A11C0102.

- In a 2007 runway overrun occurrence, the airport did not have an aircraft rescue and firefighting service, resulting in a delay in the emergency response by the municipal fire service.[44]
- In a 2009 occurrence involving controlled flight into terrain (CFIT), the pilots did not have up-to-date information on runway conditions needed to check runway contamination and landing distance performance.[45]
- In a 2010 occurrence involving a birdstrike on takeoff and collision with terrain, a cannon to keep birds away from the runway was not working.[46]

4.2.1.4 Summary

Table 6. Aerodromes and infrastructure: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• Some communities have only basic aerodromes with limited infrastructure (insufficient lighting, limited navigational aids, short runways, limited runway maintenance, and limited weather reporting). • Maintenance facilities and de-icing equipment absent or inadequate at some aerodromes	Operations into some remote areas and/or northern communities with limited aerodrome infrastructure may be carried out with a reduced level of safety.	• The following are required: • More RNAV approaches at remote airports • More AWOS stations and weather cameras • More accurate reporting of runway conditions • Better maintenance of runways at remote and northern aerodromes • De-icing equipment at away bases • PDM training to mitigate infrastructure issues

Conclusion: Remote and northern communities of Canada require appropriate aerodrome facilities and infrastructure to ensure that air-taxi operators can provide safe air services for those communities.

4.2.2 Safety theme: Availability of qualified personnel

4.2.2.1 Background

The air-taxi sector needs enough qualified personnel if it is to remain viable. It also needs enough resources to be able to recruit and train pilots, aircraft maintenance engineers (AMEs), and others to work, and continue working, in the challenging environments in which the air-taxi sector operates. However, the sector faces problems with turnover, demographics, and barriers to recruitment.

Although some personnel spend their entire career in the air-taxi sector, particularly in the helicopter industry, the air-taxi sector often serves only as a training ground for new personnel, who then move on to careers in larger air carriers. At the same time, highly

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44 TSB Aviation Investigation Report A07Q0213.

45 TSB Aviation Investigation Report A09Q0203.

46 TSB Aviation Investigation Report A10Q0162.

experienced pilots and AMEs throughout the aviation industry are retiring, making the transfer of knowledge from these experienced people to those new to the industry even more important. This wave of retirements will increase demand for pilots in the commuter and airline sectors, leading to a shortage of adequately trained commercial pilots in the air-taxi sector, and to pilots having less industry experience.

In addition, there are significant barriers to recruiting new people for a career in aviation. The cost of training as a pilot may be out of reach. It is becoming harder to recruit young AMEs because other trades are competing for the same people. Working in another trade (e.g., as a carpenter or electrician) may seem like a more attractive prospect than working as an AME, because these trades also pay well and may not require relocation.

These challenges—high turnover, demographic shifts, and barriers to recruitment—mean that the sector needs to continually hire and train pilots and AMEs, who need on-the-job professional development for their career to advance.

4.2.2.2 What operators told us about this theme

4.2.2.2.1 Safety issues associated with this theme

Most of the safety issues that operators discussed involved personnel shortages, training of personnel who are new to the industry, risks associated with having inexperienced personnel, and not having enough highly experienced personnel to carry out the work that needs to be done.

Personnel shortages

The air-taxi sector has a high turnover of pilots, mainly because many are hired by larger air carriers. At the same time, the most experienced air-taxi pilots are retiring in greater numbers. Given how often pilots leave the sector, it is especially important that experienced pilots pass on their knowledge to new pilots. However, this does not always happen, because some experienced pilots can leave on fairly short notice.

A number of operators said that, when it came to replacing or hiring more pilots, it was hard to find qualified candidates in Canada generally. The high turnover in the sector means that the pool of pilots with a level of experience attractive to operators is limited. Helicopter operators had particular difficulty attracting new personnel. Many operators were concerned that the pilot shortage could be made worse by the new flight and duty day regulations[47] that have been proposed by Transport Canada (TC), because they will have to hire more pilots to accomplish the same amount of work. Some said that, if those proposed regulations came into force, they would try to hire more pilots, but they expected it to be difficult because of the shortage.

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47 The proposed regulations have since been published: Government of Canada, Canada Gazette, Part II, Vol. 152, No. 25 (12 December 2018), Regulations Amending the Canadian Aviation Regulations (Parts I, VI and VII—Flight Crew Member Hours of Work and Rest Periods).

There are shortages not only of pilots but also of AMEs: an industry-wide AME shortage is affecting operators in all sectors, including the air-taxi sector.

Many operators believed that the attitudes and preferences of potential new recruits played a part in those shortages. Some considered the culture among the current pool of young adults to be a barrier to hiring. In their view, young pilots and AMEs tended to see working in aviation as "just a job" rather than a career. They also believed that younger recruits had an inconsistent work ethic and lacked passion and drive. They also said it was difficult to find pilots willing to work in small communities, because young people want to live and work in larger centres. Operators have also observed reluctance on the part of younger staff to work away from base temporarily in remote places that lack modern infrastructure such as internet service.

Training of new personnel

The learning curve is steep for new pilots entering the industry. They have to learn not only how to operate particular aircraft, but also how their company and the air-taxi sector as a whole operate. However, they may have gained all of their knowledge around an airport in a training environment and not in locations more typical of day-to-day operations in the sector. Furthermore, there is no formal mentorship program for younger pilots who are entering the aviation industry.

Operators mentioned that some new pilot candidates had not been trained in, or were not adequately prepared for, the types of entry jobs pilots should expect to take after graduating from commercial flight school (see also **Section 4.2.15 Safety theme: Training of pilots and other flight operations personnel**). Operators expressed concern that new pilots' life experiences had not given them the opportunity to develop skills that would help them operate in remote locations without any support. On a more general level, operators believed that new pilots might not have the flexibility or adaptability that they would consider necessary for working in smaller, more remote locations.

Risk associated with inexperience

A large proportion of inexperienced personnel is seen as posing a higher risk to safety. However, as shown in **Section 4.2.2.3 Previous TSB findings and recommendations on this theme**: only 1 accident type (fuel-related accidents) involved pilots with relatively low experience.

Having large numbers of inexperienced pilots makes it difficult to use risk-reduction strategies, such as pairing them with more experienced crew members for support. Operators recognized that the extent of pilots' experience and completed training influences the type of work to which they can be assigned and that they can perform. Some pilots may be more experienced at certain types of jobs than others (e.g., helicopter longlining or landing an aircraft on a gravel esker).

Insufficient highly experienced personnel

Some operators observed that currently available pilots have less industry experience and fewer flying hours than in previous decades, and that this shortfall affects both captain and first officer positions. As a result, operators may not have enough highly experienced pilots to meet their requirements. Several operators expressed concern that pilot experience may be inadequate for the aircraft type being flown, and that pilots were being assigned pilot-in-command duties on high-performance, complex aircraft despite having very low levels of experience.

This issue also affects specialized operations. Pilots have to have a high number of flight hours to be eligible for medical evacuation (MEDEVAC) contracts, making it difficult to find and hire pilots with the required experience. Some operators also said that it was becoming more difficult to find experienced floatplane pilots, including seasonal floatplane pilots who work only from spring to fall.

4.2.2.2.2 How operators are managing these issues

Operators would prefer to mitigate safety issues by hiring more experienced personnel. Some operators had set minimum flight-hour requirements specific to their companies for new hires, ranging from 1000 hours to 3000 hours. Some were giving preference to candidates with some experience on turbine aircraft. In some cases, these minimum requirements had not been set by the company, but were customer-driven. For example, some contracts specified a minimum number of flight hours that pilots had to have (e.g., 2000 hours). Some operators identified that they rarely hire pilots with a low number of flight hours.

Operators also mentioned that they have minimum flight-hour requirements for pilots to upgrade to a captain's position, and that they try to hire pilots who qualify as captains.

Some said they looked for pilots with instructing experience, stating that flight instructors are more familiar with the regulations. At a company that has many different operations under various subparts of the *Canadian Aviation Regulations* (CARs), new line pilots usually start out as instructors on the company's small aircraft and work their way up to larger aircraft as a means of progression within the company. One company mentioned that, when it hired new pilots, it focused on type currency as well as total hours when reviewing the qualifications of potential candidates. Some operators indicated that they generally hired new pilots with some instrument flight rules (IFR) experience.

A number of well-established operators mentioned that they hired only licensed AMEs and did not hire apprentices in their operations. However, given the unavailability of experienced pilots and AMEs, some operators were focusing instead on recruitment, hiring, training, development, and retention.

To attract new employees to the sector over the long term, one strategy involved conducting local outreach on career days at secondary schools to interest potential recruits in a career in the aviation industry.

Operators were taking various measures with regard to recruitment. The list below contains recruitment strategies for both helicopter and airplane personnel:

- Establishing a good relationship with the local college that trained recent AMEs; this allows operators to gain insight into the new roster of high-quality graduates.
- Putting in place an extensive hiring process that goes beyond the usual checks of references and pilot experience and includes steps such as enhanced medical screening or flight simulator evaluations.
- Hiring full-time helicopter pilots rather than hiring them on contract.
- If hiring pilots with limited experience, hiring younger pilots whom the company can train and develop for the long term.

Some operators had put measures in place to develop inexperienced personnel, such as the following:

- Scheduling a newly hired or promoted captain to fly with experienced first officers for a certain period of time.
- Having new pilots work with maintenance or in other ground positions such as dispatch before they are rewarded with a flying position. This way, the pilot can get acquainted with how the company operates, and the company can get acquainted with the new hire.
- Developing crew-pairing policies, such as a “no green-on-green” policy under which an inexperienced pilot is paired with a more experienced one. For example, using a “green pilot” checklist to optimize crew pairings and guard against pairing 2 less-experienced crew members, or instituting a policy in which a new pilot needs to fly with an experienced pilot for 1000 hours before the new pilot can be paired with any other pilot.
- Having a pilot mentorship program that pairs junior pilots with senior pilots. Many operators were doing this to support knowledge transfer within a company. This mentorship program could also be extended to new captains within the company.
- Conducting all operations using 2 pilots (i.e., no single-pilot operations) to mitigate the risk associated with a less experienced pilot flying alone.
- Using succession planning to develop new pilots and transition them to larger equipment or into pilot-in-command roles. Some companies were also using peer recommendations before a pilot was awarded an upgrade to captain.
- Rather than hiring experienced pilots, hiring pilots with fewer flight hours and training them to meet the company’s operational requirements. For example, some floatplane operators preferred to hire licensed pilots without a seaplane rating and then train them to attain it. Those pilots would then operate seaplanes in accordance with the company’s particular procedures. Along the same lines, a number of operators mentioned that they preferred to hire pilots with fewer flying hours and train them specifically to meet their own companies’ operational requirements.

- Providing crews with line indoctrination training. One operator with a wide range of aircraft operations was providing 40 to 50 hours of such training as well as conducting regular line checks for all crews.
- Specifically developing standard operating procedures (SOPs) to accommodate less experienced pilots.
- Leasing a medium-sized floatplane for the summer season to help transition the company's less experienced pilots from its smaller floatplane to its very large floatplane.

Operators are using many approaches to improve personnel retention, such as the following:

- Paying competitive salaries as well as offering attractive benefit packages to keep experienced employees.
- Paying a yearly salary to ensure that seasonal pilots return to the job the following season.
- Hiring local candidates, because local employees are more likely to stay with a company in their hometown.
- For air-taxi operators that also have commuter or airline operations, providing opportunities for development or for pilots to upgrade to larger aircraft within the company.
- Having pilots sign a training bond when they start, to allow the company to recoup all or a portion of the costs associated with training if the pilot resigns before the end of the training bond period (typically 2 years).
- Offering first officers with fewer pilot-in-command flight hours an opportunity to upgrade to a captain's position through an enhanced training program at the company.
- To help retain AMEs, providing maintenance personnel with a defined work schedule that allows them to plan their personal lives.

4.2.2.2.3 What operators said could be done

Operators felt that requirements for experienced personnel should be revisited. To avoid the difficulty of having insufficient highly experienced personnel, one helicopter operator suggested making clients aware that requiring a minimum of 2000 hours' flight time is not necessarily a good approach to risk mitigation.

On the other hand, some suggested raising the flight time required to obtain an airline transport pilot licence (ATPL), to prevent the drain of experienced pilots from the air-taxi sector to commuter and airline operators.

Operators said that educational institutions should better prepare pilots and AMEs, and made several comments about the standards of education at flight schools. They said they found inconsistent standards of training reflected among new pilot candidates who have graduated from different flight schools and colleges. Operators also felt that flight schools should provide better training for pilots in coastal flying and in decision making specific to weather-related issues.

Operators said that trade schools need to prepare apprentice AMEs for the challenges of northern or remote work, and that, currently, most new AMEs are unaware of what to expect when working in such locations.

Further measures were suggested to train and develop inexperienced personnel:

- Increased mentoring for new personnel entering the industry, and possibly an industry-wide mentorship program, was discussed. Some operators said that new pilots should take part in a mentorship program for their first 1000 flight hours.
- There was a suggestion to review procedures and train pilots throughout the year, rather than once a year, to maintain a high level of competency.
- In general, operators stated that training should be competency- or performance-based rather than prescriptive.
- Operators suggested training in specific areas: IFR approaches, floatplane operation (requiring a special qualification beyond a seaplane rating), and risk management training to help conduct day-to-day operations and improve decision making. (See also **Section 4.2.15 Safety theme: Training of pilots and other flight operations personnel** and **Section 4.2.14 Safety theme: Pilot decision making and crew resource management**.)
- There was a suggestion that pilot competencies for single-pilot, high-performance aircraft be regulated.
- Companies suggested the need for a policy regarding “green-on-green” crew pairings, and this should be managed effectively by providing the company crew scheduler with a list of new captains and first officers.
- Some comments on training and development concerned TC inspectors: inspectors should conduct more check rides to help gauge safety in the sector, and TC needs to create an environment in which junior TC inspectors can be mentored by senior inspectors.

Pay is a key personnel strategy. Fair pay for the type of work being done was mentioned many times as a way to improve recruitment and retention. Better pay for training pilots was also mentioned.

4.2.2.3 Previous TSB findings and recommendations on this theme

A review of the 167 occurrences with published investigation reports during the study period did not reveal any findings specific to this theme. However, findings have been made about training available personnel: see **Section 4.2.15 Safety theme: Training of pilots and other flight operations personnel**.

Data from the review of aviation occurrences in Phase 1 of this investigation showed that there was only one accident category in which pilots with relatively fewer flight hours were involved. In all other accident scenarios, the pilots involved had a high average flight time.

4.2.2.4 Other reviews and safety studies

4.2.2.4.1 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) Final Report, published in 1998, made 2 recommendations relevant to this theme:

> SR 24 Recommend industry associations and flight training units promote VFR [visual flight rules] Air Taxi flying as a career at the high school level, specifically targeting northern or remote communities.
>
> IA 24 Recommend air operators hire high school students to work in the summer to gain experience in Air Taxi operations.[48]

4.2.2.5 Summary

Table 7. Availability of qualified personnel: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• Commercial aviation is experiencing a significant number of retirements. • Commercial aviation is competing with other industries for new entrants. • There is a limited pool of experienced pilots and AMEs. • It is difficult to find personnel willing to work in small communities, because young people want to live and work in larger centres. • Having a large proportion of inexperienced personnel within one company poses a higher risk to safety. • Lower pay and benefits hinder recruitment and retention of personnel. • The high turnover of pilots puts a strain on day-to-day operations because experienced pilots are providing training as well as doing their regular work. • The drain of experienced personnel reduces the resources available for training.	There is a risk that there will be a shortage of qualified personnel for air-taxi operators to conduct business safely.	• Requirements for experienced personnel should be revisited. • Customers should be made aware that requiring a minimum number of hours of flight time (e.g., 2000 hours) is not necessarily a good approach to risk mitigation. • The flight time required to obtain an ATPL could be increased, to prevent the drain of experienced pilots. • Training standards among different flight schools and colleges need to be made consistent. • Better training is needed for pilots in coastal flying and in decision making specific to weather-related issues. • Trade schools need to prepare apprentice AMEs for the challenges of northern or remote work, because most new AMEs are unaware of what to expect when working in such locations. • Increased mentoring could be provided for new personnel: possibly an industry-wide mentorship program for their first 1000 flight hours.

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48 Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1998), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

Hazards	Description of risk	What operators said
		• Procedures should be reviewed and pilots trained throughout the year to maintain a high level of competency. • Training should be competency- or performance-based. • Training should be given in pilot decision making and crew resource management, IFR approaches, risk management, and a special qualification for floatplanes beyond the seaplane rating. • Pilot competencies for single-pilot, high-performance aircraft should be regulated. • Policies to prevent "green-on-green" crew pairing should be required. • Pay should be fair for the type of work being done. • Training pilots should be paid better. • TC inspectors should conduct more check rides. • Junior TC inspectors need mentoring by senior inspectors.

Conclusion: The availability of qualified personnel is critical to safety; competent personnel are a key component in managing risk.

4.2.3 Safety theme: Airborne collision avoidance

4.2.3.1 Background

Maintaining separation—keeping an aircraft a minimum distance from other aircraft—is critical to prevent collisions and other accidents. Air traffic control plays a key role in maintaining separation; however, around aerodromes that do not have air traffic control (known as uncontrolled aerodromes), special procedures are needed to maintain separation effectively. These procedures are found in the *Transport Canada Aeronautical Information Manual* (TC AIM).

In the absence of air traffic control, the best way to avoid collisions is to see and be seen, and to hear and be heard (via broadcasting on radio frequencies); consequently, there is a safety benefit to ensuring that all traffic monitors the same frequency.

According to Transport Canada's *Aviation Safety Letter*:

> Risk factors associated with flight in the vicinity of uncontrolled aerodromes can be greatly reduced with the application of acute visual and aural awareness combined with familiarity with, and adherence to, the established rules and procedures. Used

> in conjunction with timely position reports and the communication of intentions between aircraft, these defences build and reinforce situational awareness and, ultimately, serve to assist aircraft in their avoidance of one another.[49]

Despite these procedures and measures to ensure broadcast communication, aircraft operating under visual flight rules (VFR) have collided or narrowly avoided collision in uncontrolled airspace. To be effective, communications procedures must be followed by all aircraft in uncontrolled airspace.

In addition to the challenges posed by the uncontrolled airspace around remote aerodromes, a significant mix of IFR and VFR traffic at controlled airports creates complexity that can increase the risk of collision.

4.2.3.2 What operators told us about this theme

4.2.3.2.1 Safety issues associated with this theme

Among the highest-risk safety issues identified by operators were flights carried out in areas with uncontrolled airspace and/or high traffic.

This theme emerged in discussions of operations into and out of uncontrolled aerodromes, especially those in northern and other remote locations. Communications can be limited at such aerodromes, and information about weather and runway conditions is often lacking. In addition, navigation services at these locations were said to be insufficient.

Approaches with a lack of vertical guidance for shorter runways and approaches without area navigation (RNAV) can be safety issues. NAV CANADA was criticized by some operators for the perceived slow pace of adding RNAV approaches at northern aerodromes.

Radio communications are a clear safety issue: operators said there was often congestion on mandatory frequencies, and some operators were not reporting on mandatory frequencies as required.

Airspace congestion due to a mix of VFR and IFR traffic was identified as a hazard, and the floatplane traffic operating near an airport with continuous IFR operations, as at Vancouver International Airport (CYVR), was mentioned specifically. Operators expressed concern that NAV CANADA staffing levels at CYVR might be insufficient to manage all VFR traffic effectively. They were also concerned that the procedures to avoid flight paths of IFR traffic at CYVR could result in VFR aircraft flying over water during sea states that make it unsafe to perform a forced landing in an emergency.

4.2.3.2.2 How operators are managing these issues

Operators have taken several measures to avoid collisions in mixed IFR/VFR traffic and in remote aerodromes.

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49 M. Paddon, "See, Hear, Comply and Avoid — Maintaining Separation at Uncontrolled Aerodromes," *Aviation Safety Letter* (Issue 3/2008), at https://www.tc.gc.ca/eng/civilaviation/publications/tp185-3-08-operations-3923.htm (last accessed on 01 October 2019).

Because of the problem of a lack of radio reporting at uncontrolled aerodromes, several operators ensure pilots follow the requirements for position reporting on the applicable mandatory frequency.

Operators that fly in the same area told the safety issue investigation (SII) team that they worked together to ensure that everyone was aware of when and where flights will be carried out.

Additionally, to mitigate the risks associated with low-level departure routes in place at CYVR to separate IFR and VFR traffic, floatplane operators have established limits of wind conditions in which they will fly, to avoid flying a low-altitude departure route over rough seas in the CYVR area.

4.2.3.2.3 What operators said could be done

Operators suggested implementing automatic dependent surveillance – broadcast (ADS-B), a surveillance technology in which aircraft position is determined by satellite navigation and broadcast periodically, enabling it to be tracked.

Operators also suggested that, because of current radio frequency congestion, more frequencies are needed for use in uncontrolled airspace. Measures are also required to ensure that pilots follow the requirements to report on the applicable mandatory frequency.

For the problem of mixed IFR/VFR traffic in the vicinity of aerodromes with a water aerodrome close by, operators suggested that procedures should be developed and existing ones reviewed for VFR traffic to avoid conflicts with IFR traffic or other VFR traffic in congested areas.

Many of the mitigations suggested for infrastructure issues at remote aerodromes (see **Section 4.2.1 Safety theme: Aerodromes and infrastructure**) would also contribute to collision avoidance.

4.2.3.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period revealed 3 findings involving a collision. All of these findings related to problems with broadcast information at uncontrolled aerodromes:

- In a 2004 occurrence, pilots were not using the same frequency.[50]
- In a 2008 occurrence, the pilot had only a single VHF-AM radio.[51]
- In a 2007 occurrence, not broadcasting an aircraft position contributed to a collision.[52]

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50 TSB Aviation Investigation Report A04P0057.

51 TSB Aviation Investigation Report A08P0353.

52 TSB Aviation Investigation Report A07A0118.

4.2.3.4 Other reviews and safety studies

4.2.3.4.1 Transport Canada Safety of Air Taxi Operations Task Force

The TC SATOPS Final Report, published in 1998, made 1 recommendation relevant to this theme:

> SR 20 Recommend NAV CANADA promote the benefits of having Community Aerodrome Radio Station Observers/Communicators in northern aerodromes where the service is not presently established.[53]

4.2.3.5 Summary

Table 8. Airborne collision avoidance: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• There are no air navigation services in some areas of operation. • In some areas of uncontrolled airspace, there are not enough radio frequencies to prevent frequency congestion. • There is a risk of traffic congestion related to a mix of IFR and VFR operations being carried out in the same area. • Communication procedures in uncontrolled airspace are not consistently being followed.	The absence of air navigation services in some areas and non-adherence to established communication procedures may result in a reduced level of safety.	• ADS-B should be implemented. • More frequencies are needed for uncontrolled airspace. • In areas of mixed IFR/VFR traffic, new procedures need to be developed and existing ones reviewed for congested areas. • Many of the mitigations suggested for infrastructure issues would also contribute to collision avoidance. • Pilots must report on the applicable mandatory frequency.

Conclusion: Traffic avoidance services and procedures are critical elements to mitigate the risk of collision.

4.2.4 Safety theme: Interruptions and distractions

4.2.4.1 Background

Interruptions and distractions can make it more difficult to complete a task, primarily because they break the flow of the specific activity in progress. Personnel may feel that they are rushed and have to deal with competing tasks of varying priority. Interruptions and distractions can result in an increase in workload, even when the actual task load is reasonable and steady. As a result, personnel will focus on one or a few tasks while ignoring others—a typical response when dealing with excessive workload.

In aviation, interruptions and distractions can affect pilots during flights, aircraft walkarounds, and weather or safety briefings. They can also affect maintenance personnel who also perform safety-critical tasks.

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[53] Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1993), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

4.2.4.2 What operators told us about this theme

4.2.4.2.1 Safety issues associated with this theme

One of the highest-risk safety issues that operators identified was the effect of distractions on maintenance, as these can lead to mistakes in maintenance tasks, affecting safety. For example, aircraft maintenance engineers (AMEs) using cellphones on the maintenance floor can distract from their performance of safety-critical maintenance functions.

Other examples of interruptions and distractions were also raised:

- Pilots using cellphones in the cockpit while manoeuvring on the ground or in flight, which can distract from safety-critical activities
- Distractions and interruptions during weather and safety briefings, which can affect attention to and comprehension of information being conveyed.
- During flight planning, interruptions and distractions can result in a critical item being overlooked.
- Pilots can be distracted by passenger behaviour, including passengers who are under the influence of alcohol.

4.2.4.2.2 How operators are managing these issues

In discussing ways to manage interruptions and distractions, companies mentioned fostering an environment in which personnel are encouraged to take the time needed to do the job properly.

Most of the other mitigations involve cellphones. Some companies have “no cellphone” policies, where cellphones are not allowed on the hangar floor and must be left in a locker or in the break room. Other companies mentioned managing cellphone use during shift hours in a more general way and minimizing the use of cellphones during flights.

To manage the effects of distractions on maintenance, many companies use a dual-inspection process for most maintenance jobs. This provides an independent check of critical maintenance tasks that go beyond the number of dual-inspection checks required by regulation.

4.2.4.2.3 What operators said could be done

Companies that do not have a cellphone policy or strategy in place must develop such policies to deal with business or personal cellphone use, both on the maintenance floor and during flights.

4.2.4.3 Previous TSB findings and recommendations on this theme

A review of the 167 occurrences with published investigation reports during the study period revealed 2 findings related to distraction:

- In a 2008 occurrence involving loss of control and collision with terrain, a pilot did not remove the engine cover before the flight, probably as a result of distractions during his normal routine.[54]
- In a 2010 occurrence involving fuel starvation and a forced landing, the pilot became distracted while communicating with the Flight Information Centre by cellphone, did not prioritize an electrical failure and navigation, and consequently became lost.[55]

4.2.4.4 Summary

Table 9. Interruptions and distractions: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• There are not enough adequate policies, procedures and programs in place to reduce the likelihood of personnel being interrupted and/or distracted. • The use of cellphones (for business or personal purposes) while performing maintenance tasks or operating an aircraft can result in distraction during safety-critical activities.	Interruptions and distractions can result in an increase in workload: as a result, personnel focus on one or a few tasks while ignoring others.	A cellphone policy or strategy should be implemented to deal with cellphone use (both business and personal) on the maintenance floor and during flights

Conclusion: Well-developed company policies and standard operating procedures are critical to reduce the likelihood and effects of personnel being interrupted and/or distracted.

4.2.5 Safety theme: Medical evacuation operations

4.2.5.1 Background

Almost every province and territory uses some type of air ambulance (medical evacuation or MEDEVAC) service: the geography and population distribution of Canada have led naturally to the use of such services.[56] Although most MEDEVAC flights are routine transfers of stabilized patients to higher-care facilities, some are urgent missions with life-or-death consequences, and they are often conducted at night or in adverse weather.[57] These types of operations therefore pose 2 types of hazard: physical hazards associated with landing at unprepared sites and at helipads and/or operating into remote aerodromes in adverse weather; and the psychological hazard of pressure to carry out the flight, even when weather conditions are marginal.

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54 TSB Aviation Investigation Report A08P0244.

55 TSB Aviation Investigation Report A10C0060.

56 Transport Canada, TP 10839, *Guide to Air Ambulance Operations,* "Background," at https://www.tc.gc.ca/eng/civilaviation/publications/tp10839-section3-1592.htm (last accessed on 01 October 2019).

57 Ibid., "Personnel."

4.2.5.2 What operators told us about this theme

4.2.5.2.1 Safety issues associated with this theme

Operators told the safety issue investigation (SII) team that many aspects of both airplane and helicopter MEDEVAC operations were among the highest-risk issues. Crews performing MEDEVAC flights may be influenced by the seriousness of a patient's condition when deciding to accept the flight, which may override information relevant to flight safety and may affect other operational decisions. Furthermore, flight crews receive little to no training on the potentially traumatic or distressing circumstances they may encounter when transporting patients.

As with other air-taxi operations, MEDEVAC operations can involve airplanes flying into remote communities and helicopters landing at unprepared sites. However, helicopters on MEDEVAC operations face additional hazards on the scene, such as power lines, vehicles, and trees. When a helicopter arrives at a hospital, the pilot makes a visual flight rules (VFR) landing on the hospital helipad, where there may be structures (e.g., buildings, power lines) that pose hazards if the winds and weather are challenging. The MEDEVAC crew also needs to coordinate with ground ambulances to transfer the patient to the hospital building.

Other aspects of MEDEVAC operations also contribute to risk. For example, at some operators, the flight crew start their duty day when they are called for a flight, but they may be on call for many hours before receiving the call, creating a risk of fatigue.

Some operators questioned the safety of using single-engine airplanes for all-weather MEDEVAC operations.

As well, some operators need to reconfigure the interior of the aircraft before performing a MEDEVAC flight. This can introduce scheduling challenges and requires performing additional steps, including changing the weight-and-balance calculations based on configuration adjustments.

4.2.5.2.2 How operators are managing these issues

Many operators have taken steps to mitigate these issues, mainly through procedures, crew preparation, and maintenance.

Procedures specific to medical evacuation operations

- In response to scene calls, not carrying out night landings at unprepared sites.
- At the site of a scene call, performing both high- and low-reconnaissance flights before landing.
- Carrying out night landings at a helipad only when the helipad has adequate lighting.
- Maintaining a clear separation between the medical and the flight operations, to prevent medical issues from affecting flight crew attention and decision making.
- Treating flight medics as part of the crew: giving them a pre-flight briefing and keeping them informed about the progress of the flight.

- Having the flight crew involve the dispatcher and flight medics when deciding whether to accept the flight.
- Having dedicated aircraft for MEDEVAC flights; therefore, the flight crew are scheduled for that specific operation and the aircraft are configured with all MEDEVAC equipment and are ready to be dispatched when a call comes in.
- Using a tracking process that records when and why a flight is declined (e.g., weather conditions, an unserviceable aircraft) so that trends can be analyzed.

General safety procedures

- Carrying out crew briefings at the start of the shift.
- Performing all flights under instrument flight rules.
- Using a trained dispatcher on all flights.
- Using a satellite tracking system to track the progress of flights.

Crew preparation

- Providing personnel with additional time off between duty periods if requested.
- Providing flight crews with training in critical incident stress management, human factors, and air medical resource management.
- Reviewing overtime reports to identify situations that could result in fatigue.

Maintenance

- Maintaining a spare aircraft at all times to be available for MEDEVAC use.

4.2.5.2.3 What operators said could be done

Operators said that the duty day for MEDEVAC flight crews should include the time during which the pilot is on call. Some operators already do this, but many do not.

Operators also said that a dedicated radio frequency is required so that MEDEVAC flight crews can communicate directly with first responders (police, fire) on the ground when going to a scene call. Among other benefits, this would allow first responders to give flight crew valuable information about the landing scene.

4.2.5.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period revealed few findings specific to MEDEVAC operations.

- In a 2014 occurrence, findings were made relating to reconfiguring the aircraft for MEDEVAC operations.[58]

[58] TSB Aviation Investigation Report A14A0067.

4.2.5.4 Other reviews and safety studies

4.2.5.4.1 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) Final Report, published in 1998, made 1 recommendation relevant to this theme:

> SR 35 Recommend that air operators and pilots not be told of the patient's critical condition prior to or during a MEDEVAC flight, only cabin requirements, such as temperature or cabin altitude, should be discussed.[59]

4.2.5.5 Summary

Table 10. MEDEVAC operations: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• MEDEVAC operations often involve unfamiliar areas or locations. • MEDEVAC helicopter operations often involve the need to communicate directly with first responders (police, fire) on the ground, yet there may be no effective means of doing so. • MEDEVAC operations may involve responding to life-and-death situations. • The seriousness of a patient's condition may affect operational decision making.	Operational decision making is more complex and may be degraded when a pilot or a flight crew takes into consideration a patient's condition.	• Duty day for MEDEVAC flight crews should include the time on call. • A dedicated radio frequency is required so that MEDEVAC flight crews can communicate directly with first responders on scene.

Conclusion: The unique nature of conducting MEDEVAC operations can place a great deal of stress on pilots, which may have a negative influence on their decision making.

4.2.6 Safety theme: Night operations

4.2.6.1 Background

Night flying is inherently riskier than flying during the day: there are fewer visual cues when taking off or landing in the dark, and pilots are vulnerable to illusions (e.g., black-hole illusions) that can lead to accidents. There is an increased risk of specific types of accidents at night, such as inadvertent visual flight rules (VFR) flight into instrument meteorological conditions (IMC) and controlled flight into terrain (CFIT).[60] For VFR flight at night, current regulations do not define a visual reference to the surface: as a result, pilots may continue

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59 Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1998), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

60 Transport Canada (TC), TP 14112, *System Safety Summer Briefing Kit, Hazards Associated with Flying at Night* [slide presentation], at https://www.tc.gc.ca/eng/civilaviation/publications/tp14112-hazards-ppt-6035.htm (last accessed on 01 October 2019).

these VFR flights into areas with no cultural or ambient lighting from urban areas and other developments.

4.2.6.2 What operators told us about this theme

4.2.6.2.1 Safety issues associated with this theme

When asked to identify the issues that posed the highest risk to air-taxi operations, several operators identified VFR night flights as one such issue, because of the inherent risks associated with these flights. Specifically, in areas with limited cultural lighting, flight crews may not have adequate visual references to safely conduct VFR flights at night.

4.2.6.2.2 How operators are managing these issues

Operators identified many mitigations they use to manage night flying; these mitigations relate to crew, training, procedures, and equipment.

Crew

- Using 2 crew members for flights; both pilots may be qualified as captains.
- Providing crew with adequate rest periods and suitable facilities for resting.

Training

- Providing specific training for conducting night operations.
- Providing additional training that exceeds the requirements for pilot proficiency under regulations.
- Providing simulator training when a simulator is available.

Procedures

- Developing robust standard operating procedures (SOPs) and ensuring adherence to them.
- Carrying out all night flights under instrument flight rules (IFR), regardless of the weather conditions.
- Conducting briefings at the beginning of a shift to review flight safety information, such as an overall look at the weather (pilot reports [PIREPs], known hazards, equipment status, etc.).

Equipment

- Equipping aircraft with high-powered landing lights.
- Requesting lighting improvements at northern airports.
- Equipping aircraft with global positioning systems (GPS) and terrain awareness and warning systems (TAWS).

4.2.6.2.3 What operators said could be done

Operators said that remote airports should be equipped with GPS approaches; some airports currently do not have any published GPS approaches.

Operators also indicated that the quality and timeliness of reporting on weather at remote airports with limited services needs to be improved, due to the higher risks of loss of visual references at night. They also indicated that reporting on airport conditions at remote airports with limited services needs to be improved.

Operators asked that a standard minimum runway length be defined for remote northern aerodromes.

For helicopter operations at night, some medical evacuation (MEDEVAC) operators suggested that night-vision goggles be used.

4.2.6.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period revealed 12 findings relevant to night operations in the air-taxi sector. Most of these involved visual illusions, disorientation, or loss of visual reference affecting pilot judgment.[61]

Other findings specifically mentioned problems at aerodromes, including limited visual cues and navigational aids.[62] Others mentioned out-of-date recency for night flights,[63] absence of SOPs for night flights,[64] and the absence of a definition of visual reference to the surface in regulations.[65]

The TSB has 1 active recommendation relevant to this theme:

> the Department of Transport amend the regulations to clearly define the visual references (including lighting considerations and/or alternative means) required to reduce the risks associated with night visual flight rules flight.
>
> **TSB Recommendation A16-08**

4.2.6.4 Summary

Table 11. Night operations: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• Some remote aerodromes have fewer and more basic facilities and infrastructure.	Conducting night operations with limited visual references may result in a reduced level of safety.	• Remote airports should be equipped with GPS approaches.

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61 TSB aviation investigation reports A01C0236, A01W0261, A05O0225, A08O0029, A08C0237, A09C0172, and A13H0001.

62 TSB Aviation Investigation Report A07C0001.

63 TSB Aviation Investigation Report A01W0261.

64 TSB Aviation Investigation Report A13H0001.

65 Ibid.

• Conducting night operations into remote aerodromes and other sites with few visual references poses a hazard.		• The quality and timeliness of weather reporting and reporting on airport conditions at remote airports should be improved. • A standard minimum runway length should be defined for remote northern aerodromes. • Night-vision goggles should be used for helicopter operations.

Conclusion: Adequate visual references during night operations are critical to ensuring the safety of the flight.

4.2.7 Safety theme: On-board technology

4.2.7.1 Background

Automation incorporated into aviation has become one of the main resources for making critical decisions and a means to enhance safety. Air-taxi operators are using a wide range of technology, from basic global positioning systems (GPSs) to autopilot systems and full glass cockpits.[66] However, many aircraft used in this sector are still equipped with traditional instruments and basic systems, and some were built more than 70 years ago.

Making changes to older aircraft, such as updating navigation systems or installing a glass cockpit, requires a change to their original type design. To accomplish this, Transport Canada (TC) requires that a supplemental type certificate (STC) be developed, which can be a costly and burdensome process. For some of the smaller operators, which might operate 1 or 2 older aircraft, the costs associated with these changes can be prohibitive.

While the main safety issue is a lack of on-board technology, some operations have a very high level of automation, in which case the issue is *over-reliance* on technology. Pilots who routinely fly aircraft with automated systems may feel fully confident in their ability to control the aircraft's path only when using such systems. Thus, they may lack confidence if any of the systems become unavailable or if they have to fly and manage the aircraft manually.

This lack of confidence usually stems from a combination of inadequate knowledge of the automated systems and a lack of competence in manual flying and aircraft management.[67] For example, pilots who rely too heavily on GPS may depend on it to perform the entire navigation task, and their navigation skills, such as map-reading and flight planning, may deteriorate as a result. This can lead to unsafe conditions: for example, a pilot operating in

66 A glass cockpit is an aircraft cockpit that features electronic instrument displays rather than mechanical gauges.

67 Skybrary, "Cockpit Automation — Advantages and Safety Challenges," at http://www.skybrary.aero/index.php/Cockpit_Automation_-_Advantages_and_Safety_Challenges (last accessed on 01 October 2019).

reduced visibility conditions and relying on the GPS for navigation information may not watch for traffic and obstacles.

4.2.7.2 What operators told us about this theme

4.2.7.2.1 Safety issues associated with this theme

No operators identified this theme specifically among the highest risks to safety. However, it was raised in other contexts.

Adoption of new technologies in this sector is in flux, and operators described a confusing situation in which the technology installed may be inconsistent across operators' fleets and the sector.

For example, operators mentioned that not all aircraft are equipped with transponders. Although they are not required, transponders would be beneficial to other aircraft with a traffic-alert and collision-avoidance system (TCAS) installed.

As well, operators often install new technology only if there is a clear cost benefit. This means that technology that could improve safety may not be available, and pilots may have to adapt to different technology used on different aircraft. This in turn affects their performance and decision making. Furthermore, pilots with extensive experience using traditional instruments may find it challenging to use new technology.

On the other hand, over-reliance on new technology can also lead to risk. Operators expressed concern that reliance on automation was causing degradation of basic piloting skills. This problem begins in flight schools, where new pilots may be trained in aircraft with glass cockpits. Although these modern instruments provide information similar to the information provided by traditional instruments, the glass cockpit does not prepare new pilots for flying using traditional instruments, which is likely what they will be exposed to early in their careers. Many comments related to over-reliance on navigation using GPS, which operators feel has resulted in loss of basic map-reading skills and may contribute to flight into adverse weather conditions ("pushing the weather").

4.2.7.2.2 How operators are managing these issues

Some companies have proactively taken steps to mitigate these issues. One common mitigation is to install new technology to enhance safety, such as

- GPS,
- terrain awareness and warning systems (TAWS),
- TCAS or airborne collision avoidance systems (ACAS),
- Mode C transponders,
- digital engine instrumentation and digitized fuel information,

- electronic flight bags,[68] and
- computerized load control for weight-and-balance calculations.

In addition, some operators are retrofitting their aircraft or purchasing new aircraft with glass cockpits.

Some operators are using computer applications for flight planning, charts, weather, airport information, document management, and flight logging.

A few operators have implemented or are implementing the use of night-vision goggles for their helicopter operations.

Some operators indicated that they installed pulsed lighting systems on aircraft to make them more conspicuous to other traffic and to prevent birdstrikes.

Some operators have installed wire cutters on helicopters to mitigate the risks of wire strikes during low-level operations.

4.2.7.2.3 What operators said could be done

Operators made multiple comments to the effect that regulations should make some on-board technology mandatory for all aircraft in this sector, including TCAS, transponders, and automatic dependent surveillance - broadcast (ADS-B) systems. They also called on the regulator to provide updated guidance for implementation and operation of night-vision goggles.

Operators stated that there needs to be an emphasis on basic manual flying and navigation and map reading skills, from flight school through to required recurrent training.

Many operators have aircraft of the same make and model that differ in the placement or position of instruments, switches, etc. There is a need to standardize these cockpit layouts to help flight crews perform reliably when they operate more than one aircraft of the same model.

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68 An electronic flight bag (EFB) is an electronic display system intended primarily for cockpit or cabin use that can display a variety of aviation data or perform calculations such as performance data and fuel calculations. (Source: Transport Canada, TP 185, *Aviation Safety Letter*, Issue 1/2013, "Pre-flight," at https://www.tc.gc.ca/eng/civilaviation/publications/tp185-6465.htm#copa [last accessed on 01 October 2019]).

4.2.7.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period revealed 12 findings as to risk that are relevant to on-board technology. Many of these findings related to the absence of technology that was not required by regulation for air-taxi operations, yet could reduce the risk of an accident, such as TCAS,[69] ground proximity warning system or radio altimeter,[70]terrain avoidance equipment or TAWS,[71] and an instantaneous vertical speed indicator.[72]

Many findings also involved reliance on or problems with GPS that contributed to risk.[73]

Technology that could enhance safety in the air-taxi sector

- Terrain awareness and warning systems
- Traffic-alert and collision-avoidance systems
- GPS
- Electronic flight bags
- Automated flight following
- Transponders
- Glass cockpits
- Tools to calculate weight and balance
- Angle-of-attack indicators
- Lightweight recorders
- ADS-B
- Night-vision goggles
- Stall warning systems in some older aircraft

4.2.7.4 Other reviews and safety studies

4.2.7.4.1 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) Final Report, published in 1998, made 2 recommendations relevant to this theme:

SR 25	Recommend flight training units emphasize to commercial students the importance of learning and maintaining VFR [visual flight rules] navigation skills without the use of electronic navigation aids.
SR 31	Recommend Transport Canada continue to publish articles in the Aviation Safety Letter and Vortex newsletters about the safe, proper use of Global Positioning System (GPS) and the hazards associated with its misuse.[74]

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69 TSB Aviation Investigation Report A03P0113.

70 TSB Aviation Investigation Report A03Q0151.

71 TSB aviation investigation reports A03W0202, A06W0139, A10A0056, and A13H0001.

72 TSB Aviation Investigation Report A04C0190.

73 TSB aviation investigation reports A07C0001, A07Q0213, A08P0353, A10A0122, and A10O0145.

74 Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1998), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

4.2.7.5 Summary

Table 12. On-board technology: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• A wide variety of aircraft types within an operator's fleet may make it more complicated to install on-board technology. • There is an absence of requirements for on-board technology. • The Transport Canada (TC) process for obtaining approval to install technology is cumbersome. • The expense of purchasing the technology and having it installed may not be cost-effective. • There are various challenges when pilots transition to and from advanced cockpits. • Pilots may become over-reliant on the technology.	• The absence of on-board technology may result in some operators not receiving the safety benefits of this technology. • If this technology is installed, over-reliance on it may lead to a degradation of basic piloting skills.	• Regulations should require mandatory TCAS, transponders, and ADS-B systems. • TC should provide updated guidance for implementation and operation of night-vision goggles. • There needs to be an emphasis on basic manual flying and navigation/map-reading skills, from initial training to required recurrent training. • Cockpit layouts in a given model of aircraft should be standardized.

Conclusion: Improved technology, if incorporated into an operation, has significant potential to enhance safety in air-taxi operations.

4.2.8 Safety theme: Survivability

4.2.8.1 Background

The chances of being involved in an aircraft accident are low when compared with other forms of travel, and many of these accidents are survivable. However, in order to survive, the occupants of the aircraft must be protected from injury due to the impact, evacuate the aircraft, and cope with the environmental conditions until they are located by first responders.

Survivability during an impact is increased by improved crashworthiness. A number of changes to modern aircraft, such as structural enhancements, changes to the seat designs, and interior flammability standards, have given passengers a better chance of surviving the impact and escaping a post-crash fire. However, in the air-taxi industry, many aircraft are older and lack these features.

Survivability is also increased when the flight crew and passengers

- know what to do ahead of time (briefings, training);
- take the proper steps during the emergency (brace positions, locating and operating exits, post-evacuation procedures);
- wear appropriate safety equipment (e.g., helmets for helicopter pilots, personal flotation devices [PFDs] in floatplanes, seatbelts, and shoulder harnesses); and

- have the necessary survival equipment and know how to use it (e.g., emergency locator transmitters [ELTs], life rafts, PFDs).

Passengers typically pay little attention to the pre-departure briefings and to the safety-features cards. As an example, a 2006 study by the Australian Transport Safety Bureau, entitled *Public Attitudes, Perceptions and Behaviours Towards Cabin Safety Communications*, found that 65% of passengers do not read the card.[75] Every aircraft has different safety features and procedures; therefore, passengers need to pay attention to the safety aids provided, as this information could be essential during an emergency. Operational measures to improve survivability have focused on pre-departure and pre-landing briefings, safety-features cards, and signage as means of conveying safety and emergency information to passengers.

Finally, once the occupants have evacuated the aircraft, they need to be found and rescued in a timely manner. Aircraft are equipped with ELTs, and the signals from these devices are monitored. To be effective, the ELT must survive the impact, activate, and be able to transmit a signal. Many accidents have demonstrated the vulnerability of ELTs in these areas.

Survivability of aircraft accidents is of particular concern in floatplane accidents, which are a major cause of deaths in the air-taxi sector. According to Transport Canada (TC),[76] there were 168 fatalities in floatplane accidents from 1976 to 1990, or an average of 11.2 per year. From 1990 to 2009, this rate has fallen, with 77 fatalities or an average of 3.85 per year. All of the accidents in the preceding review were considered survivable, but in no case were passengers or crew wearing a PFD at the time of the accident, although several survivors donned a PFD after the floatplane had ditched.

The most significant difference in cause of death in floatplanes compared with landplanes is the frequency of drowning. In many water accidents, aircraft come to rest upside down. The level of injuries will affect the occupants' ability to exit the aircraft. Thus, the key to survival is for crew and passengers to ensure that they are using restraints properly, to be aware of the location of the exits and how they operate, to wear a PFD and know how to inflate it after exiting, and to exit the aircraft as quickly as possible.

4.2.8.2 What operators and Transport Canada inspectors told us about this theme

4.2.8.2.1 Safety issues associated with this theme

Operators did not identify any aspects of survivability in the issues that they considered to pose the highest risk to safety. However, floatplane operators did discuss proposed amendments to regulations intended to address survivability aspects.

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[75] Australian Transport Safety Bureau, Research and Analysis Report, Aviation Safety Research Grant – B2004/0238, *Public Attitudes, Perceptions and Behaviours Towards Cabin Safety Communications* (June 2006), p. 20.

[76] Transport Canada (TC), Aviation Safety Analysis Policy and Regulatory Services [presentation], "Float Plane Safety Study" (March 2010).

Several floatplane operators were concerned that wearing a PFD might prevent crew or passengers from moving around freely or exiting the aircraft if the PFD was activated before or while exiting. They also said that amendments to the *Canadian Aviation Regulations* (CARs) requiring training in underwater egress for commercial pilots were unlikely to be well accepted across the floatplane industry. This sentiment was voiced especially by more seasoned floatplane operators, who felt this type of training would be unnecessary.

Some floatplane operators identified issues with egress that are unique to certain types of aircraft.

TC inspectors interviewed for this investigation expressed concern that the quality of existing passenger briefings in some floatplane operations may be inconsistent within a single operator and among different operators.

Amendments to the *Canadian Aviation Regulations* (CARs), announced on 25 February 2019, will require passengers and crew to wear a PFD when on board a seaplane operating on or above the water and apply to operations under Subpart 703.* The amendments will also require pilots of fixed-wing commercial seaplanes to take initial and recurrent training in underwater egress, affecting operations under subparts 703 and 704. Operators have 18 months to comply with the new PFD regulations and 36 months to comply with the egress training requirement.

When the interviews were being conducted for the SII, these amendments were at the proposal stage. They had resulted from a TSB recommendation, made in March 2011 following an occurrence involving a floatplane,** that all occupants of commercial seaplanes wear a PFD during flight.

* Government of Canada, Canada Gazette, Part II, Vol. 153, No. 5 (06 March 2019), Regulations Amending the Canadian Aviation Regulations (Parts I, VI and VII — Seaplane Operations).

** TSB Aviation Investigation Report A09P0397.

In helicopter operations, some operators were concerned about the inconsistencies surrounding the pilot's use of a helmet, as well as customers' perception of helmet use.

4.2.8.2.2 How operators are managing these issues

Operators manage issues related to survivability by taking action with regard to briefings, PFDs and other flotation devices, modified exits and their operation, and tracking and locating aircraft, among other things.

Some operators highlighted actions taken by their clients: for example, one operator stated that some of its clients required their personnel to wear PFDs on board, and that these personnel had received additional training.

Briefings

- Including a PFD demonstration and mock-up to help passengers understand how to use the PFD before boarding the aircraft.
- Adding a passenger safety briefing video that reinforces the need for passengers to not inflate their PFDs until they have exited the aircraft.
- Updating passenger briefings to include information about PFDs and exiting the aircraft.

PFDs and other flotation devices

- Requiring all passengers to wear PFDs while on board the aircraft.
- When flying helicopters over water for any distance from shore, providing life rafts and immersion suits, and ensuring that PFDs are worn or are available.

Modified exits

- Modifying the door handles on de Havilland DHC-2 Beaver aircraft and installing pop-out windows to make it easier for occupants to exit the aircraft.

Tracking and locating aircraft

- Installing 406 MHz ELTs or carrying SPOT Personal Trackers, a satellite GPS-based messenger device, on aircraft.
- Installing a satellite tracking system.
- Equipping aircraft with a satellite telephone for communication from remote areas.

Other

- Instituting policies that require helicopter pilots to wear helmets, or making them optional but providing incentives for pilots to use them, such as purchase plans.
- Educating clients on why the helicopter pilot is wearing a helmet but passengers are not required to wear a helmet.

4.2.8.2.3 What operators said could be done

Operators suggested the following:

- Pop-out windows should be installed whenever applicable and available for the type of aircraft.
- More thorough safety briefings should be provided for passengers before departure.
- Clear requirements are needed to ensure that all PFDs remain certified after continuous use.
- More research is required before the new PFD regulations are implemented.
- A helmet policy should make helmet use mandatory for helicopter flight crew.

4.2.8.3 Previous TSB findings and recommendations on this theme

4.2.8.3.1 TSB findings

A review of the 167 TSB occurrences with published investigation reports during the study period revealed more than 100 findings pertaining to occupants' survival of an accident. Findings were made in relation to survival equipment, passenger briefings, ELTs, PFDs, cargo in the cabin, helmet use in helicopter operations, and seatbelts.

Survival equipment

Some aircraft did not have the required survival equipment on board.[77] In other cases, the equipment was on board, but occupants had difficulty locating or accessing it.[78] In a few cases, the passengers' ability to use the survival equipment helped ensure their survival.[79]

Passenger briefings

Incomplete briefings or inadequate safety features cards were identified in a large number of findings.[80] Passengers who do not have critical safety-related information may have more difficulty exiting the aircraft after an accident.

Emergency locator transmitters

An investigation into a 2009 occurrence found a situation in which an ELT helped to locate an accident site in a timely manner.[81] However, far more findings have involved situations in which no signal had been transmitted or received because of limitations of the ELT, including how the ELT was secured to the aircraft, the built-in delay in transmitting the first signal, and the antenna separating from the ELT during the accident.[82]

Personal flotation devices

A number of reports involved the risk of drowning when an aircraft collided with water and occupants were not wearing PFDs, even if they were provided.[83] In some occurrences, PFDs were not provided or were not easily accessible.[84]

Cargo in cabin

A large number of investigations noted that cargo or baggage in the cabin was not secured and became a safety hazard during an accident.[85] Loose items can become projectiles and can injure flight crew or passengers, sometimes fatally; they can also make it difficult to exit the aircraft.

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77 TSB aviation investigation reports A01C0064, A05A0155, and A07C0119.

78 TSB aviation investigation reports A00Q0006, A00C0099, A01W0190, A05Q0008, and A05A0155.

79 TSB aviation investigation reports A10Q0148 and A14W0181.

80 TSB aviation investigation reports A00Q0006, A04H0001, A04W0114, A05Q0008, A05Q0178, A09P0397, A11C0102, A11Q0136, A11O0166, A12O0071, A12C0154, A14W0181, and A14A0067.

81 TSB Aviation Investigation Report A09C0167.

82 TSB aviation investigation reports A00Q0006, A00C0099, A01W0255, A01W0261, A02P0096, A02C0143, A03C0118, A03Q0151, A03O0341, A04C0098, A04C0190, A05A0155, A07C0082, A07Q0213, A08Q0187, A08P0241, A10C0060, A10A0056, A10Q0111, A10A0122, A10Q0132, A10Q0133, A11P0117, A11Q0136, A11W0151, A12W0031, A13H0001, and A13C0105.

83 TSB aviation investigation reports A01Q0166 and A09P0397.

84 TSB aviation investigation reports A04W0114 and A05Q0178.

85 TSB aviation investigation reports A04W0114, A04Q0196, A05O0225, A06P0095, A07W0003, A10Q0117, A10P0147, and A14A0067.

Helmet use in helicopter operations

Helicopter pilots' not using helmets has been mentioned in a number of findings over the 15-year study period, including as recently as 2013.[86]

Seatbelts

The use of seatbelts has been proven to reduce the risk of injury or death in an accident. Previous investigations have made findings related to flight crews not using the shoulder harness[87] and passengers not using the seatbelt and/or associated shoulder harness.[88] In some cases, occupants were seriously or fatally injured.

4.2.8.3.2 TSB recommendations

Over the years, the TSB has made more than 40 recommendations related to survivability of accidents in air-taxi operations, concerned mainly with measures and flammability standards to prevent in-flight or post-impact fires, comprehensive passenger safety briefings, standards for restraints, and survival equipment. Of these recommendations, 9 are currently active.[89]

4.2.8.4 Other reviews and safety studies

4.2.8.4.1 TSB Safety Study of Survivability in Seaplane Accidents

The TSB *Safety Study of Survivability in Seaplane Accidents*,[90] completed in 1994, resulted in 6 recommendations, which have all been closed.

4.2.8.4.2 Transport Canada Float Plane Safety Study

The objective of the TC *Float Plane Safety Study* was to examine previous and current data regarding floatplane accidents across Canada.[91] It found the following:

- Fatalities were high: 168 from 1976 to 1990, for an average of 11.2 per year.
- The number decreased for 1990 to 2009, with a total of 77 fatalities and an average of 3.85 per year.
- All accidents were deemed survivable.

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86 TSB aviation investigation reports A00W0105, A08A0007, A12W0031, A12W0088, and A13H0001.

87 TSB aviation investigation reports A00P0010, A01W0261, A05Q0178, A08A0007, A12O0071, and A14O0105.

88 TSB aviation investigation reports A01Q0166, A01W0261, A02C0145, A05Q0008, A05Q0178, A06W0104, A08A0095, A10P0147, A11C0102, A12O0071, A14A0067, and A14O0105.

89 TSB recommendations A13-03, A15-02, and A16-01 to A16-07.

90 Transportation Safety Board of Canada, Aviation Safety Study SA9401, *A Safety Study of Survivability in Seaplane Accidents* (Ottawa, 1994), at http://www.bst-tsb.gc.ca/eng/rapports-reports/aviation/etudes-studies/sa9401/sa9401.html (last accessed on 01 October 2019).

91 Transport Canada Aviation Safety Analysis Policy and Regulatory Services [presentation], "Float Plane Safety Study" (March 2010).

- No one was wearing a PFD when an accident occurred.
- Of flight crew and passengers in accidents from 1990 to 2009, 235 survived, and 21 of these survivors had donned their PFD after the accident.
- The aircraft involved in these occurrences were most often the types of aircraft in common use in commercial floatplane operations: Cessna 180, 185, and 206; and de Havilland DHC-2 and DHC-3.

4.2.8.4.3 Fatal and Serious Injury Accidents in Alaska – A Retrospective of the years 2004 through 2009 with Special Emphasis on Post Crash survival

This study of air accidents in Alaska between 2004 and 2009[92] included the following conclusions relevant to this theme:

- 31 lives might have been saved through the installation of air bag seat belts
- 33 lives might have been saved through the use of helmets in tandem seat airplanes, such as Super Cubs
- 28 lives might have been saved with the use of shoulder harnesses, primarily in passenger seats
- 19 lives might have been saved through survival training
- 21 lives could have been saved through the proper use of personal floatation devices in float planes
- 18 lives could have been saved through the use of rescue air bottles to prevent drowning in float plane accidents
- 12 lives could have been saved if the airplane had been equipped with an effective emergency location device, such as a 406 Mhz Emergency Locator Transmitter[93]

4.2.8.4.4 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) Final Report, published in 1998, made 2 recommendations relevant to this theme:

SR 52 Recommend Transport Canada develop a brochure outlining underwater egress procedures that air operators can provide to their passengers and clients.

IA 52 Recommend float-plane pilots and helicopter pilots operating over water include information on underwater egress procedures in the passenger briefing.[94]

[92] K. W. Williams, DOT/FAA/AM-11/20, *A Human Factors Analysis of Fatal and Serious Injury Accidents in Alaska, 2004–2009* (Civil Aerospace Medical Institute, Federal Aviation Administration, December 2011).

[93] Federal Aviation Administration, Aviation Safety, Alaskan Region, Fatal and Serious Injury Accidents in Alaska – A Retrospective of the years 2004 through 2009 with Special Emphasis on Post Crash survival (December 2010), p. 62.

[94] Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1998), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

4.2.8.4.5 Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast – Report to the Chief Coroner of British Columbia

This report, prepared by British Columbia's Chief Coroner in 2012 following several fatal accidents in the air-taxi sector, included 5 recommendations relevant to this theme:

> That Transport Canada create a regulatory requirement that all new and existing commercial seaplanes be equipped with emergency exits that would allow rapid egress following a collision with water.
>
> That Transport Canada create a regulatory requirement that all passengers and crew of commercial seaplanes wear personal floatation devices (PFDs) during all stages of flight.
>
> That Transport Canada create a regulatory requirement that illumination strips identifying emergency exits be installed onboard all commercial seaplanes.
>
> That Transport Canada initiate research into technologies that would allow seaplanes to stay afloat, or significantly delay the rate of sinking following collisions with water.
>
> That Transport Canada develop standardized curriculum for underwater egress training and make underwater egress training mandatory for flight crews involved in commercial seaplane operations; and, further, that enhanced safety briefings outlining underwater egress procedures be mandatory on all commercial seaplane flights.[95]

4.2.8.5 Summary

Table 13. Survivability: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• Older aircraft increase the risk of impact injuries. • On- and over-water operations increase the risk of post-occurrence drowning. • The remote nature of air-taxi operations increases the time for assistance to arrive after an accident. • Helmet use by helicopter pilots is not mandatory. • Passengers do not pay attention to safety briefings. • Safety equipment may not be used. • Passengers do not know how to use the survival equipment.	The context of air-taxi operations, combined with ineffective safety briefings and improper use of safety equipment, reduces the likelihood of surviving an accident.	• Pop-out windows should be installed. • Passengers should receive more thorough safety briefings. • Clear requirements should be established to ensure that all PFDs remain certified after continuous use. • More research is required before the new PFD regulations are implemented. • Helmet use should be mandatory for helicopter flight crew.

95 Office of the Chief Coroner, British Columbia, Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast, Report to the Chief Coroner of British Columbia (Burnaby, BC, March 2012), at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/death-review-panel/aviation.pdf (last accessed on 01 October 2019).

Conclusion: Aircraft crashworthiness, safety information, and safety equipment are key components to improve occupant survival in the event of an accident.

4.2.9 Safety theme: Weather information

4.2.9.1 Background

Canada's weather varies widely and can change rapidly because of the Canadian landscape, a diverse mix of mountainous areas, coastal rain forest, large inland lakes, vast prairie, boreal forest, and Arctic regions, and the longest coastline in the world, bordering three oceans. The influence of this geography on weather is significant, both on the broader scale and in regional microclimates. These factors can make accurate forecasting difficult, posing problems for all types of aviation.

At the same time, effective flight planning requires current and accurate weather information, so that pilots can make effective weather–related decisions for departure and landing, and avoid encountering poor weather en route. In the air-taxi sector, a large proportion of operations takes place in the most remote and challenging regions of Canada, where weather can be severe and unpredictable. Weather information therefore plays a major role in safety. For the potential benefits to be realized, pilots and companies must have access to accurate weather information and must foster a positive safety culture[96] surrounding weather decisions (see also **Section 4.2.10 Safety theme: Acceptance of unsafe practices**).

Weather-related accidents are a long-standing problem in the air-taxi sector. Flights in air-taxi operations often take place at lower altitudes, under visual flight rules (VFR), to remote or unprepared landing areas with few or no support facilities. Furthermore, many flights take place in areas that have minimal weather reporting services and are not served with the latest weather forecasting and reporting technologies. In the absence of weather information from the destination aerodrome, flight planning is often based on area forecasts, as well as pilot position reports and local knowledge.

4.2.9.2 What operators told us about this theme

4.2.9.2.1 Safety issues associated with this theme

When asked which issues posed the highest risk to safety, operators identified 2 safety issues related to weather reporting: (1) the absence of detailed weather reports for many of the areas where flights are conducted, and (2) the lack of reports from other aircraft when operating in remote areas.

Operators indicated that these safety issues present challenges and often result in increased risk during adverse weather conditions. These risks include

96 Safety culture is the way safety is perceived, valued, and prioritized in an organization. For more information, see **Section 5.6.1 Safety pressure**.

- conducting takeoffs from and landings at some remote airports, at unprepared landing sites, and on bodies of water;
- conducting flights in and around obstacles such as power lines;
- encountering icing conditions when the aircraft is not equipped with anti-icing or de-icing systems;
- when such equipment is installed, inability to fly at altitudes above the icing conditions because of the aircraft's service ceiling limitations; and
- continuing flights in poor weather.

4.2.9.2.2 How operators are managing these issues

Most operators have adopted a variety of mitigations, ranging from policies and procedures to technology to reduce risk from weather factors in their operations. Companies have also taken steps to improve the culture surrounding weather decisions.

Measures include enhancements to flight planning, such as internet availability in remote locations, and the use of cellphones or satellite phones, applications, and programs to assist with weather planning and briefings. Some companies indicated that they subsidized cellphone purchases and data plans for pilots, so they can use cellphones to check weather in areas where cellular service is available. Automated weather observation system (AWOS) stations provide factual weather information in areas where it is not possible or practical to have a staffed weather station. As well, operators use weather cameras at remote airfields to obtain some insight into conditions.

Some operators train clients or other persons in remote locations to accurately observe and report the weather to flight crews. In coastal regions, lighthouse keepers can provide accurate observations combined with local knowledge that can be useful in flight planning; however, the number of staffed lighthouses in Canada has declined in recent years.

Flights in adverse weather conditions can benefit from technological advances, such as enhanced ground proximity warning systems, synthetic vision, glass cockpits, and real-time weather updates through satellite connectivity and radar (see also **Section 4.2.7 Safety theme: On-board technology**).

Because of limitations on operating Cessna 208 aircraft in icing conditions, some operators either do not use the Cessna 208 in winter or have special procedures and enhanced training for operating this type of aircraft when the potential for icing conditions exists. Others only dispatch specific aircraft when icing conditions are forecast.

4.2.9.2.3 What operators said could be done

The need for better weather reporting was a common theme among operators. Many felt that more reporting stations are needed in areas where weather is less predictable, such as coastal regions. Others said that existing weather-reporting stations should have extended hours, so that early-morning and late-evening flights have the benefit of more accurate weather information.

In areas where staffed weather observations are not possible or practical, the industry feels that additional AWOS stations and weather cameras would augment safety.

Educating crews and customers was also felt to be important. Operators said such education should emphasize helping pilots make better weather decisions and helping clients understand the risks associated with poor weather.

4.2.9.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period revealed 4 findings in which inadequate weather information influenced pilot decision making.[97]

- In a 2000 occurrence involving controlled flight onto ice, weather conditions at the time and location of the occurrence were not suitable for visual flight, and no weather reporting facilities were available en route.
- In a 2005 occurrence involving a loss of control and collision with terrain, a finding as to risk was made about generic icing forecasts in aviation weather forecasts; generic forecasts may not accurately predict the effects of icing conditions on particular aircraft.
- In a 2006 runway overrun and collision with terrain, the investigation found that the weather station at the occurrence airport did not have any air-ground communication capability with which to pass timely wind updates to the flight crew.
- In a 2008 occurrence involving controlled flight into terrain, the pilot received indications of marginal weather improvement en route and incorrect information from another weather station, possibly contributing to the decision to continue the VFR flight into instrument meteorological conditions. Findings as to risk were also made about the lack of training in pilot decision making for VFR air-taxi operators, and about customers applying pressure to complete flights despite adverse weather.

4.2.9.4 Other reviews and safety studies

4.2.9.4.1 TSB Report of a Safety Study of VFR Flight into Adverse Weather

The TSB safety study of VFR flight into adverse weather looked at 333 weather-related accidents that involved Canadian-registered aircraft in Canada over the 10-year period between 1976 and 1985.[98] Recurring themes in the causes and contributing factors to these accidents included industry practices at the time, aircraft equipment, and weather briefing facilities.

The report made 25 recommendations, most aimed at mitigating these major causes and contributing factors. Of these 25 recommendations, 1 is currently active:

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[97] TSB aviation investigation reports A00P0019, A05C0187, A06P0036, and A08P0353.

[98] Transportation Safety Board of Canada, Aviation Safety Study 90-SP002, *Report of a Safety Study on VFR Flight into Adverse Weather* (Ottawa, 13 November 1990), at http://www.tsb.gc.ca/eng/rapports-reports/aviation/etudes-studies/90SP002/90SP002.html (last accessed on 01 October 2019).

> the Department of Transport require all commercially-operated helicopters to be equipped with appropriate instrumentation for the conduct of basic instrument flying.
>
> **TSB Recommendation A90-84**

4.2.9.4.2 Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast – Report to the Chief Coroner of British Columbia

This report, prepared by British Columbia's Chief Coroner in 2012 following several fatal accidents in the air-taxi sector, included a recommendations relevant to this theme:

> That NAV Canada engage in consultation with Environment Canada Meteorological Services staff and BC's floatplane community, with the objective of improving the quality of weather camera imagery available through the Aviation Weather web site and increasing the number of web camera placements in critical coastal locations.[99]

4.2.9.4.3 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) Final Report, published in 1998, made 3 recommendations relevant to this theme:

> SR 69 Recommend Transport Canada consult with the British Columbia Air Operators Group and NAV CANADA to determine what is being done to improve the weather reporting services on the west coast of British Columbia. A safety review of the issues would be justified if there is no obvious and timely solution to these problems.
>
> SR 71 Recommend Transport Canada Commercial and Business Aviation and Flight Training Standards inspectors and flight instructors promote the benefits of filing PIREPs [pilot reports] and that Transport Canada publish an article in the Aviation Safety Letter and Aviation Safety Vortex newsletters encouraging pilots to file PIREPs.
>
> IA 71 Recommend pilots file PIREPs especially in areas of variable weather conditions and where weather reporting is less available or reliable.[100]

4.2.9.5 Summary

Table 14. Weather information: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• Many areas (e.g., coastal regions) have rapidly changing weather. • Weather forecasting and reporting, as well as pilot	Inaccurate or incomplete weather information negatively impacts safety.	• More reporting stations are needed in areas where weather is less predictable. Existing weather-reporting stations should have extended hours.

99 Office of the Chief Coroner, British Columbia, Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast, Report to the Chief Coroner of British Columbia (Burnaby, BC, March 2012), at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/death-review-panel/aviation.pdf (last accessed on 01 October 2019).

100 Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1993), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

reports, are lacking in many locations. • Pilots may not receive the training necessary (local knowledge) to operate in areas where it may not be possible to obtain accurate and complete weather information.		• Additional AWOS stations and weather cameras would augment safety. • Educating crews and clients would help pilots make better weather-related decisions.

Conclusion: Accurate weather information is a critical component of flight planning and allows pilots to make effective weather-related decisions.

4.2.10 Safety theme: Acceptance of unsafe practices

4.2.10.1 Background

In the course of an organization's activities, unsafe practices may be introduced as personnel work to accomplish goals. These unsafe practices may gradually become accepted as part of the job—in an undetected drift from safe practices—and eventually be taught to newcomers, perpetuating their use. Because these unsafe practices continue with no negative outcomes or often with positive outcomes, such as successful flights or satisfied customers, accepting them can sometimes be seen as rational, and at other times they become the norm.

These practices develop as a result of a number of factors, including pressure to get the job done (see also **Section 4.2.13 Safety theme: Operational pressure**) and an underestimation or non-recognition of the associated risks. Examples of unsafe practices include flying overweight, flying with inadequate fuel reserves, not recording defects in aircraft logs, and "pushing the weather" (see also **Section 4.2.9 Safety theme: Weather information**).

There are many underlying factors that lead to the development of unsafe practices in aviation. When personnel carry out routine activities time after time, such as the same scheduled flight or the same aircraft inspection, these activities may become habitual, resulting in reduced vigilance. Personnel may find more efficient ways of doing something but may not account for the associated risk or relationships between tasks. In some cases, personnel are placed in situations where they must improvise and solve problems as they arise; the procedure as written may not always be practical in the field. In other cases, personnel and organizations need to make the most of the resources they have. In extreme cases, a company culture develops in which unsafe practices are accepted as a way of doing the job.

4.2.10.2 What operators told us about this theme

4.2.10.2.1 Safety issues associated with this theme

When asked about the hazards and risks associated with air-taxi operations, operators identified several factors contributing to the acceptance of unsafe practices. There were many comments that pilots can become complacent[101] after performing the same scheduled flights on the same routes, making them less likely to adapt to changes in conditions. Aircraft maintenance engineers (AMEs) can also become complacent when performing routine, repeated maintenance activities. For pilots and AMEs alike, such complacency can result in practices or actions that do not follow regulations or procedures.

Operators also identified pressure from many sources to continue flights in poor weather (see also **Section 4.2.13 Safety theme: Operational pressure**). This can lead to flight in adverse weather conditions below minima required under regulations.

Operators mentioned several aspects of adaptations or deviations from procedures and regulations. Newer pilots are generally more likely to follow procedures and regulations than more experienced pilots. Thus, operators felt that experience may contribute not only to inconsistent adherence to procedures and regulations, but also to a higher risk tolerance.

4.2.10.2.2 How operators are managing these issues

Many operators have recognized the risks associated with acceptance of unsafe practices and have taken steps to avoid the situations leading to such acceptance. Some of these measures also mitigate against other safety issues found in this investigation, such as dealing with adverse weather, training less-experienced pilots, and avoiding fatigue.

Routine practices

- Deliberately varying flight schedules to avoid having pilots fly the same routes repeatedly.
- Instituting a policy requiring flight crews to review emergency procedures while en route, to reinforce procedures, and to keep pilots mentally engaged.
- Fostering open communication between AMEs and pilots.

Training

- Pairing inexperienced pilots with experienced pilots to foster transfer of knowledge (“no green-on-green” policy) and instituting mentoring programs.
- Offering training programs in advanced decision making and weather to crews operating in harsh environments.
- Instituting line indoctrination and familiarizing crews with the local area to help ensure that crews are ready for operations in remote regions or challenging conditions.

Weather

- Developing policy and procedural defences against weather hazards: these include operational control mitigations such as prohibiting flights in icing conditions and

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101 In this report, “complacency” refers to a reduced level of awareness of the risks associated with a particular operation. This is a normal product of repeated exposure to specific hazards and risks, and can result in changes to operational practices and the gradual erosion of safety margins.

departures in weather below required minima, and reviewing weather-related policies and procedures.

- Improving the culture surrounding weather decisions by encouraging pilots to contact base, dispatch, or a senior or chief pilot to discuss weather conditions and plans.
- Holding mandatory weather briefings before flights to ensure that crews have the latest weather information available.
- Providing instrument flight rules (IFR) practice for pilots who perform most of their flying under visual flight rules (VFR).

4.2.10.2.3 What operators said could be done

Operators identified a need for increased enforcement of current regulations governing weather minima, with some operators believing that Transport Canada should put more effort into finding and punishing violators.

Educating crews and clients was also felt to be important. Operators said that this education should help pilots make better weather decisions and help clients understand the risks associated with operating in poor weather.

4.2.10.3 Previous TSB findings and recommendations on this theme

4.2.10.3.1 TSB findings

A review of the 167 TSB occurrences with published investigation reports during the study period revealed findings that show many examples of risks that have become accepted over time. These include pushing the weather, flying into forecast icing conditions with aircraft that are not certified for flight in such conditions, flying with inadequate fuel reserves for IFR flight and unserviceable equipment, flying overweight, and defects not being recorded in the aircraft journey log.

Pushing the weather

The TSB has investigated many accidents in which flight has been attempted or continued in unsuitable weather conditions. The investigations provide examples of how previous experience of pushing the limits leads to unsafe practices and how these practices can continue if operators tacitly accept them.

In its report on a 2013 occurrence involving a controlled flight into terrain (CFIT) near Hesquiat Lake, British Columbia, the TSB examined why a pilot who did not hold a current instrument rating and was flying an aircraft that was not equipped for IFR flight proceeded into instrument meteorological conditions (IMC). The report stated that

> the pilot had flown in this area of British Columbia’s west coast, an area well known for mountainous terrain, rain, fog, wind, low ceilings, etc., for much of his career and

> had almost certainly flown in challenging weather conditions on many occasions. Though no longer current, the pilot had once held an instrument flight rating.[102]

The investigation also found that the company did not have effective methods to monitor its pilots' in-flight decision making and associated practices.

Similarly, in the report on a 2008 CFIT accident on South Thormanby Island, British Columbia, following VFR flight into IMC, the investigation found that the pilot had a tendency to push the weather.[103] In briefing the passengers on the day of the occurrence, the pilot informed them that the flight would be conducted at low altitude and that, if they were concerned, they could leave the aircraft. This is not a normal part of the pre-flight briefing and indicates that the pilot was aware that the weather along the route was likely to be poor enough that, in order to maintain ground reference, the flight would have to be conducted at a lower altitude. The report also stated that, although the company had a general approach to avoid pushing the weather, pilots were not provided with procedures or tools to enable effective decision making in this regard. The occurrence pilot had been previously counselled with respect to weather-related decision making, but this was informal and not documented.

Flight into forecast icing conditions

There are also examples of pilots flying into forecast or known icing conditions with aircraft that are not certified for flight in these conditions. Previous experience with icing conditions may have contributed to these decisions, as the following examples demonstrate.

In a 2000 occurrence involving in-flight icing and loss of control, a Cessna 310 departed on an IFR flight with inadequate fuel reserves for IFR flight and then continued into known icing conditions, even though the aircraft was not certified for those conditions. The analysis stated that, "having experienced flights into icing conditions previously in his career and in similar conditions, the pilot decided to continue."[104]

In a 2001 occurrence involving a CFIT, it could not be determined why the pilot chose to complete the flight in the conditions prevailing at the time.[105] In this occurrence, the pilot was relatively inexperienced and landed the Cessna 182 with a considerable amount of airframe icing, removed the ice, then departed for the return leg of the trip into known icing conditions.

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102 TSB Aviation Investigation Report A13P0166.

103 TSB Aviation Investigation Report A08P0353.

104 TSB Aviation Investigation Report A00W0079.

105 TSB Aviation Investigation Report A01W0304.

Flight with inadequate fuel reserves for instrument flight rules flight and unserviceable equipment

In a 2002 occurrence involving fuel exhaustion and collision with terrain,[106] the pilot departed on a single-pilot IFR flight without the fuel reserves or a functioning autopilot required by regulations. The report stated that the company had insufficient procedures and oversight in place to prevent such practices.

Flying overweight

In a 2010 occurrence involving a loss of visual reference with the ground, loss of control, and collision with terrain,[107] a customer requested a chartered helicopter flight that could not be completed with normal fuel reserves because of the total weight of the passengers and baggage. Nevertheless, the company carried out the requested flight, with the helicopter departing overweight. Additionally, although scales were available, the baggage was not weighed, so the pilot did not accurately assess the weight and balance. The report emphasized the role of the company and the customer in encouraging the acceptance of unsafe practices: "by accepting charters that cannot be carried out in compliance with regulations, the carrier sends a tacit message to the pilot to take off with an overloaded aircraft."[108]

Defects not recorded in the aircraft journey log

In a 2010 occurrence involving an engine problem and collision with terrain, the TSB found that poor safety culture at the company contributed to the acceptance of unsafe practices in its operations.[109] One such practice was not recording all defects in the aircraft journey log. The investigation report indicated that not recording defects in the journey log poses a safety risk because crews are unable to determine the actual condition of the aircraft at all times and, as a result, could be lacking critical information in an emergency.

4.2.10.3.2 TSB recommendations

The TSB has made multiple recommendations highlighting that the acceptance of unsafe practices is a long-standing problem in the air-taxi sector. These include recommendations relating to pushing the weather[110] and to training in decision making for flight crew members.[111] The responses to these recommendations have been assessed as **fully satisfactory** and the recommendations are now closed. In December 2018, the TSB issued a new recommendation for TC and operators to take action to increase compliance with existing regulations related to taking off with contaminated critical surfaces.[112]

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106 TSB Aviation Investigation Report A02C0124.

107 TSB Aviation Investigation Report A10Q0132.

108 Ibid.

109 TSB Aviation Investigation Report A10Q0098.

110 TSB recommendations A90-82, A94-18, and A94-20.

111 TSB Recommendation A96-12.

112 TSB Recommendation A18-03.

4.2.10.4 Other reviews and safety studies

4.2.10.4.1 Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast – Report to the Chief Coroner of British Columbia

This report, prepared by British Columbia's Chief Coroner in 2012 following several fatal accidents in the air-taxi sector, included 2 recommendations relevant to this theme:

> It is recommended that Transport Canada eliminate the granting of Operations Specifications that allow commercial VFR fixed-wing operations in reduced visibility conditions.
>
> It is recommended that Transport Canada create a requirement that all commercial seaplane pilots undergo training that includes a component on avoidance of, and recovery from, sudden encounters with hazards such as conditions that are below Visual Meteorological Conditions (VMC) minima, low level flight over glassy water and in poor visibility, and other typical hazards frequently encountered by seaplane pilots.[113]

4.2.10.4.2 Factors associated with pilot fatality in work-related aircraft crashes, Alaska, 1990–1999

Results of a study into work-related aircraft crashes in Alaska over a 10-year period were published in 2001.[114] The study focused on accident data gathered from U.S. National Transportation Safety Board reports, which examined differences between fatal and non-fatal aircraft accidents. One of the findings was that poor weather was associated with a 7-times-greater likelihood of a fatality.

Associated with this finding was a recommendation for "Improved procedures training for pilots that inadvertently enter poor weather conditions while flying under VFR."[115]

4.2.10.5 Summary

Table 15. Acceptance of unsafe practices: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• Pilots may have a reduced level of awareness of the risks associated with a particular operation. • Operational pressures may be exerted by several sources. • Unsafe acts and conditions may not have previously resulted in any negative outcomes.	Accidents and/or incidents may result when organizations do not recognize and mitigate unsafe practices.	• Increased enforcement of current regulations governing weather minima is needed. • Crews and customers need to be educated about safe practices. Such education should emphasize helping pilots make better weather decisions and helping clients understand the risks associated

113 Office of the Chief Coroner, British Columbia, Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast, Report to the Chief Coroner of British Columbia (Burnaby, BC, March 2012), at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/death-review-panel/aviation.pdf (last accessed on 01 October 2019).

114 D. M. Bensyl, K. Moran, and G. A. Conway, "Factors associated with pilot fatality in work-related aircraft crashes, Alaska, 1990–1999," *American Journal of Epidemiology*, Vol. 154, No. 11 (01 December 2001), pp. 1037–1042.

115 Ibid.

• The shift away from safe practices may have been gradual and unrecognized.		with operating in poor weather.

Conclusion: If unsafe practices are not recognized and mitigated, or if they are accepted over time as the "normal" way to conduct business, there is an increased risk of an accident.

4.2.11 Safety theme: Fatigue

4.2.11.1 Background

Because flight and maintenance operations take place around the clock, the risks of performance impairment due to fatigue are a long-standing problem in aviation and may never be eliminated. Furthermore, the safety-critical nature of both of these operations mean that the consequences of fatigue can be severe.

One primary mitigation for the risk of fatigue for pilots is the flight and duty-time limitations in the *Canadian Aviation Regulations* (CARs). These regulations set out maximum flight times in a given period, limit the number of hours a pilot can work on a given day, and provide for minimum rest periods between work periods. However, the regulations do not identify a similar defence to mitigate the risks associated with fatigue for maintenance personnel. Some organizations establish their own maintenance duty-time limitations, while others rely on individual personnel to determine their own limits.

Transport Canada (TC) has determined that regulations currently in place to manage fatigue in flight operations are not supported by current evidence on fatigue and do not meet the standards of the International Civil Aviation Organization (ICAO). As a result, TC has published changes to the CARs that would result in more stringent flight and duty-time limitations for pilots and encourage operators to use fatigue risk-management systems (FRMS)[116] based on modern principles of fatigue science to address specific risks to their operations. It was not within the scope of the SII to determine the appropriateness of these regulations.

Even though the issue of fatigue in maintenance personnel does not arise as an issue in TSB data, the operators interviewed feel it is an area of risk.

4.2.11.2 What operators told us about this theme

4.2.11.2.1 Safety issues associated with this theme

Crew scheduling is a major concern: operators need to be able to manage scheduling effectively to avoid fatigue in crew members.

Operators also identified fatigue in maintenance personnel as a safety issue. Aircraft maintenance engineers (AMEs) often experience fatigue when working, especially when

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[116] Government of Canada, Canada Gazette, Part II, Vol. 152, No. 25 (12 December 2018), Regulations Amending the Canadian Aviation Regulations (Parts I, VI and VII — Flight Crew Member Hours of Work and Rest Periods).

they are working in a remote location or away from their main base. They may also face long duty days, given that duty-day hours for AMEs are not subject to TC regulations. Some operators mentioned that duty days for AMEs are often not defined by operators. This can also contribute to ineffective scheduling of maintenance staff to avoid fatigue, similar to difficulties with effective scheduling of flight crews.

In discussing fatigue, some operators viewed the problem in the overall context of fitness for duty. Staff reporting for duty when fatigued, ill, or otherwise unfit creates risks for flights and for coworkers. Managing duty hours and crew scheduling within regulations does not, on its own, go far enough to ensure fitness for duty. Some operators therefore supported having an FRMS in place, as currently proposed by TC.

Fatigue was specifically mentioned by several helicopter operators and by medical evacuation (MEDEVAC) operators as a risk for pilots and other crew members. Many helicopter pilots are paid by the flight hour, so there is a financial incentive to fly for more hours; however, maximizing the financial benefit may create a risk of flying while fatigued.

4.2.11.2.2 How operators are managing these issues

There are a number of areas in which operators have implemented mitigations for their operations, such as scheduling, training, and physical environment. Operators have also introduced general strategies for dealing with fatigue.

Scheduling

Many operators stated that, in general, they manage work schedules effectively and monitor schedules closely. Some of the measures they take to manage and monitor schedules are

- taking pilots' personal lives into account when scheduling flights, to accommodate work/life balance, such as childcare and other personal needs;
- having pilots in management positions take on flights to mitigate pilot shortages rather than having pilots fly additional hours;
- creating shifts that are shorter than the maximum allowed by regulation, as a matter of course, in all crew schedules;
- limiting flight crews to 2 consecutive night flights per shift;
- using a flight-risk assessment tool to schedule the appropriate pilot and crew for a specific flight;
- using the operator's safety management system (SMS) to track and identify fatigue: a report is filed when a staff member declines to work owing to fatigue, and the company uses this information to mitigate future fatigue issues;
- scheduling AME shifts based on the hours and days the AMEs wish to work; this strategy gives the AMEs some flexibility and input in their schedule, which promotes work/life balance; and
- scheduling a day shift and a night shift for maintenance so that AMEs are not working long duty days.

Training

Some operators indicated that they include fatigue management in crew resource management (CRM) training. Others mentioned that fatigue and other fitness-for-duty topics such as drug and alcohol use are covered in the company's employee manual.

Physical environment

Many operators recognize that aspects of the physical environment play a role in fatigue and have taken steps to address this, as follows:

- educating clients on the specific requirements for proper crew accommodations, especially while working in very remote locations
- ensuring that crews have access to proper layover accommodations at their destination
- modifying all of their aircraft to provide better cockpit ventilation for pilots while operating in warm temperatures
- changing their dress code to allow crews to wear weather-appropriate clothing based on temperature conditions
- setting up rest facilities for flight crews in the hangar, especially for MEDEVAC operators

General strategies

Many operators also use general human resources or workplace measures to avoid fatigue-related risks. For example, operators add staff as needed to accommodate the amount of work, rather than overloading existing staff. They provide staff with sufficient paid sick leave or extra time off, which can be used to recover from fatigue. Other strategies are designed to promote physical fitness, through gym equipment at bases and/or subsidized gym memberships and bicycle purchases. Operators noted that new aircraft have improved technology that alleviates pilot workload, and they therefore view fleet renewal as a mitigation for fatigue.

A few operators require crews to monitor each other and to assess themselves for fatigue. To help crews self-assess, some operators have developed a checklist for fatigue risk assessment when the crew duty day goes beyond 12 hours.

For AMEs, some operators said they assigned AMEs non-critical maintenance tasks during early morning hours or when an AME reports not feeling well. Also, one operator said it tries to avoid scheduling any heavy maintenance during early morning hours. Some operators said that AMEs are generally scheduled to work with others and are rarely alone.

4.2.11.2.3 What operators said could be done

Operators expressed wide-ranging views on the effectiveness of regulations in mitigating fatigue. While many operators interviewed asked for more limited duty-day hours, many also said that regulations should be tailored to the type of operations. For example, some suggested that single-pilot operations should have more restricted hours than multi-crew operations in this sector. However, some said that regulations limiting duty-day hours should not be changed. Furthermore, some stated that such regulations and crew scheduling do not provide sufficient mitigation of fatigue.

To go beyond duty-day hours and crew scheduling, operators suggested additional mitigations such as

- scheduling that takes into account the time of day and the type of work being done
- a review of the pay structure for helicopter operators to avoid the financial incentive to work extra hours
- training to help personnel manage and cope with fatigue
- methods of self-assessment for fatigue

A few operators said that the sector needs to adopt an FRMS, and some said the issue was broader than the air-taxi sector and required a national discussion about fatigue and scheduling for all commuting pilots, regardless of sector.

One of the main points made by operators was that fatigue is an issue for AMEs as well as flight crew, and a large number of operators suggested that AME duty-day regulations are needed.

4.2.11.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period revealed 8 findings related to fatigue:

- In 2 occurrences, flight- and duty-time limitations were exceeded. In one case, this was because the pilot’s rest period the night before the accident was less than the minimum required by regulation. In the other case, there were 2 instances of exceeding flight- and duty-time limitations (insufficient rest, exceeded duty time).[117]
- In 2 occurrences, flight and duty time were not monitored.[118]
- In 2 occurrences, other employment was not accounted for in flight- and duty-time monitoring.[119]
- In 2 occurrences, the decision to take off was affected by a combination of stress and fatigue.[120]

4.2.11.4 Other reviews and safety studies

4.2.11.4.1 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) Final Report, published in 1998, made 5 recommendations relevant to this theme:

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[117] TSB aviation investigation reports A02C0145 and A11W0048.

[118] TSB aviation investigation reports A05Q0178 and A07Q0063.

[119] TSB aviation investigation reports A09P0187 and A13H0001.

[120] TSB aviation investigation reports A04H0001 and A09Q0203.

SR 3	Recommend Transport Canada provide Aircraft Maintenance Engineers (AME) and air operators with information about fatigue, the effects of fatigue, and fatigue countermeasures.
IA 3	Recommend air operators provide AMEs and apprentices with information about fatigue, the effects of fatigue and fatigue countermeasures and consider the negative effects of fatigue when assigning work and planning work schedules.
SR 4	Recommend Transport Canada initiate a Canadian Aviation Regulation Advisory Council (CARAC) review to determine if AME duty times should be regulated, and if so, determine appropriate limitations.
IA 4	Recommend air operators, air operator associations, AMEs and AME associations participate in or provide input to the CARAC AME duty time working group.
IA 46	Recommend air operators ensure their clients are aware of the requirement for pilots to be provided with suitable accommodation and ensure their clients provide pilots with suitable accommodation.[121]

4.2.11.5 Summary

Table 16. Fatigue: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said

• There are no regulatory requirements for duty-time limitations for maintenance personnel.
• Pilot flight and duty-time regulations may not be appropriate for all types of air-taxi operations.
• The practice of pilots being paid by the flight hour increases the risk that these pilots will work longer hours.
	Ineffective management of fatigue may result in a reduced level of safety in all aspects of an operation.	• There need to be greater limits on duty-day hours.
		• Regulations should be tailored to the type of operations.
		• Regulations limiting duty-day hours should not be changed.
		• Regulations and crew scheduling do not provide sufficient mitigation of fatigue.
		• Operators suggested mitigations beyond duty-day limits:
		  ◦ scheduling that takes into account the time of day and the type of work
		  ◦ reviewing the pay structure for helicopter operators to avoid the financial incentive to work extra hours
		  ◦ providing fatigue-related training and methods of self-assessment for fatigue
		• The sector needs to adopt fatigue risk-management systems.

[121] Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1998), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

		• The issue is broader than the air-taxi sector; there should be national discussion about fatigue and scheduling for all commuting pilots, regardless of sector. • AME duty-day regulations are needed.

Conclusion: Fatigue-related impairment has a detrimental effect on aviation safety.

4.2.12 Safety theme: Maintaining air-taxi aircraft

4.2.12.1 Background

The air-taxi sector is a competitive environment with slim profit margins, and operators often face complex decisions about maintaining and upgrading their fleets of aircraft. When making these decisions, they need to consider costs, safety, and performance.

A common problem is whether to keep older aircraft operating or buy new aircraft—and the decision is typically determined by economics. The company must weigh the price and availability of new aircraft against the operating efficiency and costs of maintaining older aircraft in safe operating condition. Operators also have to determine whether there is a replacement aircraft that can perform comparably. In many instances, there may not be a suitable replacement.

One of the issues contributing to the cost and complexity of keeping an older aircraft in service is the availability of parts. Most of the older aircraft built by companies still in business are reasonably well supported. However, if the original manufacturer no longer exists or no longer supports that aircraft, then parts become more difficult or impossible to locate.

4.2.12.2 What operators told us about this theme

4.2.12.2.1 Safety issues related to this theme

Many operators commented on the difficulties associated with maintaining older aircraft.

The availability and quality of parts was mentioned several times. Parts are becoming very difficult to find, and the quality of overhauled components has degraded. Operators believe this may be because there are fewer specialists and more lower-skilled workers involved in overhauling parts.

Related to the parts problem are service bulletins issued by aircraft manufacturers to alert operators to unsafe conditions with the aircraft. Implementing these bulletins can be challenging, because the manufacturer may not have the required parts available.

As well, deficiencies in maintenance manuals make it difficult to maintain aircraft properly. Some operators said the quality of information included in the aircraft maintenance manuals is often poor; errors have even been found in some manuals. Helicopter maintenance manuals were described as difficult to use.

Operators found that the costs of maintenance were continuing to rise, but at the same time, the quality of maintenance performed by third-party services had deteriorated.

Replacing aircraft or adding aircraft to a fleet can be problematic because of limitations of existing or newer aircraft. Operators said it was difficult to determine what aircraft was best suited to performing the roles or tasks required and to the types of airports where the company operates. As an example, from a maintenance perspective, they mentioned that certain aircraft are not suitable for landing on gravel airstrips.

One solution is to modify older aircraft with modern equipment, but some operators pointed out that this can lead to safety issues. For example, replacing older avionics with new, lighter-weight avionics can create challenges in maintaining an acceptable centre of gravity.

4.2.12.2.2 How operators are managing these issues

Operators have implemented the following mitigations to assist in maintaining aircraft:

- Having maintenance personnel file an alert when errors are found in the maintenance manual.
- Providing maintenance manuals in electronic formats.
- Delivering in-house training to reduce confusion resulting from the original equipment manufacturers' aircraft manuals.
- Using electronic databases for all maintenance tracking.
- Conducting trend monitoring for aircraft engines.
- Providing wireless internet access in hangars to allow maintenance personnel to consult online resources.
- Providing laptops or tablets for maintenance personnel to use in tracking maintenance and downloading online resources, such as aircraft operating parameters, to troubleshoot new aircraft.
- Using refurbished parts or parts that have received parts manufacturer approval.
- Working with the aircraft manufacturer to develop procedures to address specific maintenance issues.
- Working with other companies to exchange parts, services, etc.
- Using checklists when checking equipment for serviceability, to ensure consistency.
- Repairing and overhauling components in-house, rather than using outside providers.
- Standardizing fleets as much as possible, which reduces the cost and complexity of maintaining aircraft.

4.2.12.2.3 What operators said could be done

Operators suggested the following ways to improve maintenance:

- Transport Canada should provide a single source for all aircraft maintenance manuals and a means for operators to access all of the current aircraft manuals.
- Operators require better product support from the type certificate holder for aircraft that are no longer in production.
- Component overhaul facilities should have sufficient aircraft maintenance engineers on staff to ensure high-quality overhauls.
- Logistics to obtain parts and other resources on short notice needs to be improved.
- Operators asked that the regulatory process be streamlined to allow operators to incorporate newer technology into older aircraft more easily.

4.2.12.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period revealed 11 findings related to aircraft maintenance. Most of these involved the lack of optional safety equipment or systems[122] that could have helped avoid the accident, mainly stall warning systems. Other equipment cited included a fuel boost pump and an instantaneous vertical speed indicator (helicopter). Other investigations found that fuel-quantity indicators were unreliable or not marked with a yellow band, as required by regulation.[123] In one occurrence, a passenger seat did not meet aeronautical standards.[124]

4.2.12.4 Summary

Table 17. Maintaining air-taxi aircraft: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• Spare parts have limited availability and are expensive. • Newer aircraft may not be capable of performing the same role as older aircraft. • Replacement aircraft are expensive and may not be cost-effective. • The regulatory process for modifying or updating older aircraft is cumbersome and time-consuming. • Deficiencies in maintenance manuals make it difficult to maintain aircraft properly.	The challenges of maintaining and/or replacing air-taxi aircraft may lead to decisions that result in a reduced level of safety.	• Transport Canada should provide a single source for all aircraft maintenance manuals and a means for operators to access them. • Operators should require better product support from the type certificate holder for aircraft that are no longer in production. • Overhaul facilities should have sufficient aircraft maintenance engineers on staff to ensure quality.

[122] TSB aviation investigation reports A02C0143, A03W0210, A04C0190, A09P0397, A12O0071, A13P0278, and A14O0105.

[123] TSB aviation investigation reports A10C0060 and A11Q0136.

[124] TSB Aviation Investigation Report A10Q0111.

		• Better logistics are needed for obtaining parts on short notice. • The regulatory process needs to be streamlined to incorporate newer technology into older aircraft.

Conclusion: Maintaining aircraft in a serviceable condition is fundamental to ensuring the safety of flight.

4.2.13 Safety theme: Operational pressure

4.2.13.1 Background

There are many pressures in the air-taxi sector that can lead individuals to accept operational risks in the interest of completing flights. These pressures can have several sources: competitive pressure among operators, pressure within operators, and self-induced pressure. No matter the source, pressure to get the job done can have a negative impact on safety when it leads an individual or organization to accept unsafe practices (see also **Section 4.2.10 Safety theme: Acceptance of unsafe practices**).

Competitive pressure, if not properly managed, can negatively affect an organization's ability to manage safety. Air-taxi operators compete for contracts from private- and public-sector clients, and winning and retaining contracts depends at least partly on price. This sector is very competitive, and profit margins can be narrow, which may create financial constraints for organizations. Many of the companies are small and provide a limited range of services, so they may not have the resources to withstand competitive pressures as well as a larger company can.

As well, companies may conduct work only seasonally (usually from spring to fall), causing difficult economic adjustments and loss of staff during the off-season (usually winter). The need to be economically viable during such a short period can result in companies focusing on getting the job done. Therefore, operational concerns may be more salient than concerns dealing with safety.

Clients may intentionally or unintentionally apply pressure on pilots to conduct a flight with more equipment or baggage than allowed, or to depart or continue a flight into poor weather. This pressure can also be applied to aircraft maintenance engineers (AMEs), to have them perform maintenance quickly. Clients may be unaware of the risks and the effect on aviation decision making that can result from the pressure they put on an operator.

Pressure can also come from within a company, either from management or from employees themselves. Owners and company executives can apply pressure on managers to ensure that deadlines are met and costs are reduced. This, in turn, can result in the managers applying pressure on pilots, AMEs, and other company personnel to get the job done within the constraints that they have been given, or in some cases within tighter constraints to exceed the executive's expectations.

Individuals may, and typically do, apply self-induced pressure to do the job well, and to meet or exceed the manager's or company's expectations, even if it means deviating from standard operating procedures (SOPs). This pressure may be especially prevalent in situations that are necessary and time-sensitive, such as medical evacuation (MEDEVAC) operations or transporting workers in harsh environments. This can contribute to the acceptance of unsafe practices if these pressures are not properly managed.

4.2.13.2 What operators told us about this theme

4.2.13.2.1 Safety issues associated with this theme

Operators found that competitive pressure within the air-taxi sector led to the following safety issues:

- Some operators stick to the minimum requirements under the regulations to carry out their operations—both flight operations and maintenance—in order to limit spending. The regulations may not cover all of the risks associated with a particular operation.
- When clients specify minimum flight hours for flight crews, operators find it difficult to provide crews with enough experience.
- Clients may choose air carriers based on price alone and may not be willing to pay based on safety records or practices. In these cases, clients do not seem to be aware of the risks associated with choosing an air operator based only on the price.
- Cyclical demand in the air-taxi sector means that, during periods of low demand, operators feel more pressure to accept risk in the interests of completing flights.

When asked about the highest risks associated with their operations, air-taxi operators mentioned the following:

- Clients put pressure on them to continue flights into poor weather conditions or to fly beyond the limits of the aircraft.
- Unexpected changes to flight schedules—either because crew members are unavailable or because an aircraft has become unserviceable—need to be managed.
- Company management puts pressure on maintenance and flight operations staff to get the job done quickly.
- It is difficult to schedule maintenance to make sure an aircraft is available when needed. Because operational needs often take priority over maintenance, maintenance tasks may be postponed to a less disruptive time.

Operators also commented on other safety issues arising from the underlying pressure to conduct and complete flights. They said it affected pilot decision making in many areas. As an example, operators and pilots have felt pressured to land at landing strips in remote northern communities regardless of runway and weather conditions. Other examples from staff included pilots being expected to carry out unsafe practices—such as not recording defects in the log book, operating aircraft with known defects, and entering inaccurate time entries in the log book—or face discipline.

Operators also spoke about scheduling pressures. Operational staff are under time pressure to make scheduling arrangements, which can be difficult if they are not informed of changes to the schedule. To expedite training of newly hired pilots, one operator conducted training on empty legs of revenue-generating flights.

4.2.13.2.2 How operators are managing these issues

There were very few mitigations in place. Some operators indicated that they try to maintain a higher safety standard despite the pressures to compromise these standards, that they invest in the company, and that they focus on hiring experienced personnel.

The main mitigations for pressure at the operational level involve support for decision making. The following mitigations help crews make good decisions in the context of pressure to get the job done:

- Using risk-assessment tools for pre-flight operational flight planning.
- Providing decision-making training for pilots as well as mentoring of junior pilots by senior pilots.
- Having an open-door policy to allow staff to bring issues forward to management as soon as possible.
- Having specific SOPs for weather limits to help with flight planning.
- Providing support to pilots to make appropriate weather decisions.
- Making computerized flight-planning programs available for the flight crews.
- Providing proper resources so that flights could operate smoothly, for example providing ground handlers to help load aircraft, or including an AME in a helicopter flight crew to handle any mechanical problems.
- Matching crews with the type of flying that needed to be conducted. Some flight crews may be more experienced with certain operations than others.
- Scheduling an appropriate length of time for maintenance tasks to be completed.
- Educating clients to help them understand the risks associated with certain jobs.
- On MEDEVAC flights, training medical personnel to refrain from interacting with flight crew during critical phases of flight.

4.2.13.2.3 What operators said could be done

Operators indicated the following mitigations are needed:

- Transport Canada (TC) should treat all operators equally, and all operators should operate to the same regulatory standard. This suggests that not all operators are following the regulations and that oversight may not be detecting this (see also **Section 4.2.19 Safety theme: Regulatory oversight**).
- Clients should pay for safety. A number of operators said that more should be done to educate clients about the risks associated with selecting contract aviation operators solely on the basis of price. Educating clients may be a way to make them

more willing to select operators with high safety standards, although this may increase the price.

- Standards and costs should be consistent across the industry in order to level the playing field and to establish industry-wide performance measures in the air-taxi sector.

Operators said it is important to take steps to help reduce pressure on flight crew and maintenance personnel. Some of the ways this could be achieved include the following:

- Implementing duty-day regulations for maintenance staff (see also **Section 4.2.11 Safety theme: Fatigue**).
- Paying pilots a fixed salary instead of an hourly rate or by distance flown. This would reduce pressure on pilots to work as many hours as possible or to fly as far as possible each day despite safety risks. Many operators have implemented this.
- Providing adequate resources, including adequate time and staffing levels for maintenance, as well as dedicated training departments and/or training flights, to provide a consistent training environment for flight crews.

4.2.13.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period revealed 15 findings involving multiple accident scenarios related to pressure to get the job done. Sources of pressure included pressure exerted by companies,[125] pilot payment incentives (remuneration based on flight hours),[126] customers,[127] and lack of required equipment and resources.[128] As well, some pressure was self-induced.[129]

In these occurrences, pressure led to the acceptance of unsafe practices: aircraft flying overweight, problems not being recorded in the aircraft log book, and insufficient fuel (see also **Section 4.2.10 Safety theme: Acceptance of unsafe practices**). The investigation reports identified the benefits of educating clients.

4.2.13.4 Other reviews and safety studies

4.2.13.4.1 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) Final Report, published in 1998, made 6 recommendations relevant to this theme. Many of these recommendations concerned customer education as a mitigation to address pressure from clients:

SR 8	Recommend Transport Canada, in association with the aviation industry, review and update promotional material to educate clients about human

125 TSB aviation investigation reports A10Q0098, A10Q0132, A11W0048, and A12C0005.

126 TSB Aviation Investigation Report A10Q0098.

127 TSB aviation investigation reports A08P0353, A10Q0111, and A10Q0132.

128 TSB Aviation Investigation Report A00H0001.

129 TSB aviation investigation reports A04Q0199, A10A0122, and A10Q0132.

factors and safety issues and distribute information about how clients can identify safety-minded air operators.

IA 8 Recommend air operator associations participate in the review of promotional material aimed at educating clients, and produce and distribute information to their member air operators.

SR 9 Recommend Transport Canada amend the Company Aviation Safety Officer course and Air Taxi client briefings to include a module on client education and customer relations.

IA 23 Recommend air operators not pressure pilots to operate in marginal weather conditions and support the pilot's decision to wait for suitable weather before departing or to turn around when the weather deteriorates, etc. Recommend pilots stop pushing the weather.

SR 37 Recommend Transport Canada investigate a means to require air operators to remunerate pilots in a way that eliminates the operating pressures associated with the method of payment.

IA 37 Recommend air operators and pilots acknowledge the negative effect that the "pay-by-the-mile" method of payment can have on safe operational decision making. Recommend air operators and pilots make decisions based on safety, not remuneration and that air operators consider other methods of remunerating pilots.[130]

4.2.13.5 Summary

Table 18. Operational pressure: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said

• Operators are faced with many and varied types of demands in different environments using many different types of equipment.
• Personnel operate with less operational support than in other sectors.
• For seasonal operations, the need to be economically viable during a short period can result in operators focusing on getting the job done.
• Cyclical demand in the air-taxi sector means that, during periods of low demand, operators feel more pressure to accept risk in the interest of completing flights.
• Clients may intentionally or unintentionally apply pressure on operators.
	The impact of operational pressures may lead to decisions that result in the acceptance of unsafe practices.	• TC should treat all operators equally to ensure all operators comply with the regulatory standard.
		• Clients should pay for safety. More should be done to educate clients about the risks associated with selecting contract aviation operators solely on the basis of price.
		• Standards and costs should be consistent across the industry in order to level the playing field.
		• Pressure on flight crew and maintenance personnel should be reduced by
		  • implementing duty-day regulations for maintenance staff
		  • paying pilots a fixed salary

130 Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1998), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

• Competitive pressure may create financial constraints for organizations. • Operational needs may take priority over maintenance. • Various internal company pressures may lead to deviations from established procedures to complete the task more efficiently. • Training requirements may affect the resources available to conduct normal operations. TC's oversight may not ensure that all operators are meeting regulatory standards.		• providing adequate resources (maintenance and training staff)

Conclusion: Internal and external pressures, including pressure to get the job done, can negatively impact safety.

4.2.14 Safety theme: Pilot decision making and crew resource management

4.2.14.1 Background

The purpose of pilot decision-making (PDM) training is to develop skills to make decisions that manage the risks associated with a flight effectively. Risks encountered in air-taxi operations include aircraft loading, adverse weather conditions, unserviceable equipment, pressure to conduct and complete flights, and specific risks associated with medical evacuation (MEDEVAC) and night operations.

Contemporary crew resource management (CRM) training, which includes the principles of threat-and-error management (TEM), helps crews or single pilots develop the skills necessary to work with all resources to manage the risks associated with aircraft operations.

At the time of the industry-consultation phase of this safety issue investigation (SII), there were no regulatory requirements for CRM training for air-taxi operations, nor was there a

Pilot decision making

An important aspect of flight safety, PDM can be defined as a 4-stage process: gathering information, processing information, making a decision based on the possible options, and acting on that decision. For PDM to succeed, the pilot must continually reassess the conditions and determine whether the plan is still sound or whether a different course of action is required. Accurate and timely interpretation of the information available to the pilot is critical to the success of the process.

Crew resource management

The cockpit or flight deck of a multi-crew aircraft is a dynamic, challenging workplace where flight crews are constantly interacting with the aircraft, the environment, and each other. CRM is about making effective use of the resources available—human, hardware, and information—to manage the threats and challenges that can arise during any flight.

requirement for these operators to provide PDM training, except for those operating under the reduced visibility operations specification.[131,132]

However, while this SII was underway, Transport Canada (TC) made significant progress in creating a standard that would require all air-taxi operators to implement CRM training. It published a new standard, Advisory Circular AC 700-042, "Crew Resources Management (CRM)," which took effect on 31 July 2017. The standard had an 18-month time frame for implementation, meaning that all operators in aerial work operations, air-taxi operations, and commuter operations were originally required to be compliant by 31 January 2019. However, TC has since published an exemption to delay the implementation date of this standard until 30 September 2019.[133]

The diversity of operations in the air-taxi sector, combined with greater turnover of personnel than in other sectors, means that efforts to enhance PDM and CRM competencies have significant potential to enhance safety. However, for the potential benefits of PDM and CRM training to be realized, pilots must be supported effectively in employing these skills on the job. The benefits of TC's efforts to update the CRM standards for all operators, with modern content, will not be realized if operators and customers do not support the practice of strong PDM/CRM in operations.

PDM is part of the commercial pilot training syllabus, but once pilots are employed in the air-taxi sector, there is no regulatory requirement for any additional training, except for those operating under the reduced visibility operations specification.[134] PDM training is therefore a one-time requirement. Initial and recurrent training will not be mandatory until this type of training comes into effect in 2019.

4.2.14.2 What operators told us about this theme

4.2.14.2.1 Safety issues associated with this theme

When asked which issues posed the highest risk to safety, operators identified two safety issues related to PDM or CRM: insufficient PDM and CRM skills and the inability to apply PDM and CRM effectively in the operating environment.

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131 Transport Canada, Commercial & Business Aviation, Operations Specification 004, Subject: Day VFR Flight Minima Flight Visibility– within Uncontrolled Airspace - Aeroplanes at https://www.tc.gc.ca/eng/civilaviation/standards/commerce-certification-ops-004-1425.htm (last accessed on 01 October 2019).

132 Transport Canada, Commercial & Business Aviation, Operations Specification 005, Subject: Day VFR Flight Minima Flight Visibility– within Uncontrolled Airspace - Helicopters at https://www.tc.gc.ca/eng/civilaviation/standards/commerce-certification-ops-005-1426.htm (last accessed on 01 October 2019).

133 Transport Canada, Exemption from subsections 722.76 (24), 723.98(33) – Aeroplanes, 723.98(25) - Helicopters, 724.115(38) - Aeroplanes, 724.115(28) – Helicopters, and 725.124(39) of the *Commercial Air Service Standards* made pursuant to subsection 702.76(1), subparagraph 702.76(2)(d)(vi), subsection 703.98(1), paragraph 703.98(2)(d), subsection 704.115(1), paragraph 704.115(2)(e), subsection 705.124(1) and paragraph 705.124(2)(e) of the *Canadian Aviation Regulations* (effective 31 January 2019).

134 Ibid.

Operators indicated that these safety issues contributed to unsafe decisions and operating practices (see also **Section 4.2.10 Safety theme: Acceptance of unsafe practices**), such as departing or continuing flight in adverse weather, flying with defective equipment, not using checklists, or estimating rather than calculating weight and balance.

Pilot decision making and crew resource management skills

Operators noted that there was an absence of CRM training and that ineffective decision making and CRM skills increase the likelihood of unsafe decisions, especially decisions to change plans for safety reasons (e.g., making decisions related to weather or deciding to execute a go-around).

Reasons cited by operators for ineffective PDM skills included insufficient or ineffective training and crew experience. Operators questioned the efficacy of online PDM or CRM courses, which were thought to be missing the discussion component of classroom-based training that provides practical application of PDM or CRM concepts.

With regard to MEDEVAC flights, operators noted that the medical staff on these flights should be considered part of the crew for CRM purposes.

Ability to apply pilot decision making and crew resource management principles

The ability to make safe decisions and apply resources to manage risks effectively requires more than training. Pilots must be supported effectively in making good decisions. Operators noted that the practice of self-dispatch in the air-taxi sector increases the demands placed on the pilot compared with other types of operations. That is, instead of benefiting from the assistance of a dispatcher, the pilot alone is responsible for all aspects of flight planning, loading, etc. Dispatchers can support pilots by providing them with additional information and logistical support to make it easier for them to make safe decisions.

Experience was cited as a factor in the effectiveness of PDM. Pilots on both ends of the experience spectrum were at risk for ineffective decision making, although for different reasons. Operators described inexperience as a factor that makes it more difficult to identify and assess risks. However, as pilots gain more experience, often their perception of risk will change, making them more willing to take risks.

Related to the issue of experience was crew pairing. Operators described how ineffective crew pairing (for example, pairing 2 pilots who both have limited experience, a practice known as “green on green”) can lead to poor PDM and CRM.

Issues related to equipment and infrastructure were also cited by operators as affecting pilots’ abilities to make safe decisions. Examples of situations that made it more difficult for pilots to make safe decisions included the inability to weigh passengers and baggage at some airports, lack of available de-icing facilities, difficulties obtaining weather information, and pilot pay structures (e.g., pay calculated by miles flown) that impose additional pressure to complete flights.

4.2.14.2.2 How operators are managing these issues

Operators use a variety of mitigations to improve PDM and CRM. Some provide decision-making support for pilots via telecommunications—in some cases, 24 hours a day, 7 days a week. Some have pilot consultation available; one operator mentioned consultation with the chief pilot on go/no-go decisions.

Operators discussed the value of flight planning by dispatch and mandatory consultation with dispatch before flying. Flight following by a dispatcher or the operations manager can also support pilots.

Many operators conduct PDM training and offer mentoring for junior pilots. In crew pairing, they pair less experienced pilots with their more experienced counterparts, under a "no green-on-green" policy. Operators also discussed setting standard operating procedures (SOPs) and ensuring that operations are within the SOPs.

For some of the specific problems encountered, operators have conducted risk assessments or provided risk assessment tools to their crews. For example, one mentioned a risk matrix tool that pilots could use to evaluate airport landing strips.

To provide better information to crews to make safe decisions, some operators have adopted methods of improving weight-and-balance calculations. They mentioned weighing all cargo, instead of estimating, and using the actual weight of passengers, rather than segmented weights provided by Transport Canada[135] based on sex, season, and number of passengers. Some have implemented electronic weight-and-balance systems, and some have made scales available at outstations to ensure correct weight-and-balance calculations when away from the base airport.

4.2.14.2.3 What operators said could be done

Operators supported the idea of making CRM training mandatory for air-taxi operators. As well, they said they needed updated CRM training materials from TC. They felt that online training for CRM is inadequate and that pilots need structured classroom instruction with interaction between the instructor and participants.

Several operators saw flight following and pilot support as important mitigations. Specific measures mentioned were instituting a requirement for a flight following and operational control centre, and using satellite tracking.

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[135] Transport Canada, Advisory Circular 703-004: Use of Segmented Passenger Weights by Commercial Air Operators under Subpart 703 of the *Canadian Aviation Regulations* (Issue 03: 18 September 2013), at https://www.tc.gc.ca/eng/civilaviation/opssvs/managementservices-referencecentre-acs-700-703-004-1787.html (last accessed on 01 October 2019).

4.2.14.3 Previous TSB findings and recommendations on this theme

4.2.14.3.1 TSB findings and recommendations

A review of the 167 TSB occurrences with published investigation reports during the study period revealed 20 findings related to PDM or CRM.[136]

Many of the accidents that included such findings were in accident categories that frequently result in fatalities. Of the findings, 22 findings involved approach-and-landing accidents[137]; 10 findings involved visual flight rules + loss of visual reference + controlled flight into terrain[138]; 3 findings were related to in-flight component failure and the crew's response to this failure[139]; and 2 findings were related to icing.[140]

The findings related to CRM involved problems with crew pairing[141]; crew coordination in initiating or conducting a missed approach[142]; and/or adequacy of SOPs or crew failure to follow SOPs.[143]

Many of the PDM-related findings were related to weather, the use of available weather information, and pilot decisions to depart.[144]

The TSB has issued multiple recommendations related to PDM and CRM training that have included repeated calls for all pilots engaged in commercial operations to receive training to make better decisions and use resources effectively to mitigate risk.

Following TC's publication of Advisory Circular AC 700-042, "Crew Resources Management (CRM)," requiring the CRM training standard as of 30 September 2019, any outstanding recommendations[145] have all been assessed by the TSB as **fully satisfactory** and are now closed.

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136 TSB aviation investigation reports A04C0051, A04Q0049, A04Q0196, A04Q0199, A05O0225, A05P0298, A06P0036, A07C0001, A07Q0213, A07W0003, A08O0029, A08P0353, A08Q0187, A10O0145, A10Q0098, A10Q0111, A10Q0148, A13H0001, A14A0067, and A14W0181.

137 TSB aviation investigation reports A04Q0049, A04Q0196, A04Q0199, A06P0036, A07C0001, and A14A0067.

138 TSB aviation investigation reports A04C0051, A05O0225, A08O0029, A08P0353, A08Q0187, A10O0145, A10Q0111, A10Q0148, and A13H0001.

139 TSB aviation investigation reports A05P0298 and A10Q0098.

140 TSB aviation investigation reports A07W0003 and A14W0181.

141 TSB aviation investigation reports A04Q0049, A05P0298, A07C0001, A07Q0213, and A13H0001.

142 TSB aviation investigation reports A04Q0049, A04Q0196, A04Q0199, A06P0036, A07C0001, A07Q0213, A08O0029, A10Q0098, and A14A0067.

143 TSB aviation investigation reports A04Q0049, A04Q0196, A05O0225, A07C0001, A07Q0213, A08P0353, and A10O0145.

144 TSB aviation investigation reports A04C0051, A04Q0199, A07W0003, A08Q0187, A10O0145, and A10Q0148.

145 TSB recommendations A96-12, A00-06, and A09-02.

4.2.14.4 Other reviews and safety studies

4.2.14.4.1 Transport Canada Safety Study on Risk Profiling the Air Taxi Sector in Canada

TC's 2007 review of safety in the air-taxi industry[146] recommended that TC and the industry work together to provide more support to all pilots in the air-taxi sector in Canada.

4.2.14.4.2 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) Final Report, published in 1998, made 9 recommendations relevant to this theme:

SR 21	Recommend Transport Canada System Safety regional offices tailor Decision Making/Human Factors courses to meet the specific needs of air operators and specific types of operations.
IA 21	Recommend air operator management attend Decision Making/Human Factors courses and support pilots, aircraft maintenance engineers (AMEs) and apprentices in attending these courses.
SR 22	Recommend Transport Canada make Decision Making/Human Factors course material available in alternate media such as video tapes.
SR 23	Recommend Transport Canada review the Commercial Air Service Standard authorizing operations in reduced visibility, provided the pilot has taken a Pilot Decision Making (PDM) course, to determine if a one-time attendance at the PDM course is sufficient.
SR 26	Recommend Transport Canada develop a standard for human factors and decision making training. This training should start as early as possible and continue throughout the curricula of flight training units, aviation colleges and AME programs.
SR 53	Recommend Transport Canada develop various modules of the surface contamination training program that are relevant to specific types of VFR operations, such as Air Taxi, Aerial Work operations and helicopters.
SR 54	Recommend Transport Canada advertise safety courses, safety programs and safety information (brochures, videos, etc.) on the System Safety Website and in the various Aviation Safety newsletters.
IA 54	Recommend air operators, pilots and AMEs attend safety courses and distribute the information to other employees. Recommend air operators support their employees' participation in these courses.
SR 55	Recommend Transport Canada include safety quizzes in the various Aviation Safety Letters targeting new or amended procedures and regulations to provide the aviation industry with a more interesting way of learning.[147]

[146] Transport Canada, Safety Study on Risk Profiling the Air Taxi Sector in Canada (Ottawa: September 2007).

[147] Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1993), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

4.2.14.4.3 Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast – Report to the Chief Coroner of British Columbia

This report, prepared by British Columbia's Chief Coroner in 2012 following several fatal accidents in the air-taxi sector, included 1 recommendation relevant to this theme:

> That Transport Canada require commercial VFR operators to provide their pilots with annual decision-making training specific to the scope of operations; and, further, that Transport Canada require commercial VFR operators to provide annual decision-making training to all critical personnel that provide support to the pilot, including flight followers and company management.[148]

4.2.14.5 Summary

Table 19. Pilot decision making and crew resource management: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• Pilots may not have sufficient PDM and CRM skills and may not be able to apply them effectively in the operating environment. • Crews may not receive sufficient or effective training, and may not have sufficient experience. • There were few regulatory requirements for operators to provide PDM/CRM training.* • Personnel may not always receive the necessary support to make safe decisions.	• Operational risks may be higher when pilots do not have critical competencies to make safe decisions that manage the risks effectively. • Operational risks may be higher when PDM/CRM practices are not supported and reinforced by managers, supervisors, and peers.	• CRM training should be mandatory.* • TC should provide updated CRM training materials. • Structured classroom learning should be offered to supplement online CRM training.** • A requirement for a flight following and operational control centre should be instituted, and satellite tracking should be used. •

* This will be addressed by implementation of the new CRM training standard on 30 September 2019.
** The interview data were collected before the update to the CRM standard was published.

Conclusion: PDM and CRM are critical competencies that help flight crew manage the risks associated with aircraft operations.

4.2.15 Safety theme: Training of pilots and other flight operations personnel

4.2.15.1 Background

The purpose of training for pilots and other flight operations personnel is to develop their knowledge and skills to manage the diverse risks associated with flights and other operations effectively.

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148 Office of the Chief Coroner, British Columbia, Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast, Report to the Chief Coroner of British Columbia (Burnaby, BC, March 2012), at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/death-review-panel/aviation.pdf (last accessed on 01 October 2019).

Although there are many similarities among commercial aviation operations, training requirements are less stringent for pilots flying in air-taxi operations than for pilots flying in commuter or airline operations.

As well, although the flight training requirements for air-taxi operations have been increased, the minimum training time has not increased accordingly. Relevant subjects, some of which are required for commuter and airline operations, are not included in the training requirement. As a result, training may be compressed, subjects may not be covered sufficiently to manage known risks, and some relevant subjects may not be covered at all.

Although air-taxi operations have mandatory training requirements for certain high-risk operations, such as night flying, such requirements are lacking for many other high-risk operations, such as mountain flying and coastal flying. Mandatory training may therefore be inadequate to meet the many unique requirements of air-taxi operations. Without the requirement for specialty training for high-risk operations, pilots may lack the knowledge and skills to ensure safe flight operations.

Because of the nature and diversity of air-taxi operations, operators are exposed to risks that would not typically be seen in other types of operations (such as airline operations): unprepared landing sites, float-equipped aircraft, helicopter operations, locations with poor or no weather reporting, pilot self-dispatch, etc.

Although the commercial pilot training syllabus includes topics such as pilot decision making (PDM), once pilots are employed in the air-taxi sector, there is no regulatory requirement for any additional PDM training.[149] Unlike airline operations, which require initial and annual training in controlled flight into terrain (CFIT), air-taxi operations require this training only when the operator is authorized for flight under instrument flight rules (IFR) or night visual flight rules (VFR), and then only initially and every 2 years. Passenger airline operations are required to have an operational control system with shared authority between the pilot-in-command and a certified flight dispatcher, who is responsible for flight watch. By contrast, in air-taxi operations, the pilot-in-command is responsible for operational control and flight watch (self-dispatch).

The air-taxi sector, particularly airplane operations, is to a large extent a training ground for pilots before they move to commuter or airline operations.

4.2.15.2 What operators and Transport Canada inspectors told us about this theme

When asked which issues led to the highest risk to safety, operators described a number of issues related to training for pilots and other flight operations personnel (e.g., flight followers or other required company positions).

Gaps in many types of training were identified: flight, ground operations, aircraft systems, flight following, specialty operations, non-technical aspects, and emergency procedures.

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149 The reduced visibility operations specification requires PDM training; however, it is a one-time requirement only. PDM content is now included in the new CRM standard applicable to all commercial operations, which became effective on 31 July 2017, with a date for full implementation of 30 September 2019.

Additionally, new pilots (those with a commercial or airline transport pilot licence [CPL or ATPL] but little experience) may not be adequately prepared for the specialty competencies required for air-taxi operations.

Training requirements in air-taxi operations are less stringent or have deficiencies. Training time allotted for mandatory training is too short to provide adequate training on the content, and mandatory content is being added without additional time allotted. Furthermore, training materials are unavailable or have not been modernized by Transport Canada (TC).

4.2.15.2.1 Pilots unprepared for demands of air-taxi operations

New commercial pilots receive their training from a variety of flight-training providers: licensed flight-training units and college and university programs. Operators expressed concern that the training new pilots receive does not fully prepare them for their first job. Operators also observed inconsistent skills and knowledge among newly hired pilots, stating that training does not fully prepare pilots and other flight operations personnel for specific risks associated with air-taxi operations in general and certain specialty operations in particular. These include coastal flying, non-precision approaches, mountain flying, off-strip operations (specific to floats, wheels, and skis), unusual landing sites (in helicopter operations), operations in areas congested with overhead power lines (specific to helicopter operations), flight following, and underwater egress.

While pilots and other flight operations personnel working in these operations may have received training, operators expressed concern that the training may not be effective, because it is difficult for any training program to address all higher-risk operational scenarios.

4.2.15.2.2 Deficiencies in training requirements

The *Canadian Aviation Regulations* (CARs) set out the required training for operators, but the actual training provided can vary widely, as operators observed. While some operators provide training only to a level that meets the requirements of the CARs, others provide extra training beyond the requirements, to address needs and/or to derive benefits that mitigate risk in their operation.

Operators stated that the current training requirements for air-taxi operations should be increased. Many said the minimum training time allotted in the regulatory standards is insufficient; as a result, training may be compressed, and the subjects may not be covered as thoroughly as they need to be.

Operators described some aspects of pilot training as deficient:

- The IFR portion of Standard 723 Schedule I – Pilot Proficiency Check (PPC) may be inadequate for some operators. Operators stated that there was not enough emphasis on the actual instrument procedure portion of the PPC.
- There is no regulation addressing line indoctrination training, which pairs an experienced pilot with a newly qualified pilot for on-the-job mentoring. This type of

training usually occurs for a fixed number of hours and is typically followed by an evaluation once it has been completed.

- Flight crews have not received proper training with regard to a specific route, known as a route check. Route check training is designed to familiarize flight crews with the route to be flown, navigation aids and facilities, as well as any company-specific procedures for the route.
- New pilots enter the air-taxi industry with some or all of their flight training having been given by flight instructors with little experience in the air-taxi sector.
- There is inadequate training for single-pilot IFR operations on small-piston aircraft. In many cases, pilots with less flying time are hired to fly cargo flights on these aircraft. They may not fly these operations for long, because they are often groomed for advancement to a larger aircraft type. As these pilots move on, their knowledge about flying these higher-risk operations may be lost. Operators said it was important to ensure that former pilots' knowledge was passed along to new pilots to preserve the training benefit.
- Operators may not keep high-quality training records, affecting their ability to assess training needs or deficiencies, or to assess the usefulness of training.
- Operators do not allocate enough money for training.
- Training in underwater egress at small helicopter operators is missing or inadequate.
- Flight training in helicopters is limited with regard to the type of emergencies that can be safely simulated while airborne. Simulators are common for some types of airplanes, but few simulators are available for the types of helicopters used in the air-taxi industry in Canada.

With regard to the training of other flight operations personnel, the following aspects were described as deficient:

- The absence of formal training requirements for key positions within a company (e.g., chief pilot, operations manager, and the person responsible for maintenance). The roles and responsibilities of these positions are set out in the regulations, but no training requirements are attached to these roles.
- The fact that written examinations for the positions of chief pilot and operations manager are no longer required. This concern was raised by operators and TC inspectors. Eliminating the written examinations removes one of the steps in vetting these key positions within a company.

Most air-taxi operators employ a Type D operational control system, under which operational control is delegated to the pilot-in-command of a flight by the operations manager, who retains responsibility for day-to-day flight operations. Under this type of control system, pilots self-dispatch, as the regulations do not require dispatchers or dispatcher training. However, some operators told the safety issue investigation (SII) team that air-taxi operations would benefit from having company personnel assigned to, and trained to carry out, dispatch duties such as monitoring weather and assisting with flight planning as well as providing flight following.

TC inspectors said that, while the type of existing training is not in question, they were concerned about the quality of the training being provided by operators.

4.2.15.3 How operators are managing these issues

As mentioned above, operators mitigate some risks associated with training by providing high-quality training, in some cases exceeding the training required under the CARs governing air-taxi operations.

Additional training provided by these operators may include the following general types of training:

- enhanced training in emergency procedures for pilots and flight crews
- CFIT (not required under regulation for day VFR operations)
- crew resource management (CRM)
- pilot decision making (PDM)
- line indoctrination
- human factors
- fatigue awareness
- stabilized instrument approach

Additional training may include the following for specific types of operations:

- power-line awareness and avoidance for helicopter operations
- low-visibility operations, other than that required for reduced-visibility operations in uncontrolled airspace
- refresher training for floatplane pilots at the start of the flying season
- approach-and-landing accident reduction, usually specific to IFR operations
- enhanced icing training (beyond that required by regulations), specific to the operation, area, and aircraft

Some operators have developed meaningful training that is specific to the operation by, for example, using safety reports from the safety management system concerning close calls, near misses, and other types of incidents. With this information, they can identify hazards and develop training in mitigation strategies to prevent future events.

Other operators have engaged the aircraft's original equipment manufacturer in training development. Original equipment manufacturers can validate existing training and provide feedback to help develop new and improved training.

With regard to delivering more effective training, operators indicated that group training is very effective and much more beneficial for the candidates. Group training tends to involve more conversation, interaction, and sharing of experience and learning.

Other operators have used computer-based training through online resources; such training may be conducted anywhere there is internet access. Some operators make use of flight simulators and other flight training devices to enhance the training they offer.

Operators also reported that they train crews on the standard operating procedures (SOPs) and emphasize their use.

For training in flight following, some operators took flight followers to visit all of the operator's destinations, to help familiarize them with the routes and destinations where the operator regularly flies. This provides the flight followers with first-hand knowledge of the area.

For training specific to helicopter operations, some operators had instituted the following measures:

- All flight training was conducted at an airport, except for training requiring a specific scenario such as confined-space training. Training at an airport has the benefit of emergency services in case of a training accident.
- Ground training reinforced aerodynamic effects on control of the helicopter, including topics such as loss of tail rotor effectiveness or vortex ring state.
- Training included helicopter underwater egress.
- Training included confined-space training specific to helicopter operations.

4.2.15.4 What operators said could be done

Operators mentioned that the following training areas that need improvement:

- Additional time allotted for training that is required by regulation, specifically training for area navigation (RNAV) and localizer performance with vertical guidance approaches

Additional training that is not currently required by regulation:

- CRM and PDM: Some suggested a day-long PDM course package, while others said they needed better CRM guidance materials to help develop courses[150]
- Line indoctrination for pilots
- Egress training (for floatplane operators) (see also **Section 4.2.8 Safety theme: Survivability**)
- CFIT

Operators said they needed materials for specific training curricula, including the following:

- Guidance on how to train pilots in conducting stabilized constant descent angle (SCDA) approaches
- Updated global positioning system (GPS) guidance materials for training and development purposes

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150 TC has published the new standard, Advisory Circular AC 700-042, "Crew Resources Management (CRM)," which became effective on 31 July 2017, with a date for full implementation of 30 September 2019.

- Updated TC icing examination for operators to use in developing training

They also said they required the following general mitigations:

- operator training programs need to provide crews with knowledge of the local area
- pilots require better understanding of and training on mandatory frequency procedures in uncontrolled airspace
- for seaplane pilots, the hours required to attain a seaplane rating need to be increased to allow adequate training
- operators need to share their observations with flight schools regarding training subjects needed by new pilots entering the air-taxi industry

4.2.15.5 Previous TSB findings and recommendations on this theme

4.2.15.5.1 TSB findings

A review of the 167 TSB occurrences with published investigation reports during the study period revealed a total of 33 reports that identified training issues, across a broad range of accident scenarios.[151] In particular, the reports identified issues related to aircraft- or equipment-specific training; PDM and CRM; and operation-specific training.

Findings concerning aircraft- and equipment-specific training included the following:

- In a 2007 occurrence involving a loss of control in marginal weather, the crew was not trained in the use of, and did not understand the function of, the GPS.[152]
- In a 2008 occurrence involving fuel starvation and a forced landing, the pilot did not have a full understanding of the aircraft's fuel system or how to operate that system, and had not been tested on knowledge of the specified aircraft system.[153]
- In a 2009 occurrence involving a collision with trees on a missed approach, the crew conducted an RNAV approach for which they were not trained, with an aircraft that was not properly equipped or approved for such a purpose.[154]

Other findings involved a lack of proficiency in handling an aircraft emergency:

- In a 2006 occurrence involving an engine power loss and a forced landing, the investigation determined that the crew had no training for a single-engine IFR flight forced landing and was not prepared to handle this type of emergency.[155]

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151 TSB aviation investigation reports A01Q0034, A01W0297, A03W0074, A04A0111, A04C0190, A06P0010, A06P0157, A07C0001, A07W0003, A08C0124, A08P0353, A09C0012, A09C0167, A09P0397, A09Q0111, A09Q0203, A10A0122, A10C0060, A10Q0098, A10Q0111, A10Q0132, A11C0102, A11P0149, A11Q0170, A12C0005, A12O0071, A12W0031, A13C0073, A13H0001, A13Q0098, A14A0067, and A14W0181.

152 TSB Aviation Investigation Report A07W0003.

153 TSB Aviation Investigation Report A08C0124.

154 TSB Aviation Investigation Report A09C0012.

155 TSB Aviation Investigation Report A06P0010.

- In a 2011 occurrence involving a loss of control and collision with the ground, the crew did not understand aircraft speed limitations in an asymmetric thrust condition following an engine failure in which the crew lost control of the aircraft.[156]
- In a 2013 occurrence involving fuel exhaustion and a forced landing, the investigation made a finding related to task saturation and the ability to prioritize tasks in a complex emergency; the flight crew was inadequately prepared for the fuel emergency situation.[157]

Some findings were related to inadequate training in CRM or PDM. CRM issues were identified in findings from investigations into 2 approach-and-landing accidents involving multi-person crews.[158] PDM issues were identified in at least 2 occurrences involving a VFR flight with a loss of visual reference with the ground and CFIT[159] (see also **Section 4.2.14 Safety theme: Pilot decision making and crew resource management**).

A number of findings were directly related to operation-specific training.

- In a 2011 runway overrun occurrence, the pilot was not aware of the increased aerodynamic drag during takeoff when using a soft-field take-off technique.[160]
- Two accidents involved VFR flights in which the crew subsequently lost visual reference with the ground. In a 2013 occurrence, the crew had insufficient night training and lost visual reference with the ground, resulting in a CFIT.[161] In a 2010 occurrence, the pilot had insufficient training in recognizing degraded visual cues, instrument use, and unusual attitude recovery; this resulted in a loss of control in flight.[162]
- Three findings were related to loss of control in flight. The 1st was linked to the lack of mountain flying training and its relationship to aerodynamic effects on control of a helicopter.[163] The other 2 were related to floatplanes and an absence of underwater egress training.[164]

4.2.15.5.2 TSB recommendations

The Board has made multiple recommendations related to training over the years, all of which have been closed.

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156 TSB Aviation Investigation Report A11P0149.
157 TSB Aviation Investigation Report A13Q0098.
158 TSB aviation investigation reports A07C0001 and A14A0067.
159 For example, TSB aviation investigation reports A08P0353 and A10Q0111.
160 TSB Aviation Investigation Report A11C0102.
161 TSB Aviation Investigation Report A13H0001.
162 TSB Aviation Investigation Report A10Q0132.
163 TSB Aviation Investigation Report A04A0111.
164 TSB aviation investigation reports A09P0397 and A12O0071.

4.2.15.6 Other reviews and safety studies

4.2.15.6.1 TSB Safety Study on VFR Flight into Adverse Weather

This safety study found that accidents in which VFR flight was continued into instrument meteorological conditions accounted for a disproportionate number of fatalities, and that the causes and contributing factors involved in these accidents had recurring themes. Such themes included inappropriate pilot qualifications or proficiency for the conditions encountered, and serious shortcomings in the permissible weather minima for VFR flight, in pilot training, and in pilot licence privileges.[165] The absence of qualifications and proficiency are related to shortcomings in training.

4.2.15.6.2 TSB Safety Study of Survivability in Seaplane Accidents

The TSB *Safety Study of Survivability in Seaplane Accidents*[166] identified 2 issues relevant to this theme: inadequacy of both pilot training (in PDM, flight in reduced visibility, and mountain flying) and egress training.

4.2.15.6.3 TSB Safety Study of Piloting Skills, Abilities and Knowledge in Seaplane Operations

In this safety study,[167] the TSB examined 1432 seaplane accidents to identify areas of seaplane operations with safety deficiencies. The study confirmed that the incidence and severity of seaplane accidents is disproportionately high compared to landplanes. Loss of control during takeoff, engine failure after takeoff, collision with objects during takeoff, and loss of control during approach and landing were the most frequent types of accidents resulting in serious injuries or fatalities. The most frequently cited contributing factors in these accidents strongly indicated serious shortcomings in pilot knowledge, skills, techniques, and/or judgment in decision making (see also **Section 4.2.14 Safety theme: Pilot decision making and crew resource management**).

The study resulted in 3 recommendations related to training for seaplane operators, all of which have been closed.

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165 Transportation Safety Board of Canada, Aviation Safety Study 90-SP002, *Report of a Safety Study on VFR Flight into Adverse Weather* (Ottawa, 13 November 1990), at http://www.tsb.gc.ca/eng/rapports-reports/aviation/etudes-studies/90sp002/90sp002.html (last accessed on 01 October 2019).

166 Transportation Safety Board of Canada, Aviation Safety Study SA9401, *A Safety Study of Survivability in Seaplane Accidents* (Ottawa, 1994), at http://www.tsb.gc.ca/eng/rapports-reports/aviation/etudes-studies/sa9401/sa9401.html (last accessed on 01 October 2019).

167 Transportation Safety Board of Canada, Aviation Safety Study SSA93001, *A Safety Study of Piloting Skills, Abilities and Knowledge in Seaplane Operations* (Ottawa, 1993), at http://www.bst-tsb.gc.ca/eng/rapports-reports/aviation/etudes-studies/ssa9301/ssa9301.html (last accessed on 01 October 2019).

4.2.15.6.4 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) Final Report, published in 1998, made 2 recommendations relevant to this theme:

> IA 31 Recommend air operators inform their pilots about the operating limitations and company limitations of GPS equipment. Recommend pilots be aware of and respect the operating and company limitations of GPS and practice good airmanship by having back-up navigation equipment tuned and identified and by referencing maps when operating VFR.
>
> SR 53 Recommend Transport Canada develop various modules of the surface contamination program that are relevant to specific types of VFR operations, such as Air Taxi, Aerial Work operations and helicopters.[168]

4.2.15.6.5 Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast – Report to the Chief Coroner of British Columbia

This report, prepared by British Columbia's Chief Coroner in 2012 following several fatal accidents in the air-taxi sector, included 2 recommendations relevant to this theme:

> That Transport Canada create a requirement that all commercial seaplane pilots undergo training that includes a component on avoidance of, and recovery from, sudden encounters with hazards such as below Visual Meteorological Conditions (VMC) minima, low level flight over glassy water and poor visibility, and other typical hazards frequently encountered by seaplane pilots.
>
> That Transport Canada develop standardized curriculum for Mountain Flying Training and develop criteria for measuring students' proficiency in reaching acceptable standard.[169]

4.2.15.7 Summary

Table 20. Training of pilots and other flight operations personnel: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• There are no formal training requirements for key positions within a company: chief pilot, operations manager, and the person responsible for maintenance. • There may be limited training provided for specific types of operations, and operations	Operational personnel who do not have the necessary skills and knowledge may not be able to manage operational risks effectively.	• Additional time allotted for training RNAV and localizer performance with vertical guidance approaches. • Additional training is required for • CRM and PDM (implementation required by

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168 Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1993), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

169 Office of the Chief Coroner, British Columbia, Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast, Report to the Chief Coroner of British Columbia (Burnaby, BC, March 2012), at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/death-review-panel/aviation.pdf (last accessed on 01 October 2019).

personnel may not be adequately prepared for the specialty competencies required for air-taxi operations. • There are limited regulatory requirements for PDM and CRM, safety management, flight following, and operation-specific skills. • The minimum training time allotted in the regulatory standards is insufficient. • There are no regulations addressing line indoctrination training. • Training materials may be unavailable or may not have been modernized.		30 September 2019 under new regulations) ◦ line indoctrination ◦ underwater egress ◦ CFIT • Training materials are needed for the following: ◦ Guidance on how to train pilots in conducting SCDA approaches ◦ Updated GPS guidance materials for training and development purposes ◦ Updated TC icing examination for operators to use in developing training • General mitigations are required: ◦ Training programs to provide local area knowledge ◦ Better training on mandatory frequency procedures ◦ Seaplane rating qualification training needs to be increased • Operators need to share training requirements with flight schools for new pilots entering the air-taxi industry.

Conclusion: Providing training for pilots and other flight operations personnel is essential for them to develop the skills and knowledge they need to effectively manage the diverse risks associated with air-taxi operations.

4.2.16 Safety theme: Training of aircraft maintenance engineers

4.2.16.1 Background

Applicants for aircraft maintenance engineer (AME) positions currently need to have completed a training course in aircraft maintenance, avionics, or structural repair (as applicable) that has been approved or accepted by Transport Canada (TC). In addition, they must have relevant maintenance experience and pass a TC examination on regulatory requirements. AMEs may also need to complete an approved course on a specific type of aircraft, engine, or system.

Because of the wide range of equipment used in the air-taxi sector—from airplanes designed and built more than 70 years ago to state-of-the-art helicopters—AMEs' college training may be inadequate to meet an operator's immediate needs. It is up to individual operators to ensure that AMEs receive the appropriate on-the-job training and that their technical knowledge is continually reinforced.

4.2.16.2 What operators told us about this theme

4.2.16.2.1 Safety issues associated with this theme

Operators did not identify issues in AME training as a high-risk safety issue; however, they did raise several safety issues falling under this theme:

- There is no formal training available or required for certain positions in the company, such as the person responsible for maintenance or the director of maintenance.
- When a fleet has many aircraft types, it can be challenging to adequately train maintenance personnel for all types.
- AME training schools are teaching students on older aircraft and maintenance technology; students are thus unprepared for newer aircraft and maintenance technology in use at many companies.
- College programs are not preparing new AMEs to handle the documentation associated with doing a maintenance task.
- There is inconsistent use of maintenance manuals by AMEs in the air-taxi industry. That is, AMEs may perform tasks from memory rather than consulting the manual while they perform the task. Training should include appropriate use of manuals to ensure tasks are performed correctly.

Maintenance training provided by operators may not be as effective as it could be. One factor contributing to this issue may be that some AMEs do not stay with operators long enough for the operator to feel that it is worth the time to provide a consistent level of training.

4.2.16.2.2 How operators are managing these issues

The main mitigation is to provide adequate on-the-job training to address inconsistent prior training and experience. Operators shared some examples of the measures being taken with regard to training content, mentoring of newly hired AMEs or apprentices, external resources for the delivery of training, and other practices to encourage safe maintenance.

Training content

- Training includes human factors, crew resource management, safety management systems, company policies, and maintenance control manuals.
- Training also includes a new-aircraft inspection program when new equipment is purchased.
- Specific training for internal quality-assurance auditors is provided.

Mentoring of newly hired AMEs or apprentices

- Apprentices always work with an AME on all tasks.
- Apprentices are provided with gradually increasing responsibility as they progress through their training period.

- Newly hired AMEs always spend the first 2 weeks at the main base before they work at an away base.

Use of external resources for the delivery of training

- Operators hire an outside agency to provide specialized training such as human factors.
- AMEs take training with the aircraft manufacturer for 1 week every year to learn from and interact directly with the manufacturer.
- Operators regularly work with aircraft manufacturers to validate the content of in-house training and to suggest any additions to the curriculum.

Other practices to encourage safe maintenance

- Reinforcing good tool control and maintenance practices to minimize the possibility of errors.
- Varying the schedule worked by AMEs in a specific department. For example, an AME working in the heavy maintenance department would be assigned daily line maintenance to allow the AME to gain additional experience.
- Strongly encouraging the use of maintenance manuals for all tasks being done.
- Instilling a philosophy of continuous improvement that encourages questioning discrepancies in a maintenance procedure, challenging any procedures that appear to be incorrect, and adopting a more efficient method that is discovered and approved.

4.2.16.2.3 What operators said could be done

Operators suggested that colleges and training facilities spend more time training future AMEs in all aspects of the documentation required in maintenance.

For training in human factors in maintenance, guidelines need to specify what type of experience the trainer needs and how to measure the effectiveness of such training.

Overall, operators said that AME training should be taken more seriously in the industry. There needs to be more structured recurrent training for AMEs, similar to that for flight crew.

4.2.16.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period did not reveal any findings or recommendations related to the training of AMEs.

4.2.16.4 Other reviews and safety studies

4.2.16.4.1 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) final report, published in 1998, made 1 recommendation relevant to this theme:

SR 5 Recommend Transport Canada develop a standard for initial and recurrent aircraft type training for Aircraft Maintenance Engineers.[170]

4.2.16.5 Summary

Table 21. Training of aircraft maintenance engineers: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• Some operations have a wide variety of aircraft types and models to maintain. • AME school curriculum and training may be inadequate to meet operators' immediate needs. • Regulatory requirements for AMEs' human factors and recurrent training may be inadequate. • There is inconsistent use of maintenance manuals by AMEs.	Inadequate initial and/or recurrent training may result in a reduced level of safety during operations.	• Colleges and training facilities need to spend more time training on all aspects of maintenance documentation. • Human factors guidelines need to specify trainers' experience and how to measure the effectiveness of the training. • More structured recurrent training for AMEs is needed, similar to that for flight crew.

Conclusion: AMEs working in air-taxi operations require extensive technical knowledge to ensure that the wide variety of aircraft types and models used in this sector are maintained in airworthy condition.

4.2.17 Safety theme: Safety management

4.2.17.1 Background

Organizations must strike a balance between safety and production by managing risks to safety within acceptable levels in their operation. However, production or operational concerns may at times seem more pressing, because they are more easily measured and provide immediate results. Therefore, operational concerns may be more salient than safety concerns in the minds of decision makers. In this context, organizations may unwittingly introduce risk into their operations.

Organizations vary considerably in the level of risk they tolerate within their operations. Some take proactive steps to identify and reduce risks and are considered to have a positive safety culture, while others with a less robust safety culture knowingly or unknowingly operate with higher levels of risk and greater potential for an accident.

In the air-taxi sector specifically, the diverse operations and often hazardous conditions require greater safety and risk management than do other operations. Air-taxi operators need to be able to continuously identify hazards and risks and to reduce them to a level as low as reasonably practicable. Safety management remains an important way to achieve

[170] Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1993), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

this and to address many of the other issues that came to light in this safety issues investigation.

Transport Canada (TC) expects transportation companies to proactively manage the safety of their operations and to have programs in place to ensure that they continue to comply with all regulatory requirements.

The traditional approach to safety management is based on compliance with regulations and a reactive response to incidents and accidents. Although compliance with regulations is fundamental to the development of sound safety practices, operators that consider simply complying with the standards set by the regulations to be adequate may not identify emerging safety problems. The regulatory requirements alone cannot possibly cover all risks.

The Transportation Safety Board (TSB) has repeatedly emphasized the advantages of a safety management system (SMS), which, when implemented properly, allows companies to manage risk effectively and make operations safer. TC had previously committed to requiring SMS in all aviation operators, but backed away from that commitment.

Safety management system

According to the International Civil Aviation Organization, a safety management system (SMS) is "a systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures."* Other definitions state the approach is for the purpose of achieving acceptable or tolerable safety levels. Regardless of the specific definition used, SMS involves a quality management approach to safety, in which planning, procedures, and feedback from data are brought to bear to improve safety.

* International Civil Aviation Organization, Doc 9859 AN/474, *Safety Management Manual*, 3rd Edition (Montreal, 2013).

Solutions must be found to apply SMSs effectively and flexibly, despite the many pressures on air-taxi operators, and solutions need to be tailored or scaled for small operators. Furthermore, to succeed, SMSs need to be driven by a proactive safety culture.

4.2.17.2 What operators told us about this theme

4.2.17.2.1 Safety issues associated with this theme

Operators identified a number of issues related to safety management, such as inadequate skills, knowledge, and experience, as well as the diversity of approaches and attitudes to managing safety.

Operators indicated that these safety issues contributed to, and were a direct reflection of, not only a company's safety culture but that of the air-taxi sector.

Safety management skills, knowledge and experience

Among the issues raised by operators regarding skills, knowledge, and experience were

- inadequate leadership skills in management,
- ineffective communication between management and staff,
- inadequate definition of roles and responsibilities,
- insufficient aviation knowledge among aviation company owners,

- insufficient qualified staff in required positions (director of maintenance, chief pilot, director of flight operations, etc.), and
- an absence of tool-control policies and procedures.

Communications and interpersonal relations were raised repeatedly as factors undermining safety. Various operators said that management did not have “people skills,” that interpersonal relations among staff were poor, and that there was not enough communication between pilots and maintenance.

Safety management approaches

Operators expressed concern about problems with safety culture and risk management in their operations. Others said that safety was managed to ensure compliance with regulations. However, risks specific to the operation that were not covered by the regulations were not adequately managed. Some provided examples of poor safety culture, such as inconsistent safety reporting, no follow-ups on reported safety issues, a reactive approach to safety, insufficient quality-assurance processes, and local “fixes” to safety problems that fail to identify the root cause.

This safety issue investigation (SII) found that many operators, including those that already had an SMS, fully supported the idea that all air-taxi operators should be required by regulation to have an SMS. However, others felt that informal measures worked well and that SMSs would be a detriment to small air-taxi operators. Many operators voluntarily apply safety management principles and are seeing value from these policies and procedures. Operators described proactive and innovative solutions to improve their safety, but others complained about the absence of a safety culture and practices that compromise safety.

These mixed views may stem from a wide spectrum of safety management practices in the sector and from concern that an SMS can be burdensome for small operators, owing to its lengthy timelines and costly processes.

4.2.17.2.2 How operators are managing these issues

Operators use a variety of mitigations to manage safety effectively that go beyond the requirements under regulations:

- carrying out all flights under instrument flight rules (IFR)
- using 2 pilots for all operations
- establishing their own minimum requirements for pilot flight experience

Tool-control policies and procedures can be used as a mitigation measure, as can dual inspection for regular maintenance activities.

For some specific operators, twin-engine aircraft could be used for their floatplane operations during windy days, while others have decided to provide a more detailed safety briefing (specific to the operation). A number of operators have implemented a method of flight following and have provided computer-based tools for this purpose.

Furthermore, many operators had adopted an SMS or extended the SMS from their airline operations to their air-taxi operations. In some cases, air-taxi clients required operators to have an SMS structure in place as a condition of their contract. SMS features implemented by operators included

- an SMS tool for risk assessments,
- online SMS reporting,
- feedback loops based on SMS reporting,
- SMS training from a third-party provider,
- changes to the company structure to support an SMS,
- an SMS coordinator or manager, and
- an SMS based on TC's guidance on SMS development.[171,172]

Operators also mentioned putting in place practices that normally form part of an SMS, whether or not they were identified as such, for example:

- identifying hazards associated with operations
- using a flight risk-assessment tool
- following incident-reporting processes
- using a safety-reporting database to track issues
- assigning a risk factor for specific flights, based on a database that flags risks associated with destinations
- monitoring the safety of operations
- putting quality-assurance processes in place for all flight operations
- using flight data analytics
- using guidelines provided by associations

Safety audits were mentioned as a risk mitigation measure. In addition to the oversight conducted by TC, audits could be conducted by clients or by a third party. The audits conducted by clients were more frequent than TC oversight activities or were on an unannounced ("surprise") basis.

Mitigations to promote open communication about safety include

- encouraging reporting and a flow of information about safety;
- holding daily, weekly, or monthly staff meetings;
- conducting an annual safety survey of all employees in the company to gauge the effectiveness of their safety program;

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171 Transport Canada, Advisory Circular No. 107-001: Guidance on Safety Management Systems Development, at https://www.tc.gc.ca/eng/civilaviation/opssvs/managementservices-referencecentre-acs-100-107-001-toc-117.htm (last accessed on 01 October 2019).

172 Transport Canada, Advisory Circular No. 107-002: Safety Management Systems Development Guide for Smaller Aviation Organizations, at https://www.tc.gc.ca/eng/civilaviation/opssvs/managementservices-referencecentre-acs-100-107-002-461.htm (last accessed on 01 October 2019).

- publishing a monthly safety newsletter; and
- sharing information informally with other operators.

With regard to safety training, mitigations include developing a manual of best practices to help inform the operator's staff, and delivering training in root-cause analysis for all staff involved in safety.

With regard to emergency preparedness, mitigations include emergency response planning, performing annual mock-crash exercises, and having an emergency response manual for air-taxi operations.

Ways to ensure that all safety-related events have been reported and captured include providing a standard memo for sign-off following safety-related events, and encouraging clients to file safety reports.

4.2.17.2.3 What operators said could be done

Many operators told the SII team that SMSs should be required for air-taxi operators. However, some stated that, in this sector, SMSs need to be designed for small companies.

Some suggested that SMSs should be required only for companies that have a minimum number of employees or aircraft. Others suggested an SMS based on shared data for the overall air-taxi industry rather than for a specific company.

Other proposed mitigations centred on training in safety management. Many operators commented that their staff need training in investigating safety issues and conducting root-cause analysis. They also said that relevant training in risk assessment and root-cause analysis should be provided to managers. Some mentioned training in developing a corrective action plan (CAP),[173] and some said college programs should include SMS training. Operators asked for more support for safety training, including better guidance from TC regarding SMSs, a better definition of SMSs, and a manual containing examples of SMSs and other safety initiatives.

Because safety data for a small operator can be limited, operators suggested sharing safety information among operators, and collecting accurate data on safety incidents in the sector. Regional aviation safety councils (RASCs) were formed to provide an opportunity for members of the aviation industry to meet twice a year and identify, discuss, and resolve issues that have the potential to impact aviation safety. Operators said that these were no

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[173] A corrective action plan (CAP) is "a plan submitted in response to findings. The CAP outlines how the enterprise proposes to address identified regulatory non-compliances and ensure on-going compliance." (Source: Transport Canada, Advisory Circular (AC) No. SUR-004, Civil Aviation Surveillance Program Issue 01 [19 November 2015], at https://www.tc.gc.ca/eng/civilaviation/opssvs/managementservices-referencecentre-acs-sur-2177.html#s2 [last accessed on 01 October 2019]).

longer taking place, although they found them helpful and believed they should be reinstated.

Finally, operators called for more effective oversight from TC, which would require TC inspectors to improve their understanding of SMSs as they applies to smaller operators.

4.2.17.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period revealed that safety management issues were contributory in 14 accidents.[174] The issues identified in the reports were mainly in the following areas:

- Inadequate supervision of pilots and flights, including self-dispatch
- Failure to identify hazards or to follow up on hazards once these were identified
- Deviations from standard operating procedures, company manuals, and the *Canadian Aviation Regulations* (CARs)
- Operational shortcomings that had not been corrected
- Absent or inadequate SMS or aspects of an SMS such as proactive monitoring, voice and data recording systems, data collection, or risk analysis
- Absent or inadequate safety culture and acceptance of unsafe practices

The TSB has made 1 recommendation regarding SMSs, which is active:

> the Department of Transport require all commercial aviation operators in Canada to implement a formal safety management system.
>
> **TSB Recommendation A16-12**

The issue of safety management and oversight is also on the 2018 TSB Watchlist. The Watchlist identifies the key safety issues that need to be addressed to make Canada's transportation system even safer.

With regard to safety management and oversight, some transportation companies are not effectively managing their safety risks, and many are not required to have formal safety management processes in place. TC oversight and intervention has not always proven effective at changing companies' unsafe operating practices.

All transportation companies are responsible for managing safety risks in their operations.

Safety management and oversight will remain on the TSB Watchlist until

- Transport Canada implements regulations requiring all commercial operators in the air and marine industries to have formal safety management processes and effectively oversees these processes;
- Transportation operators that do have an SMS demonstrate to Transport Canada that it is working—that hazards are being identified and effective risk-mitigation measures are being implemented; and
- Transport Canada not only intervenes when operators are unable to manage safety effectively, but does so in a way that succeeds in changing unsafe operating practices.

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174 TSB aviation investigation reports A02C0124, A05A0155, A07C0001, A07W0138, A08P0353, A10Q0098, A11W0048, A12C0154, A12W0031, A13H0001, A13P0166, A13Q0098, A14A0067, and A14W0181.

Some companies consider safety to be adequate as long as they are in compliance with regulatory requirements, but regulations alone cannot foresee all risks unique to a particular operation. That is why the TSB has repeatedly emphasized the advantages of SMSs, an internationally recognized framework to allow companies to effectively manage risk and make operations safer.

SMSs have been on the TSB Watchlist since 2010. Since then, there has been no progress on expanding the application of SMSs to a broader range of companies in the aviation sector.

4.2.17.4 Other reviews and safety studies

4.2.17.4.1 House of Commons review of the transportation of dangerous goods and safety management systems

The House of Commons *Review of the Canadian Transportation Safety Regime: Transportation of Dangerous Goods and Safety Management Systems*, prepared by the Standing Committee on Transport, Infrastructure and Communities, made 1 recommendation relevant to this theme. The recommendation was based on the TSB Watchlist issue:

> Transport Canada implement regulations requiring all operators in the air industry to have formal safety management processes, and that Transport Canada oversee these processes.[175]

4.2.17.4.2 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) Final Report, published in 1998, made 11 recommendations relevant to this theme:

SR 10	Recommend Transport Canada organize and facilitate sessions where air operators can meet as a group to take an active role in fostering a safety culture and encouraging safe operating practices, discuss common problems and arrive at industry-made solutions in cooperation with Transport Canada. Once the group is established, Transport Canada's role would diminish as the group becomes self-sufficient.
IA 10	Recommend air operators actively participate in the Transport Canada/air operator group sessions.
SR 11	Recommend Transport Canada make funding or other assistance available for air operators who are establishing safety associations or programs.
SR 27	Recommend Transport Canada provide the Chief Pilot and Operations Manager on initial appointment to that position with information about courses and training materials available from System Safety (e.g. Decision Making/Human Factors, Company Aviation Safety Officer course, etc.)
SR 28	Recommend Transport Canada encourage Air Taxi operator management to attend the Company Aviation Safety Officer (CASO) course.

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175 House of Commons, Supplementary Opinion of the Official Opposition, The New Democratic Party of Canada, Standing Committee on Transport, Infrastructure and Communities, *Review of the Canadian Transportation Safety Regime: Transportation of Dangerous Goods and Safety Management Systems* (Ottawa, March 2015).

IA 28 Recommend Air Taxi operator management attend the CASO course and implement the principles learned in the course in their company.

SR 29 Recommend Transport Canada promote the benefits of having a company safety program to Air Taxi operator management and review the requirement for Air Taxi operators to have a company safety program.

IA 29 Recommend Air Taxi operators establish a company safety program that is fully supported by management.

SR 30 Recommend the Transportation Safety Board evaluate the management factors that contributed to the accident during the accident investigation.

SR 49 Recommend Transport Canada require Air Taxi operators to submit relevant statistics to determine where accidents are occurring and to target areas where resources should be allocated for accident prevention programs.[176]

4.2.17.4.3 Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast – Report to the Chief Coroner of British Columbia

This report, prepared by British Columbia's Chief Coroner in 2012 following several fatal accidents in the air-taxi sector, included 1 recommendation relevant to this theme:

> That the British Columbia floatplane industry associations encourage the operators that make up their membership to formally compile information on significant hazards specific to the operators' routes and provide flight crews with formal briefings or training and information on such hazards, supplemented with information on standard operating procedures and best practices for mitigating these route-specific hazards.[177]

4.2.17.5 Summary

Table 22. Safety management: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said
• Inadequate skills, knowledge, and experience, as well as the diversity of approaches and attitudes to managing safety • Ineffective communications and interpersonal relations • Managing safety solely to ensure compliance with regulations • Weak safety culture • Insufficient risk management • Practices that compromise safety	Operators' safety management may not have kept up with advances in the aviation industry.	• SMSs should be required for air-taxi operators. • SMSs need to be designed for small companies. • SMSs should be required only for companies that have a minimum number of employees or aircraft. • SMSs should be based on shared data for the overall air-taxi industry rather than for a specific company. • Training should be provided in safety management,

176 Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force, *SATOPS Final Report* (Ottawa, 1998), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

177 Office of the Chief Coroner, British Columbia, Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia's Coast, Report to the Chief Coroner of British Columbia (Burnaby, BC, March 2012), at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/death-review-panel/aviation.pdf (last accessed on 01 October 2019).

• Inadequate guidance on formal SMS • No regulatory requirements for air-taxi operators to have a formal SMS in place		investigating safety issues, and conducting root-cause analysis. • Training in risk assessment and root-cause analysis should be provided to managers. • Training in developing a CAP. • College programs should include SMS training. • Support for safety training, better guidance from TC and a manual containing examples of SMSs and other safety initiatives are needed. • Safety information should be shared among smaller operators. • RASCs should be reinstated. • TC should provide more effective oversight.

Conclusion: Effective safety management is important for operators to be able to proactively identify hazards and mitigate risks to a level as low as reasonably practicable.

4.2.18 Safety theme: Regulatory framework

4.2.18.1 Background

Air transportation safety is promoted, monitored, and enforced through a regulatory framework and regulatory oversight. The framework consists not only of the *Aeronautics Act* and associated regulations, but also of policies, guidelines, standards, and educational materials that help Transport Canada (TC) personnel and the aviation industry to interpret and apply the regulations. Oversight by Transport Canada Civil Aviation (TCCA) is intended to verify the industry's compliance with the regulatory framework through certifications, assessments, validations, inspections, and enforcement.[178] Both the framework and oversight have a bearing on many of the safety issues discussed elsewhere in this report. This section addresses issues in the regulatory framework.

Other than Part 6, General Operating and Flight Rules, of the *Canadian Aviation Regulations* (CARs), flight operations in the air-taxi sector are governed by a single set of provisions—Subpart 703 of the CARs—even though this sector has a wide variety of operations and encounters a similarly wide variety of risks. Subpart 703 has fewer regulatory requirements and, therefore, fewer regulatory defences than do aviation operations conducted under Subpart 704 (commuter operations) or Subpart 705 (airline operations). As well, the absence of regulations in specific areas may lead to lower safety standards in a sector that serves as a training ground for new commercial pilots entering the industry and has many of the higher-risk operations in Canadian aviation.

178 Transport Canada, "Civil Aviation," at https://www.tc.gc.ca/eng/civilaviation/menu.htm (last accessed on 01 October 2019).

4.2.18.2 What operators told us about this theme

4.2.18.2.1 Safety issues associated with this theme

Among the issues associated with the greatest risk, operators indicated that the Subpart 703 regulations are outdated and do not reflect the latest developments in technology or the most recent safety advances in the aviation industry.

Operators also mentioned the reduced visibility operations specification in the *Commercial Air Service Standards*,[179] which affects many air-taxi operators. They said the minima specified are so low that following them diminishes the level of safety. Most suggestions by operators concerned adding regulations in safety areas that currently have no or inadequate regulations (see **Section 4.2.18.2.3 What operators said could be done**):

- restriction on use of single-engine aircraft in instrument flight rules (IFR) operations
- traffic-alert and collision-avoidance systems (TCAS)
- line indoctrination training for new flight crew
- training in crew resource management (CRM)
- an operational control system that includes a licensed dispatcher

Some of the operators' frustration with absence of or insufficient regulation stemmed from the difficulty in changing regulations. Operators voiced concern that the current process for regulatory change through the Canadian Aviation Regulation Advisory Council (CARAC) is takes too long and is ineffective, and that the process would benefit from more effective consultation.

4.2.18.2.2 How operators are managing these issues

One operator indicated that it carried out operations in accordance with the standards under Subpart 704, which governs commuter air operations, rather than Subpart 703.

Other operators adopted practices not required by regulation under Subpart 703; for example,

- requiring 100 hours of line indoctrination training
- conducting flight following for all flights
- providing simulator training
- providing safety equipment not required by regulation

4.2.18.2.3 What operators said could be done

Operators stated that regulations for air-taxi operations under Subpart 703 are inadequate and should be closer to the standards prescribed by Subpart 704. Several operators

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179 Transport Canada, *Commercial Air Service Standards*, (last revised 01 June 2012), section 723.28: VFR Flight Minima – Uncontrolled Airspace, at https://www.tc.gc.ca/eng/civilaviation/regserv/cars/part7-standards-723a-2171.htm (last accessed on 01 October 2019).

suggested that the regulations should contain sub-categories for different types of operations, such as floatplanes, medical evacuation (MEDEVAC), helicopters, and single- and multi-engine aircraft operating under IFR. Some mentioned that regulations need to be updated to reflect new technology.

When asked what changes they would like to see, operators asked for greater regulation in areas covered in other parts of this safety issue investigation (SII), including safety management systems (SMSs), operations in adverse weather conditions, and the use of and training in new technology.

Other regulatory changes suggested by operators related to competence and fitness; visibility and visual flight rules (VFR) operations; training; equipment; and dispatch.

Crew fitness for duty was raised as an issue of concern (see also **Section 4.2.11 Safety theme: Fatigue**). Three suggestions were made with regard to competence and fitness:

- Alcohol consumption by aircraft maintenance engineers (AMEs) should be regulated, with requirements similar to those in place for pilots.
- Maximum hours on duty should be specified for maintenance personnel.
- Credentials, qualifications, and operational requirements should be prescribed for key positions in a company, such as chief pilot or operations manager (see also **Section 4.2.17 Safety theme: Safety management**).

Four suggestions were made with regard to visibility and VFR operations:

- Visibility requirements for taxi, takeoff, and landing should be easier to understand and follow.
- The reduced visibility operations specification should be eliminated, so that flights can be conducted only if visibility is at the minima currently prescribed by regulations.
- The regulations for night flights under VFR should be updated, or night operations under VFR should be prohibited (see also **Section 4.2.6 Safety theme: Night operations**).
- VFR and IFR procedures for operations in uncontrolled airspace should be updated.

Five suggestions were made with regard to training:

- The regulations should be updated to make more types of training mandatory and to increase hours for training, because current minimum training time is inadequate, especially for training in new technology (see also **Section 4.2.15 Safety theme: Training of pilots and other flight operations personnel** and **Section 4.2.16 Safety theme: Training of aircraft maintenance engineers**).
- Line indoctrination training and line checks should be required.
- CRM training should be required (see also Section 4.2.14 Safety theme: Pilot decision making and crew resource management).
- The flight hours required to obtain a seaplane rating should be increased.
- Recurrent training should be required for AMEs.

Three suggestions were made with regard to equipment (see also **Section 4.2.7 Safety theme: On-board technology**):

- High-intensity strobe lights should be installed and used on aircraft.
- TCAS should be required for all air-taxi operations.
- The approval method for modifications to older aircraft should be simplified.

One suggestion was made with regard to dispatch (see also **Section 4.2.14 Safety theme: Pilot decision making and crew resource management** and **Section 4.2.15 Safety theme: Training of pilots and other flight operations personnel**):

- A licensed dispatcher should be required for all air-taxi operations.

4.2.18.3 Previous TSB findings and recommendations on this theme

A review of the 167 TSB occurrences with published investigation reports during the study period revealed that 30 findings from 19 investigations identified regulatory issues that led to a reduced level of safety in air-taxi operations.[180] Some of the findings from these investigations corroborate comments made by operators during this SII and are discussed below.

In a 2006 occurrence involving an engine power loss,[181] 2 risk findings were made relating to restrictions on the use of single-engine IFR operations:

- One finding related to the lack of a requirement for independent terrain mapping, such as terrain awareness and warning systems (TAWS), in single-engine IFR operations in mountainous regions.
- The other finding related to the lack of a requirement for additional route evaluation or structuring to minimize the risk of an off-field landing during single-engine IFR operations.

In a 2003 occurrence involving a risk of collision between a helicopter and an airplane,[182] 1 finding was made about the lack of a requirement for transponders in Class E airspace, limiting the effectiveness of TCAS equipment.

Two findings were made relating to the requirement for line indoctrination training for new flight crew:

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180 TSB aviation investigation reports A02C0143, A03P0113, A03Q0151, A03W0074, A03W0202, A03W0210, A04H0001, A04Q0196, A06P0010, A07C0001, A09P0187, A09Q0203, A10A0122, A10Q0162, A12C0005, A12P0079, A12P0134, A13H0001, and A13Q0098.

181 TSB Aviation Investigation Report A06P0010.

182 TSB Aviation Investigation Report A03P0113.

- In a 2003 loss of control due to inadequate rotor rotations per minute,[183] the absence of a requirement for training of pilots with less flying experience was cited as a risk finding.
- In a 2013 occurrence involving controlled flight into terrain (CFIT),[184] the lack of a requirement for pilots to undergo line indoctrination was cited as a risk finding.

In a 2007 collision with terrain,[185] a finding was made relating to the absence of a requirement for training in CRM, including threat-and-error management and pilot decision making.

Three findings were made relating to competence and fitness:

- In the 2013 occurrence involving CFIT, a finding was made relating to insufficient and inexperienced personnel in key positions in a company.[186]
- In a 2013 forced landing following fuel exhaustion, a finding as to risk was made regarding pilot proficiency check requirements for a chief pilot. If these requirements are not more stringent than pilot proficiency check requirements for other pilots, chief pilots may not be able to perform the duties required to ensure the safety of company training and operations.[187]
- Also in the 2013 forced landing, it was found that the inability of operations management personnel to perform their duties and responsibilities does not constitute grounds for suspending or revoking the ministerial approval of such appointments.[188]

With regard to visibility and VFR operations, a risk finding was made in a 2012 loss of visual reference and collision with terrain,[189] stating that operations in conditions with visibility reduced to 0.5 statute miles increase the risk of inadvertent loss of visual reference.

One finding was made relating to training:

- In a 2004 loss of control, it was found that there was no requirement to conduct recurrent simulator training for pilots, and it was unclear whether such training is required after a pilot proficiency check expires.[190]

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183 TSB Aviation Investigation Report A03W0074.
184 TSB Aviation Investigation Report A13H0001.
185 TSB Aviation Investigation Report A07C0001.
186 TSB Aviation Investigation Report A13H0001.
187 TSB Aviation Investigation Report A13Q0098.
188 Ibid.
189 TSB Aviation Investigation Report A12P0079.
190 TSB Aviation Investigation Report A04H0001.

One finding was made relating to equipment (see also **Section 4.2.12 Safety theme: Maintaining air-taxi aircraft**):

- In a 2012 engine power loss and ditching, it was found that there was no requirement for flotation equipment in single-engine helicopters.[191]

In addition to the findings that corresponded with the issues raised by operators during this SII, other findings were related to the following regulatory issues:

- Few restrictions on external loads and ambiguous wording of an exemption from the CARs for external loads that led to misinterpretation of the regulation by TC and an operator[192]
- No requirement for a TAWS[193]
- Inadequate protection against ground impact in IFR approaches in reduced visibility[194]
- Standard passenger and carry-on luggage weights not being increased to reflect societal changes[195]
- Repetitive charter operators not being covered by the same regulations as scheduled air operators, even though the operations are very similar[196]
- Inadequacy of current standards regarding wake turbulence separation[197]
- Takeoff being permitted from a runway that is shorter than the accelerate-stop distance of the aircraft, as determined from the performance diagrams[198]
- No requirement for companies' standard operating procedures to be reviewed by TC[199]

4.2.18.4 Other reviews and safety studies

4.2.18.4.1 TSB Safety Study of Piloting in Seaplane Operations

This study[200] made 7 recommendations related to the regulatory framework of air-taxi operations, all of which have been closed.

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191 TSB Aviation Investigation Report A12P0134.

192 TSB Aviation Investigation Report A03W0210.

193 TSB aviation investigation reports A06P0010, A09Q0203, and A10A0122.

194 TSB Aviation Investigation Report A03Q0151.

195 TSB Aviation Investigation Report A04H0001.

196 Ibid.

197 TSB Aviation Investigation Report A09P0187.

198 TSB Aviation Investigation Report A10Q0162.

199 TSB Aviation Investigation Report A13H0001.

200 Transportation Safety Board of Canada (TSB), Aviation Safety Study SSA93001, *A Safety Study of Piloting Skills, Abilities and Knowledge in Seaplane Operations* (Ottawa, 1993), at http://www.bst-tsb.gc.ca/eng/rapports-reports/aviation/etudes-studies/ssa9301/ssa9301.html (last accessed on 01 October 2019).

4.2.18.5 Summary

Table 23. Regulatory framework: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said

• There are fewer regulatory defences in air-taxi operations than in operations conducted under commuter operations (CARs Subpart 704) or airline operations (CARs Subpart 705).
• The absence of regulations in specific areas may lead to lower safety standards.
• Regulations may not reflect the latest developments in technology or recent safety advances in aviation.
• The process for regulatory change through the CARAC takes too long and is ineffective in implementing necessary changes.
• The requirements for designated positions (chief pilot, operations manager, etc.) may not be adequate to ensure that the holder of the position is adequately equipped to do the job.
• The reduced visibility operations specifications are so low that following them diminishes the level of safety.
	Regulations that are ineffective or outdated, and/or the absence of regulations, may result in a reduced level of safety.	• Regulations for air-taxi operations are inadequate and should be closer to standards for commuter airline operations (CARs Subpart 704).
		• Regulations should contain sub-categories for different types of operations, such as floatplanes, MEDEVAC, helicopters, and single- and multi-engine aircraft operating under IFR.
		• Regulations need to be updated to reflect new technology.
		• Greater regulation is needed in areas covered in other parts of this SII, including
		  • SMSs,
		  • operations in adverse weather conditions, and
		  • use of and training in new technology.
		• Other regulatory changes needed include
		  • crew fitness
		  • alcohol consumption for AMEs
		  • maximum hours on duty for AMEs
		  • credentials, qualifications, and operational requirements for key positions in a company
		• Visibility and VFR operations:
		  • Make visibility requirements easier to understand.
		  • Eliminate the reduced visibility operations specification.
		  • Update regulations for night flights under VFR or prohibit night operations under VFR.
		  • Improve VFR and IFR procedures for operations in uncontrolled airspace.
		• Training:
		  • Make more types of training mandatory.

		• Increase hours for training. • Require line indoctrination training and line checks. • Require CRM training.* • Increase the flight time required for seaplane rating. • Introduce recurrent training for AMEs. • Equipment: • Require use of high-intensity strobe lights. • Require TCAS for all air-taxi operations. • Simplify approval method for modifications to older aircraft. • Dispatch: • Require a licensed dispatcher for all air-taxi operations.

* TC has published a new standard, Advisory Circular AC 700-042, "Crew Resources Management (CRM)," which became effective on 31 July 2017, with a date for full implementation of 30 September 2019.

Conclusion: Regulations must keep pace with advances in the aviation industry to help achieve an acceptable level of safety.

4.2.19 Safety theme: Regulatory oversight

4.2.19.1 Background

Regulatory oversight is particularly challenging in the air-taxi sector. In 2018, there were more than 500 air operator certificates in place, with a wide range of operations: seaplanes, helicopters, and landplanes; single- and multi-engine aircraft; and visual flight rules (VFR) and instrument flight rules (IFR) operations—all operating in a variety of hazardous environments.

In the face of such complexity, it is not possible to eliminate accidents completely or to have enough resources to ensure that every operator complies with every aspect of the safety regulations at all times. Risk management techniques are therefore important for setting inspection criteria and developing the skills, knowledge, and experience required for inspectors to be able to assess whether companies are complying with the regulatory framework.[201]

Previous Transportation Safety Board (TSB) investigations and safety studies have emphasized the role of Transport Canada (TC) role in ensuring that operators are capable of managing the risks inherent in their operations, that measures to enhance safety are

201 Auditor General of Canada, "Chapter 5—Oversight of Civil Aviation—Transport Canada," in: *2012 Spring Report of the Auditor General of Canada* (Ottawa, 2012), para 5.15, p. 10, at http://www.oag-bvg.gc.ca/internet/English/parl_oag_201204_05_e_36469.html (last accessed on 01 October 2019).

working effectively to identify hazards and mitigate risks, and that any non-compliance with regulations is addressed promptly and corrective action is taken.

In 2005, TC adopted a systems-based approach to regulatory oversight and transitioned from determining regulatory compliance only by direct inspection to a model that included a review of the effectiveness of a certificate holder's safety management processes. Systems that are the subject of oversight include safety management systems (SMSs), quality assurance programs, training systems, operational control systems, and others. TC evaluates these systems through surveillance procedures, including assessments (of SMS, if required by regulation), program validation inspections (PVIs), and process inspections (PIs), which have replaced traditional audits and inspections.

TC uses various types of assessments to verify that operators have adequate and effective systems in place to ensure ongoing compliance with regulatory requirements.[202] To assist TC inspectors, expectations have been developed, providing descriptions of what constitutes an effective system. For operators that are not required to have an SMS, including air-taxi operators, expectations are provided for their specific type of operation.[203]

In principle, moving to a systems-based approach should result in improved safety because verifying that an organization has systems in place to maintain compliance will have a longer-term impact than simply verifying that an organization is in compliance with regulations at a given point in time. The move to a systems-based approach has also changed how operators are expected to respond to surveillance findings. In addition to rectifying any findings of non-compliance, operators are also expected to analyze and identify the underlying causes of non-compliance and provide corrective action plans (CAPs) to TC outlining how these system-level deficiencies will be addressed.

For oversight to be effective at both the compliance and the systems level, sufficient resources and personnel with the knowledge, skills, and experience are needed to interact effectively with all levels in a company, as well as to provide consistent interpretation of the regulations and supporting documentation.

However, at the same time as it introduced the systems approach, TC scaled back safety promotion and education activities. Inspectors may be in contact with operators less frequently, and some TC activities, such as the Civil Aviation Safety Seminar, regional aviation safety councils, and Company Aviation Safety Officer courses, have been largely discontinued.

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202 Transport Canada, Advisory Circular AC SUR-004: Civil Aviation Surveillance Program (effective 19 November 2015), Section 6.0.

203 Ibid.

4.2.19.2 What operators and Transport Canada inspectors told us about this theme

4.2.19.2.1 Safety issues associated with this theme

When asked to describe the most significant risks associated with their operations, a number of operators discussed regulatory oversight.

Most operators stated that they needed more assistance, or more timely assistance, from TC. Many operators commented that TC was not focused on helping the companies and that there were not enough TC staff to provide responses in a timely manner.

Similarly, several comments related to TC's surveillance approach:

- Some operators questioned the value of a systems approach.
- Some operators stated that they found surveillance findings overly bureaucratic.
- Some operators were concerned that TC was no longer conducting traditional audits.
- Some operators were critical of the way in which PVIs are conducted; they felt that PVIs focus on finding errors.
- Some operators were concerned about the high cost of hiring external approved check pilots, who are approved by TC to conduct check flights.

While many operators welcomed help from the regulator, others raised concerns about the regulatory burden. One operator stated that there was too much regulation, and others mentioned the time required to prepare for TC surveillance activities (such as PVIs) and to develop CAPs in response to findings. At least one operator said different inspectors had different interpretations of regulations. Another said that TC interprets information, such as regulations and manuals, differently from operators.

When TC inspectors were asked to describe the most significant risks associated with air-taxi operations, a number of comments involved regulatory oversight.

TC inspectors' comments largely mirrored operators' comments with regard to inconsistent interpretation and application of regulations, and the frequency and focus of surveillance. As well, inspectors raised issues related to insufficient staffing and completing required work in a timely manner.

Inspectors also described issues with training and competence of both inspectors and managers: generalists rather than experts are being sought and, in some cases, they have limited industry experience.

Both operators and inspectors commented on inspectors having inadequate training to carry out surveillance activities (e.g., PVIs) and conduct specialized oversight (e.g., of heliports and of transportation of dangerous goods).

The surveillance processes used (e.g., PIs, PVIs) were not specific to the air-taxi sector and could not be easily adapted to the operators being inspected. Other inspectors stated that it had become more difficult to take enforcement action and that the elimination of the Civil

Aviation Issues Reporting System (CAIRS) in March 2016[204] removed a way for the public and government agencies to send concerns or direct questions to TC. Finally, some inspectors believed that their concerns about these areas were not being heard by management at TC.

Both operators and inspectors believed that TC has insufficient inspectors and other resources. As a result, TC approvals take longer and oversight is less frequent, among other effects of the lack of resources.

Operators and inspectors also identified a lack of experience and training among TC inspectors, especially in specific operations in this sector, such as floatplanes. Operators were also concerned about inconsistent interpretations of regulations by inspectors; inspectors echoed this concern, saying that there are problems with communication and consistency of interpretation.

4.2.19.2.2 How operators are managing these issues

Operators have focused on managing these issues by participating effectively in oversight activities, including by

- seeking out external training to develop CAPs,
- developing checklists to ensure all items were addressed when developing CAPs,
- making use of available guidance material from TC, and
- ensuring that all managers attend meetings with TC so that everyone receives the same message.

4.2.19.2.3 What operators said could be done

Operators and TC inspectors had many comments about improvements needed in regulatory oversight. Comments focused on the need for more TC inspectors, the frequency and scope of oversight activities, TC assistance and guidance to operators, TC processes, and the competence of TC inspectors.

Many operators indicated that more TC inspectors were required to enable the regulator to process amendment requests in a timely manner and to ensure that time frames for the CAP process are respected.

Operators frequently commented that increased oversight—both more frequent and broader in scope—would be welcome. In particular, they believe there is a need for more traditional oversight (rather than assessments, PVIs, and PIs), with more hands-on activities, including check rides, ramp checks, and line checks. Both operators and TC inspectors indicated that more frequent contact between operators and TC inspectors would be beneficial. In addition, operators indicated that TC needs to focus on holding operators accountable when they are not compliant with the regulations.

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[204] Transport Canada, Civil Aviation Issues Reporting System, at https://www.tc.gc.ca/eng/civilaviation/opssvs/secretariat-cairs-menu-209.htm (last accessed on 01 October 2019).

Operators consistently stated that they needed more support from TC. Many operators highlighted the need for a positive relationship with TC inspectors in order for a company to improve safety. Operators wanted to be able to approach TC inspectors to discuss specific issues, rather than simply receiving an acceptance or rejection of a CAP. In addition, operators said they need additional or improved guidance material in several areas, including the PI, PVI, and CAP processes; guidance for new operations managers; and updated approved check pilot manuals.

Operators frequently cited the need for improved timeliness and consistency of responses from TC. Specifically, operators said the timelines for approval processes should be shorter.

Many comments were related to the need for greater knowledge and training among TC inspectors. While many of these comments were general, operators suggested that TC inspectors should have specific knowledge and experience in the operations for which they provide oversight (such as floatplane operations).

4.2.19.3 Previous TSB findings and recommendations on this theme

4.2.19.3.1 TSB findings

A review of the 167 TSB occurrences with published investigation reports during the study period revealed several findings related to regulatory oversight of operators.

In several investigations, findings were made regarding insufficient oversight and infrequent audits, which had allowed safety deficiencies to go unidentified.[205] Other investigations found that the absence of in-depth review by TC resulted in deficiencies in operators' standard operating procedures and company operations manuals.[206]

One investigation made a finding in relation to the process for approving key positions: weaknesses were identified in TC's process for verifying the competence of operations management personnel.[207]

In several investigations, it was found that TC had identified deficiencies during its surveillance of operators, but that the deficiencies were not resolved, because the scope of the deficiency was not understood[208] or the process to bring the operator into compliance was ineffective.[209] In one investigation, it could not be determined why the deficiency was not resolved.[210]

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205 TSB aviation investigation reports A03W0210, A04H0001, A12W0031, and A12C0154.

206 TSB aviation investigation reports A10Q0098, A10Q0117, and A11O0166.

207 TSB Aviation Investigation Report A13Q0098.

208 TSB Aviation Investigation Report A07C0001.

209 TSB aviation investigation reports A10Q0117 and A13H0001.

210 TSB Aviation Investigation Report A05Q0178.

Three investigations identified contributing factors to the oversight issues described above:

- In a 2004 occurrence, internal communications issues at TC resulted in the principal operations inspector being unaware of important information about an operator.[211]
- In a 2007 occurrence, TC resources were allocated from audits to other oversight activities associated with the implementation of an SMS.[212]
- In a 2013 occurrence, inspectors received inadequate training and guidance, resulting in uncertainty and in inconsistent and ineffective surveillance.[213]

Two occurrences identified difficulties in applying a systems approach to oversight. In one case, the investigation found that the operator had not demonstrated that it could effectively manage safety,[214] and another investigation highlighted the need for a balanced approach to oversight that examines both systems and compliance with regulations.[215]

4.2.19.3.2 TSB recommendations

As part of its investigation into aviation occurrence A99A0036, involving a controlled flight into terrain in Davis Inlet, Newfoundland and Labrador, the TSB identified multiple occurrences in which the regulatory oversight process failed to identify or address unsafe practices, particularly among small operators in remote locations. The report stated:

> It appears that the traditional methods of inspection, audit, general oversight, and regulatory penalties have had limited success in fostering appropriate safety cultures in some companies and individuals; consequently, unsafe conditions continue to exist and unsafe acts are still being committed.[216]

As a result, the report recommended that

> the Department of Transport undertake a review of its safety oversight methodology, resources, and practices, particularly as they relate to smaller operators and those operators who fly in or into remote areas, to ensure that air operators and crews consistently operate within the safety regulations.
>
> **TSB Recommendation A01-01**

In its 2005 response to this recommendation, TC indicated that it planned to continually review its safety programs and that it had taken specific steps to improve its safety oversight, including

- formalized regulatory requirements for SMS in order to instill a safety culture in the aviation industry,
- a risk management philosophy for decision making,
- a new strategic plan for civil aviation, and

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211 TSB Aviation Investigation Report A04H0001.
212 TSB Aviation Investigation Report A07C0001.
213 TSB Aviation Investigation Report A13H0001.
214 Ibid.
215 TSB Aviation Investigation Report A14A0067.
216 TSB Aviation Investigation Report A99A0036.

- a review of internal TC organization to optimize its resources for safety.

The response to this recommendation was rated **fully satisfactory**, and the recommendation is now closed.

The first step in TC's response, to require SMSs through regulations, has been supported by the TSB, echoing calls from the International Civil Aviation Organization (ICAO) and the worldwide civil aviation industry. The TSB has stated the advantages of SMSs:

> Transportation companies have a responsibility to manage safety risks in their operations. Compliance with regulations can only provide a baseline level of safety for all operators in a given sector. Since regulatory requirements cannot address all risks associated with a specific operation, companies need to be able to identify and address the hazards specific to their operation.
>
> […]
>
> When implemented properly, SMS provide a framework for companies to manage risk effectively and make operations safer. Regulatory requirements for companies to implement SMS are the first step in ensuring that all operators are capable of meeting their safety responsibility.[217]

However, since making a commitment in 2005 to add SMS to aviation regulations, TC has backed away from its plan to require all commercial operators to implement an SMS.

The TSB continues to call for SMS in all types of operations. For example, in its investigation report into an accident in Moosonee, Ontario, involving a helicopter operated by Ornge, the TSB stated:

> The investigations into this accident and other recent occurrences emphasize the need for operators to be able to manage safety effectively. More than 10 years after introducing the first SMS regulations for airline operators and the companies that perform maintenance on their aircraft, SMS implementation has stalled. While many companies, such as Ornge RW, have recognized the benefits of SMS and voluntarily begun implementing it within their organizations, approximately 90% of all Canadian aviation certificate holders are still not required by regulation to have an SMS. As a result, TC does not have assurance that these operators are able to manage safety effectively.[218]

Therefore, the Board recommended that

> the Department of Transport require all commercial aviation operators in Canada to implement a formal safety management system.
>
> **TSB Recommendation A16-12**

In its response to this recommendation, TC indicated that it would continue promoting the voluntary adoption of SMSs by publishing guidance material for smaller operations. The TSB is pleased that TC has taken these measures. TC also stated that it would review the policy, regulations, and program related to SMSs in civil aviation. There is no clear indication at this time what TC will do once the review is complete and whether it intends

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217 TSB Aviation Investigation Report A13H0001, section 4.2.9.

218 Ibid.

to initiate a rule-changing process to require all commercial aviation operators to implement a formal SMS. Therefore, the response to Recommendation A16-12 is assessed as **unable to assess.** The TSB will monitor TC's actions related to the implementation of SMSs in all sectors of commercial aviation. This deficiency file is **active**.

It is insufficient to simply implement an SMS; the SMS must also work effectively to identify hazards and mitigate risks. The TSB has highlighted the need for the regulator to ensure that operators' SMSs are doing so.

Therefore, the Board recommended that

> the Department of Transport conduct regular SMS assessments to evaluate the capability of operators to effectively manage safety.
>
> **TSB Recommendation A16-13**

In its response, TC indicated that it had adopted a systems-based approach to all its surveillance activities and that it was using a suite of surveillance tools to verify compliance with the CARs, including SMS requirements. TC also indicated that it was confident in its systems-based approach to verifying regulatory compliance. The Board recognizes that TC has undertaken a number of change initiatives aimed at improving its oversight program, and that some progress has been made.

In a recent briefing to the Board, TC also reiterated its commitment to verifying regulatory compliance at appropriate intervals and carrying out enforcement effectively, as required. The Board is encouraged by the concrete enforcement actions recently taken by TC on issues that were identified through its surveillance activities. However, TC's response does not fully address the underlying safety deficiency that led to this recommendation. Achieving minimum regulatory compliance does not necessarily guarantee that all commercial aviation operators are capable of effectively managing safety within their organization. TC must also confirm that operators have a mature, effective SMS and are managing safety risks effectively.

The Board notes that TC recently conducted a Program Evaluation and Update Project to take stock of the various transformation and improvement initiatives to date. This evaluation project will assist TC in refining the various elements of its surveillance program, including regular SMS assessments of the capability of operators to manage safety effectively.

Although the numerous actions taken by TC may address the risk associated with this safety deficiency, more work remains to be done. Therefore, the Board considers the response to the recommendation to be **satisfactory in part.**

The TSB will continue to monitor the progress made by TC on the improvement of its SMS assessments within the overall surveillance program. This deficiency file is **active**.

Not only must operators have an SMS that has been verified to be effective, but the regulator also needs to be able to identify when an operator is not compliant with regulations and guide that operator back into compliance in a timely manner. Recent investigations have highlighted that, when an operator is unable or unwilling to address identified safety deficiencies, TC has had difficulty adapting its approach to ensure that deficiencies were identified and addressed in an effective and timely manner.

Under TC's risk-based approach to surveillance planning, it scheduled more frequent surveillance for the operators in question, which were all viewed as being at higher risk. However, following one occurrence, unsafe conditions remained unidentified when the surveillance remained focused on processes.[219] In other occurrences, unsafe conditions were allowed to persist for an extended period while TC relied heavily on a CAP process that the operators were ill-equipped to participate in.

Therefore, to ensure that companies use their SMS effectively, and continue operating in compliance with regulations, the Board recommended that

> the Department of Transport enhance its oversight policies, procedures and training to ensure the frequency and focus of surveillance, as well as post-surveillance oversight activities, including enforcement, are commensurate with the capability of the operator to effectively manage risk.
>
> **TSB Recommendation A16-14**

In its response, TC indicated that it has launched a Civil Aviation Surveillance Program Evaluation and Update Program, scheduled to be completed in December 2017. The Board is encouraged that TC has committed to evaluating its surveillance program and to considering opportunities for further improvements to ensure the effectiveness of its surveillance program.

In a recent briefing to the Board, TC provided a detailed update on the various program improvement initiatives undertaken since 2015–2016. The Board is pleased to note that TC has implemented concrete actions, such as

- establishment of a National Oversight Office,
- implementation of an Oversight Advisory Board,
- creation of a dedicated team working on surveillance policies and procedures,
- strengthening of oversight planning,
- risk-based decision making,
- timely enforcement actions, and
- temporary measures that will permit an increase in the number of inspections in higher-risk areas while the program evaluation and update is being done.

The Board also acknowledges TC's efforts to find the right balance between planned and reactive oversight activities, as well as balance in the use of the various types of oversight tools available. Although TC has implemented numerous improvements, it is too early to assess whether TC's actions will adequately address the safety deficiency associated with this recommendation. Therefore, the Board considers the response to the recommendation to indicate **satisfactory intent**.

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219 TSB Aviation Investigation Report A13W0120.

The TSB will monitor TC's ongoing actions to enhance its oversight policies, procedures, and training in the short and long term. This deficiency file is **active**.

4.2.19.3.3 TSB Watchlist

The need for SMSs and better regulatory oversight has been on the TSB Watchlist since 2010. Compliance with regulations provides a basic level of safety for all operators; thus, regulatory oversight needs to be able to identify and address operators that are not in compliance.

Operators also need to be able to address the risks specific to their operation, which compliance with regulations will not entirely ensure. Therefore, the TSB has repeatedly emphasized the advantages of SMSs, an internationally recognized framework to allow companies to effectively manage risk and make operations safer.

4.2.19.4 Other reviews and safety studies

4.2.19.4.1 Transport Canada Safety of Air Taxi Operations Task Force

The TC Safety of Air Taxi Operations Task Force (SATOPS) Final Report, published in 1998, made numerous recommendations that the regulator work more closely with air-taxi operators and provide more guidance for specific issues, such as competence and training of personnel in critical positions. The comments of operators, submitted as part of this safety issue investigation (SII), corroborate the task force's findings in this area. For example, the task force had the following recommendations:

SR 27	Recommend Transport Canada provide the Chief Pilot and Operations Manager on initial appointment to that position with information about courses and training materials available from System Safety (e.g. Decision Making/Human Factors, Company Aviation Safety Officer course, etc.)
SR 28	Recommend Transport Canada encourage Air Taxi operator management to attend the Company Aviation Safety Officer (CASO) course.
IA 28	Recommend Air Taxi operator management attend the CASO course and implement the principles learned in the course in their company.
SR 29	Recommend Transport Canada promote the benefits of having a company safety program to Air Taxi operator management and review the requirement for Air Taxi operators to have a company safety program.
SR 56	Recommend Transport Canada facilitate information sessions to provide a forum for the exchange of ideas and information between Transport Canada and the Air Taxi industry.[220]

The SATOPS report also made multiple recommendations about the need for increased regulatory oversight; these recommendations are consistent with the operators' comments submitted to the SII team:

[220] Transport Canada, TP 13158E, Safety of Air Taxi Operations Task Force (SATOPS), *SATOPS Final Report* (Ottawa, 1998), at https://www.tc.gc.ca/media/documents/ca-publications/tp13158.pdf (last accessed on 01 October 2019).

SR 58	Recommend Transport Canada conduct more operations-oriented audits and inspections.
SR 59	Recommend Transport Canada conduct in-flight inspections in Air Taxi aircraft.
SR 60	Recommend Transport Canada conduct more random audits and inspections.
SR 61	Recommend Transport Canada provide more regulatory compliance presence, especially in northern and remote areas.
SR 62	Recommend Transport Canada ensure all audit follow-up is completed.
IA 62	Recommend air operators ensure all audit findings are rectified.
SR 63	Recommend Transport Canada Regional Commercial and Business Aviation inspector personnel are more representative of the demographics of the aviation industry.[221]

221 Ibid.

4.2.19.5 Summary

Table 24. Regulatory oversight: hazards, description of risk, and what operators said

Hazards	Description of risk	What operators said

• The air-taxi sector has a large number of operators using many different types of aircraft in a wide variety of operations, often in remote locations.
• TC staffing levels may affect the frequency and scope of regulatory oversight.
• The frequency and scope of regulatory oversight may be inadequate for some operators.
• The support provided by TC may be insufficient for some operators.
• The competency and training of TC inspectors may be inadequate for them to perform their oversight duties.
• TC workload may hinder TC's ability to interact with operators.
• TC's safety promotion activities may be insufficient.
	Ineffective and/or inefficient regulatory oversight may result in a reduced level of safety.	The following are required:
		• More TC inspectors
		• More frequent oversight and oversight that is broader in scope
		• More traditional oversight, with more hands-on activities, including check rides, ramp checks, and line checks
		• More frequent contact between operators and TC inspectors
		• Greater support from TC
		• A positive relationship with TC inspectors in order for a company to improve safety
		• Additional or improved guidance material in several areas, including
		  • PIs, PVIs, and CAP processes;
		  • guidance for new operations managers; and
		  • updated approved check pilot manuals.
		• Improved timeliness and consistency of responses from TC
		• Greater knowledge and training among TC inspectors: TC inspectors should have specific knowledge and experience in the operations for which they are providing oversight.

Conclusion: A robust system of regulatory oversight that includes safety promotion, monitoring, and enforcement is critical to ensuring that operators are provided with the support they need to effectively manage the risks associated with their operation and that they are complying with the regulations.

5.0 DISCUSSION

Air-taxi operators provide a diverse array of air services to Canadians in a wide variety of environments, and their operating context is therefore very different from the context that would be familiar to most Canadians travelling with scheduled airline operators. At July 2018, there were approximately 500 approved air-taxi operators, 87 approved commuter operators, and 38 approved airline operators in Canada.[222] (For more information on these numbers, see **Section 1.2 Aircraft accident rates and numbers in Canadian aviation**.)

The air-taxi sector is a challenging sector of commercial aviation, given its operating context, and it experiences a high number of accidents, especially fatal accidents. (See **Section 1.3 A sector of concern**.) Air-taxi operators are exposed to diverse hazards and risks and are subject to operational pressures that are unique to their sector. They tend to be smaller, with fewer staff than commuter and airline operators. They may operate in areas that have minimal weather reporting services available, and they may not have the latest on-board technology. Pilots do not always have support from dispatch or from other support personnel. Flight crew have a more direct role in managing many of the operational risks than in other sectors and often have direct contact with clients. They do not always operate on a set schedule, and often fly into remote areas in uncontrolled airspace, with limited navigational aids and aerodrome infrastructure. The context, environment, and size of their operation will therefore influence the mitigations that can be put in place to manage risks in the field.

The purpose of this safety issue investigation (SII) was to understand the hazards and risk factors associated with air-taxi operations in Canada, not just factors that were relevant to one specific segment (such as helicopter operations or floatplane operations).

In Phase 1 of the SII, quantitative and qualitative Transportation Safety Board of Canada (TSB) data of air-taxi accidents from 2000 to 2014 were analyzed to identify the types of accidents that were happening, establish which types were fatal, and highlight the safety issues that contributed to these accidents. Because the purpose of this study was to describe and explain interrelationships between many factors that cannot be experimentally isolated or quantified, a grounded theory study, using the constant comparative method of data analysis, was conducted. This method made it possible to develop a set of descriptive and explanatory accident types—in other words, types of accidents that described the circumstances of the accident and explained the outcome. The data are presented in **Section 4.1 Information from TSB occurrence data and published investigation reports**.

A grounded theory study was also used to analyze the survey and interview data obtained from the industry consultations in Phase 2 of the SII. These data were analyzed using the constant comparative method of data analysis, and from this emerged 19 safety themes, which are presented in **Section 4.2 Information from consultations with industry**.

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[222] Transport Canada, Operator List Search, at https://wwwapps.tc.gc.ca/saf-sec-sur/2/CAS-SAC/olsrles.aspx?lang=eng (last accessed on 01 October 2019).

Each theme was supplemented with context and information from previous TSB findings and recommendations in published accident reports, and from previous studies by other organizations. A grounded theory study was then used to further analyze the themes that emerged in Phase 2. The 19 safety themes were analyzed by the investigation team using the constant comparative method of data analysis and from this emerged 3 higher-level themes, labelled "pressures." These pressures are discussed in **Section 5.5.3 Competing pressures in the air-taxi sector**.

Once the pressures had emerged from the analysis, a theory was developed from the data, building upon a dynamic safety model. **Section 5.4 A dynamic model of safety: The safe operating envelope** provides a general explanation of how the safe operating envelope model works, and **Section 5.5 The SII data and the safe operating envelope** explains how the model specifically describes the hazards and risk factors persisting in air-taxi operations in Canada. From there, **Section 5.6 Raising the bar on safety in air-taxi operations in Canada** explains how and where efforts and safety actions can be focused most effectively to improve the safety of air-taxi operations in Canada.

5.1 Information from TSB occurrence data and published investigation reports

5.1.1 Accident rates and numbers in the Canadian commercial aviation sector

A key indicator of aviation safety is the aircraft accident rate, which is calculated as the number of accidents per hours flown or per number of movements (takeoff or landing). While this rate can be calculated for the commercial aviation sector as a whole, it cannot be calculated for just the air-taxi sector or for different types of aircraft (airplane, helicopter, floatplane), because hours-flown data and movement data are currently not collected and reported by *Canadian Aviation Regulations* (CARs) subpart.

The TSB occurrence data showed that the overall total number of accidents in the air-taxi sector has declined over the study period (2000 to 2014).[223] The number of air operator certificates has also declined over the same period. This could be interpreted as an indication of a decrease in activity in the sector, which would in turn influence the accident rate; however, without hours-flown data or movement data that is specific to the air-taxi sector, it is not possible to know if the decline in the overall total number of accidents in this sector is an indicator of improvement.

Unlike the total number of accidents, there was no significant downward trend in the number of fatal accidents or fatalities over the 15-year study period.[224]

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223 A Kendall's Tau-b (τb) correlation coefficient was calculated to determine the relationship between year and number of accidents over the 15-year period. There was a negative correlation between the variables (τb = - 0.502, p = 0.0098), indicating a decrease in the number of accidents over time.

224 For the number of fatal accidents by year from 2000 to 2014, Kendall's $\tau_b = 0.010$, $p = 0.9594$; for the number of fatalities by year from 2000 to 2014, Kendall's $\tau_b = 0.000$, $p = 1.0000$.

5.1.2 Accident types and operating context

Because the accident rate data were not available and the number of accidents alone did not explain the context of the accidents, a grounded theory study was used to analyze the 167 published TSB investigation reports and establish accident types. The remaining occurrence data (i.e., data in the TSB's Aviation Safety Information System) for the 476 airplane accidents and 240 helicopter accidents in the study period were then sorted into 23 refined accident types with descriptions and explanations.

The underlying contributing factors and risks in the airplane and helicopter accidents were quite different; therefore, separate analyses were conducted for airplanes and helicopters. These analyses yielded 14 airplane-related accident types and 9 helicopter-related accident types: a total of 23 types, of which 6 were common to both airplanes and helicopters.

The analysis of the accident types provided an understanding of how these accidents were happening (description) and why they were happening (explanation of hazards and risk factors), as well as the experience of the pilots involved (pilot-in-command average total flight time).

For the purpose of this discussion, the accident types with the highest frequency or number of fatalities were selected and are presented in tables 25 and 26 below.

Table 25. Selected accident types for airplanes, with pilot-in-command average total flight time, percentage of the total number of accidents, and the number of fatalities

Accident type (with examples of TSB investigation reports)	Pilot-in-command average total flight time	Percentage of accidents	Number of fatalities
Approach and landing + single pilot (e.g., TSB Aviation Investigation Report A10A0122)	5122 hours	26%	9
Maintenance-related (e.g., TSB Aviation Investigation Report A03C0118)	8657 hours	14%	2
Takeoff condition (e.g., TSB Aviation Investigation Report A12C0154)	3311 hours	13%	14
Approach and landing + multi-crew (e.g., TSB Aviation Investigation Report A14A0067)	3416 hours	11%	12
Floatplane + loss of control (e.g., TSB Aviation Investigation Report A09P0397)	2061 hours	5%	34
Visual flight rules (VFR)+ loss of visual reference + controlled flight into terrain (CFIT) (e.g., TSB Aviation Investigation Report A10Q0111)	6219 hours	4%	26
VFR + loss of visual reference + loss of control (e.g., TSB Aviation Investigation Report A05Q0157)	4170 hours	1%	21

For airplanes, **approach and landing + single pilot** accidents had the highest percentage of the total number of accidents (26%) and resulted in 9 fatalities.

In contrast, **floatplane + loss of control** accidents resulted in the highest fatalities (34), but represented only 5% of the total number of accidents.

VFR + loss of visual reference accidents (ending in either CFIT or a loss of control) also resulted in a high number of fatalities (a total of 47), but represented only 5% of the total number of accidents.

Table 26. Selected accident types for helicopters, with pilot-in-command average total flight time, percentage of the total number of accidents, and the number of fatalities

Accident type (with examples of TSB investigation reports)	Pilot-in-command average total flight time	Percentage of accidents	Number of fatalities
Aerodynamic effects on control + loss of control (e.g., TSB Aviation Investigation Report A04A0111)	5792 hours	17%	9
Maintenance-related (e.g., TSB Aviation Investigation Report A01P0047)	1800 hours	14%	6
Exceptions (one-off scenarios or outliers) (e.g., TSB Aviation Investigation Report A11P0117)	5325 hours	14%	11
VFR+ loss of visual reference + CFIT (e.g., TSB Aviation Investigation Report A04C0051)	6837 hours	12%	14
Manufacturing-related (e.g., TSB Aviation Investigation Report A12P0134)	6185 hours	5%	2
Training-related (e.g., TSB Aviation Investigation Report A08A0007)	4683 hours	5%	0
VFR + loss of visual reference + loss of control (e.g., TSB Aviation Investigation Report A05Q0008)	2617 hours	4%	13

For helicopters, **aerodynamic effects on control + loss of control** accidents had the highest percentage of the total number of accidents (17%) and resulted in 9 fatalities.

Similarly to the airplane results above, **VFR + loss of visual reference** accidents (ending in either a CFIT or a loss of control) also resulted in a high number of fatalities (a total of 27). CFIT represented 12% of the total number of accidents, and loss of control represented 4% of the total number of accidents.

Training-related accidents represented 5% of the total number of helicopter accidents but were not a significant accident type for airplanes. This is because simulated emergencies for training purposes pose a higher risk in helicopter training than in airplane training due to the types of manoeuvres (i.e., autorotation and confined-space training) and the lower altitudes and lower speeds at which the manoeuvres are performed.

Maintenance-related accidents accounted for 14% of airplane accidents and 14% of helicopter accidents. In both cases, fatalities were low: 2 fatalities for airplane accidents and 6 fatalities for helicopter accidents. Contributing factors in this type of accident included fuel-system and fuel-contamination issues, lack of maintenance, use of unapproved parts, and not carrying out maintenance that was required by an airworthiness directive or recommended by a service bulletin.

In conclusion, the factors contributing to air-taxi accidents that occurred during the study period fall into 2 broad areas:

- **acceptance of unsafe practices** (e.g., flying overweight, flying into forecasted icing, not recording defects in the aircraft log, flying with unserviceable equipment, "pushing the weather," and flying with inadequate fuel reserves)
- **inadequate management of operational hazards** (e.g., inadequate response to aircraft emergencies, inadequate crew coordination contributing to unstable approach, VFR flight at night, loss of visual reference in marginal weather conditions, scales not available for weight and balance calculations)

The review of TSB investigation reports also identified weak or missing defences that, if improved or addressed, have the potential to enhance safety:

- aircraft not equipped with warning systems such as ground proximity warning systems or traffic alert and collision avoidance systems
- standard operating procedures not being sufficiently detailed
- aircraft flight manuals and training programs not containing critical information
- pilots with insufficient instrument flying experience
- self-dispatch or limited operational control
- inadequate training on aircraft systems and/or in handling aircraft emergencies
- weak crew coordination in normal or emergency situations
- incomplete or difficult-to-follow maintenance instructions
- no or inadequate passenger safety briefings

It was generally believed that inexperienced pilots pushing the limits would be a hazard or risk factor in air-taxi accidents; however, what emerged from the SII was that accidents involved inexperienced and highly experienced pilots alike.

5.2 Information from consultations with industry

The analysis of the TSB occurrence data and investigation reports (Phase 1 of the SII) provided accident types, common accident scenarios, and some context for air-taxi operations. However, more information was needed to validate the safety issues that had been uncovered to learn more about the actions and circumstances leading up to accidents, as well as to better understand what was happening in the air-taxi industry.

Note: The information collected in Phase 2 of the SII represents the views of those who participated in the investigation. These views have not been independently validated by the TSB, nor do they reflect ongoing initiatives by service providers or the regulator.

The industry consultations (Phase 2 of the SII) provided information about what operators perceived to be their most significant risks, what they were doing to mitigate those risks, and what more they believed needs to be done. During these consultations, operators made many suggestions for improving safety, ranging from simple best practices of their own to very specific requests to the regulator and to clients.

The consultation data were analyzed using the constant comparative method of analysis as part of a grounded theory study, resulting in 19 safety themes. Each safety theme was then analyzed to determine the main risk or risks associated with it. These safety themes are not new: previous studies, some of which were conducted decades before, have raised similar issues.[225]

5.3 Information from Phase 1 and Phase 2

The results of Phase 1 were combined with the results of Phase 2, and the 19 safety themes that arose from Phase 2 were further developed by adding the findings and recommendations from published TSB accident reports and relevant safety studies to the corresponding safety themes.

In accordance with the process of the grounded theory study, the constant comparison method of data analysis was used to analyze these 19 supplemented safety themes, which were then grouped into 3 higher-level themes.

Review of the safety science literature revealed that these 3 higher-level themes were consistent with the descriptions of the competing pressures in the dynamic model of safety as described by Rasmussen.[226]

5.4 A dynamic model of safety: The safe operating envelope

5.4.1 Models of systems and safety

Systems can be described in groups of characteristics: simple, complicated, or complex.[227,228,229] Each category can be described by understanding their component parts and how those parts work together to solve a problem or accomplish an outcome.

Simple systems are made up of individual constituents that interact in a linear way to accomplish a single process. These systems are normally controlled using approaches that include tightly prescribed procedures, linear instructions, and training specific to discrete procedures, actions, and sequences of steps. An example of a simple system is a single manufacturing line in an automotive plant.

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225 See Section 2.0 A history of concern.

226 J. Rasmussen. "Risk Management in a Dynamic Society: A Modelling Problem", *Safety Science* Vol. 27, No. 2/3 (1997), pp. 183-213.

227 C. Perrow. *Normal Accidents Living with High-Risk Technologies* (Princeton University Press, 1999), pp. 95–97.

228 K. Weick and K. Sutcliffe, Managing the Unexpected, 3rd edition (John Wiley and Sons, Inc. 2015), pp. 66–68..

229 I. Pupulidy and C. Vesel, "The Learning Review: Adding to the accident investigation toolbox," 53rd ESReDA Seminar Proceedings (December 2017), , p. 258.

Complicated systems can also be described in terms of their individual constituents; however, they contain numerous linear processes which are all oriented toward accomplishing a specific output. These systems are controlled by applying numerous processes and procedures, which are usually documented in manuals, flowcharts, and checklists. Processes and procedures cover planned and anticipated normal and emergency situations. An example of a complicated system is a modern airliner.

Complex systems, in contrast, are inherently much more diverse and interactive by design. They adapt to the nature and complexity of the environment and of the operation itself. Adaptive responses are needed in order to cope with the uncertainty and many variables that are a natural by-product of the problem and environment. Complex systems differ in a significant way from simple or complicated systems, because they include diverse agents that learn and adapt. Complex systems require a distinctly different approach to both understanding and management. [230] They need operators who can learn and adapt to these many variables so that the system to operate safely. Complex systems benefit from processes, procedures, and contingencies that are more flexible and are applied by operators with knowledge and experience that they continuously develop and expand in the domain to influence the system. An example of a complex system is a floatplane business operating out of a confined area in mountainous terrain: pilots operating in this system needs to apply skills-specific training, general procedures, and safe decision making based on their knowledge and experience to operate safely in that context. In this type of system, safety and risk are viewed as dynamic aspects of the system, requiring continuous adaptation and management.

In the late 1990s, safety science research focused on studying complex systems. One of the products developed during this time was Rasmussen's dynamic model of safety.[231] This model was developed through the direct observation of operations in complex systems and review of accidents in such systems.

At the time, accident investigation methods focused on separate levels of the system: at the sharp end (such as in the cockpit) or at the blunt end (such as in supervision or upper management). Rasmussen began studying accidents across the vertical layers of a system—from the cockpit to the pilots, to their supervisors, to management, to the regulator, to the client and passengers. This included studying the processes, decision making, and feedback across the layers of the system and how the information was used within each layer to influence performance. Taking this approach made it possible to identify that having information flow down through the layers and feedback flowing up through the layers, with integration of that information at each level, was critical for effective risk management of these types of systems.[232]

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[230] Ibid.

[231] J. Rasmussen. "Risk Management in a Dynamic Society: A Modelling Problem," *Safety Science* Vol. 27, No. 2/3 (1997), pp. 183–213.

[232] Ibid.

During this period, a number of societal characteristics were seen to be changing the nature of safety-critical operations, namely the following:

- A very **fast pace of technological change** (in general, if not necessarily at the local level)
- **Rapid development of information and communication technologies** leading to a high degree of integration and connections within an operation (where the effects of a single decision can have dramatic effects that propagate rapidly and widely)
- A very **aggressive and competitive environment** that focused the incentives of decision makers on short-term financial and survival criteria rather than long-term criteria concerning welfare, safety, and environmental impact.[233]

The dynamic safety model described by Rasmussen applies to systems that are complex, involving people and technology. According to this approach, safety depends on controlling work processes to avoid accidental side effects causing harm to people, the environment, or investment within a dynamic operation faced with competing pressures. Cook and Rasmussen [234] went on to further develop the model and called it the safe operating envelope. It is also described by Woods, Schenk and Allen.[235] More recently, an investigation method for accidents in complex systems has been developed by Pupulidy.[236]

Rasmussen's dynamic model of safety has 2 important aspects: the structure and the dynamics, which are described below.

5.4.2 The structure

The **structure** behind the dynamic model of safety has all stakeholders connected vertically (Figure 16). In this model, "stakeholders" consist of the work itself, staff, operators, management, the company, regulators, associations and service providers, and the political aspect of government (as opposed to the public service). In this structure, information about decisions flows down through the levels, and feedback flows up through the levels.

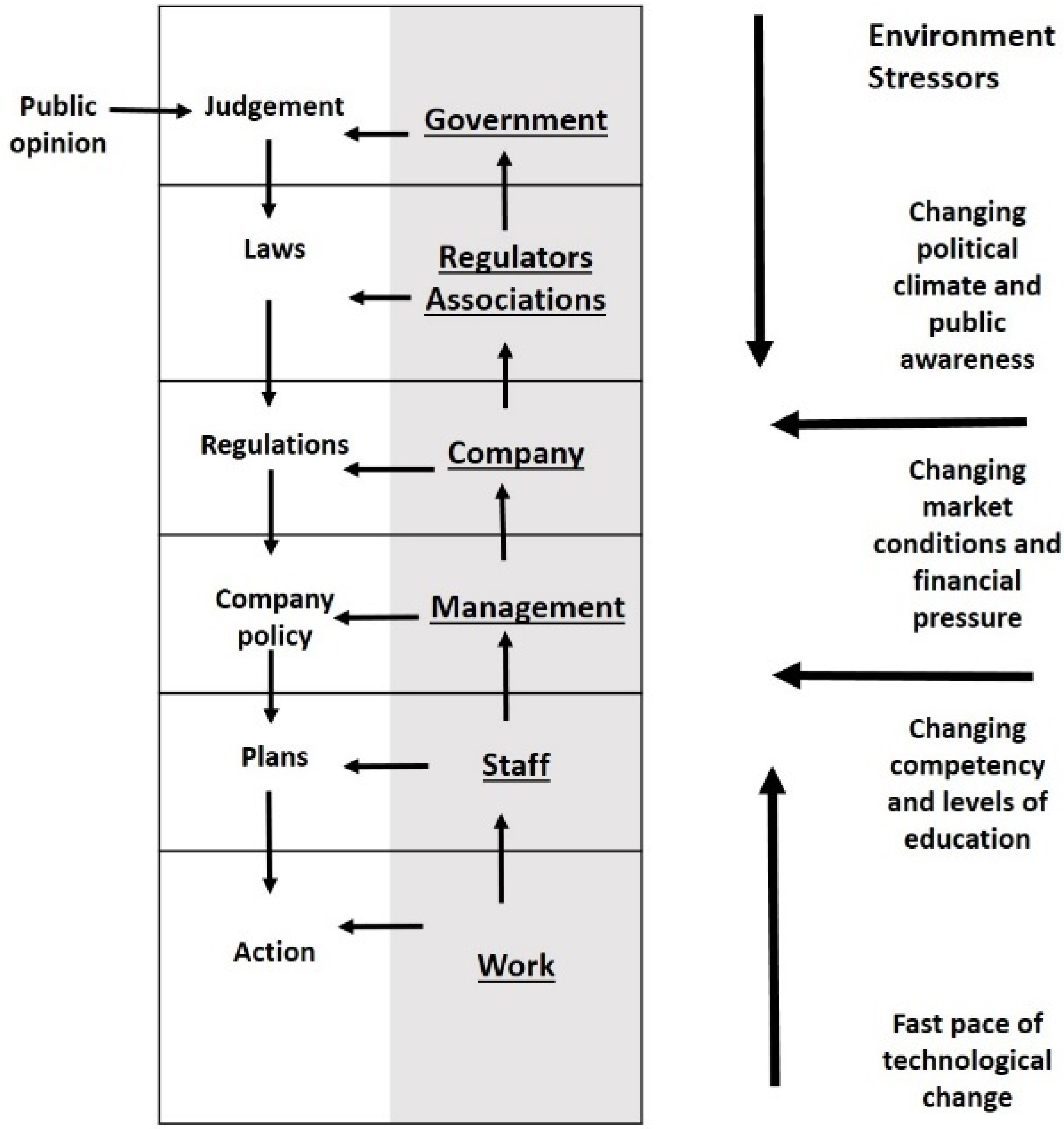
233 Ibid.

234 R. Cook and J. Rasmussen, "'Going solid': a model of system dynamics and consequences for patient safety," in: *Quality and Safety in Health Care*, Volume 14, Issue 2 (April 2005), p.131.

235 D. D. Woods, J. Schenk, and T .T. Allen, "An Initial Comparison of Selected Models of System Resilience," in: C.P. Nemeth, E. Hollnagel and S. Dekker (eds.), *Resilience Engineering Perspectives, Volume 2: Preparation and Restoration* (CRC Press, 2009), p. 78.

236 I. Pupulidy and C. Vesel, "The Learning Review: Adding to the accident investigation toolbox," 53rd ESReDA Seminar Proceedings (December 2017), pp. 255–261.

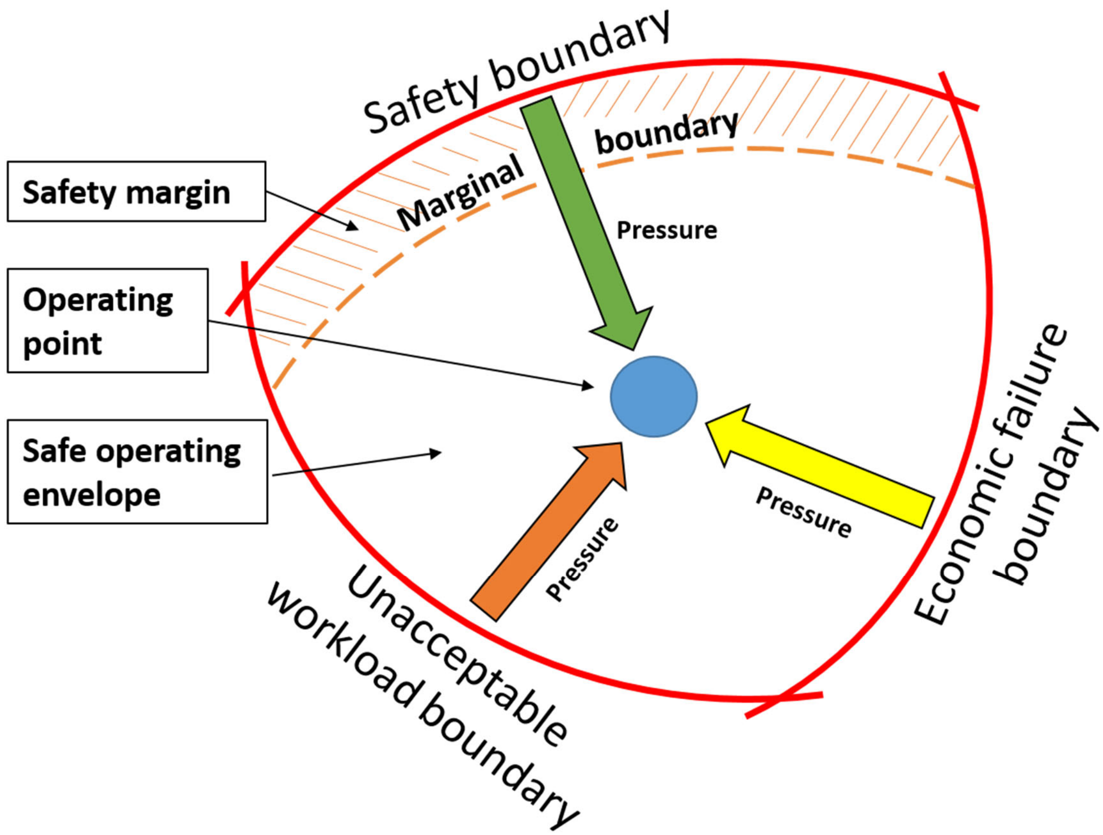
Figure 16. The vertically integrated structure of all stakeholders in the air-taxi sector (Source: Adapted from J. Rasmussen. "Risk Management in a Dynamic Society: A Modelling Problem", *Safety Science* Vol. 27, No. 2/3 (1997), p. 185)



5.4.3 The dynamics

The **dynamics** of this model of safety consist of how the work processes are carried out throughout the system and how they interact given the environment and the competing pressures within the structure. The dynamics of the safe operating envelope model adapted by the TSB for this SII are shown in Figure 17.

Figure 17. The safe operating envelope model adapted by the TSB for the safety issue investigation



The operation is represented by the operating point (the blue dot). The position of the operating point within the safe operating envelope is dictated by the way in which the hazards and risks encountered by an operator are managed.

The operating point is constantly moving. If the operating point crosses any of the boundaries, the system will break down. The boundaries are:

- The **economic failure boundary** (beyond this boundary, the financial costs become unsustainable),
- The **unacceptable workload boundary** (beyond this boundary, there are not enough time or resources available), and
- The **safety boundary** (this boundary delineates the boundary of acceptable performance past which there may be harm to workers, passengers, or the public).[237]

The marginal boundary delineates where the safety of an operation begins to erode. The safety margin is that part of the safe operating envelope between the marginal boundary and the safety boundary; the fewer or weaker the defences in place, the thinner the safety margin. As the operating point crosses the marginal boundary, the safety of the operation

[237] J. Rasmussen. "Risk Management in a Dynamic Society: A Modelling Problem", *Safety Science* Vol. 27, No. 2/3 (1997), pp. 183-213.

diminishes. When the operating point crosses the safety boundary, a failure (an accident or incident) occurs. The arrows inside the boundaries of the safe operating envelope represent the competing pressures that push the operating point away from or toward a boundary.

5.5 The safety issue investigation data and the safe operating envelope

The analysis of the data collected during this SII provided a good understanding of the hazards and risks contributing to accidents, of issues facing air-taxi operators, of what is being done by operators to manage these issues, and of what more needs to be done according to the operators. Together, the published TSB investigation reports, previous studies by other organizations, recommendations, and operator interview data painted a clear picture of how the nature of the air-taxi sector introduces risks that are different from those in other aviation sectors, and showed that these risks have persisted for decades.

One particular study reviewed as part of this SII was the Safety of Air Taxi Operations Task Force (SATOPS) final report, issued by Transport Canada (TC) in 1998. This study coincided with the introduction of the CARs in 1996, when civil aviation safety regulations and standards were newly structured according to specific aviation sectors. The SATOPS final report made 71 recommendations,[238] which were directed toward industry stakeholders, TC, or the TSB. These included recommendations that targeted pilot decision making (PDM),[239] training,[240] VFR flights in marginal weather,[241] and safety culture and unsafe practices.[242]

This SII demonstrated that many of the hazards identified in the SATOPS study, as well as in other studies conducted between 1998 and 2015, continue to exist. The analysis of the TSB occurrence data in Phase 1 of the SII showed that the same types of accidents— particularly the same types of fatal accidents—persisted throughout the study period. The industry consultations in Phase 2 of the SII further validated that these previously identified hazards and safety issues are still contributing to air-taxi accidents.

Both phases of the SII also highlighted weak or missing defences that contributed to these accidents. The fact that these defences are insufficient and have been identified in many accidents for many years speaks to the persistence of the hazards and risks in the air-taxi sector. The air-taxi sector, as a safety-critical industry,[243] must manage risk to a level that is as low as reasonably practicable. Operators need to balance many competing pressures that

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238 The official status of the SATOPS recommendations could not be obtained from TC.

239 Transport Canada SATOPS recommendations SR 23, IA 23, and IA 37.

240 Transport Canada SATOPS recommendations SR 5, SR 27, and SR 53.

241 Transport Canada SATOPS recommendation IA 23.

242 Transport Canada SATOPS recommendation SR 10.

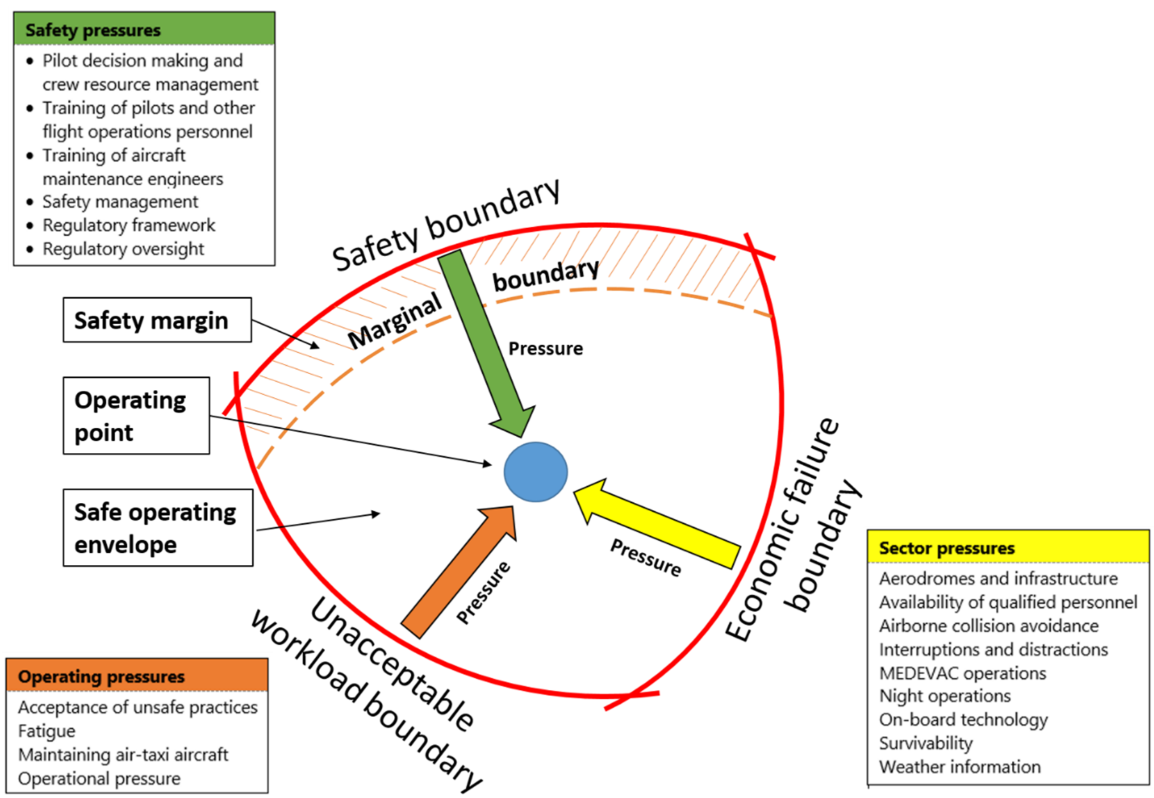
243 A safety-critical industry is one in which safety is of paramount importance and where the consequences of failure or malfunction may be loss of life or serious injury, serious environmental damage, or harm to plant or property. (Source: F. Saunders, "Safety–critical industries: definitions, tensions and trade-offs" [11 January 2015], at http://fionasaunders.co.uk/safety-critical-industries-definitions-tensions-and-tradeoffs/ [last accessed on 07 October 2019].)

ultimately come from the need to be efficient and safe. This results in goal conflicts that require trade-offs, which may increase risk and reduce safety.

While analyzing the supplemented 19 safety themes that emerged from the industry consultations, the SII team looked to previous studies, safety science literature, and the accident types. The 19 safety themes were grouped into 3 higher-level themes using the cross comparative method of data analysis. These groups of pressures emerged: sector pressures, operating pressures, and safety pressures. Each of these pressures corresponded with a boundary on the safe operating envelope model. Adapting this model to the results of the SII yielded a detailed and thorough mapping of results from the various phases of the study, generating an explanation for the persistence of hazard and risk factors in air-taxi operations and providing direction for how to raise the bar on safety.

The safe operating envelope model was adapted by the TSB for the purpose of this SII (Figure 2). The safe operating envelope model illustrates the relationships among the competing pressures in air-taxi operations. Figure 18 shows the model as adapted by the TSB in conjunction with the 19 safety themes that emerged from the industry consultations (see **Section 4.2 Information from consultations with industry**), and with the 3 competing pressures labelled.

Figure 18. The safe operating envelope model with the safety themes that emerged from industry consultations



The model illustrates the competing pressures that act on an operation as a result of goal conflicts (balancing safety, acceptable workload, and economic viability).

The green arrow represents the safety pressures that increase an operation's safety margin, pushing it away from the safety boundary.Using the SII results, the safety themes making up this pressure are PDM and crew resource management (CRM), training of pilots and other flight operations personnel, training of aircraft maintenance engineers (AMEs), safety management, regulatory framework, and regulatory oversight. These safety-related themes include activities that push operations away from the safety boundary: for example, training of personnel, and regulations and standards that keep pace with current technology and operations.

The orange arrow represents operating pressures that push the operation away from the unacceptable workload boundary and toward the safety boundary. The safety themes from the SII that fit this boundary are the acceptance of unsafe practices, fatigue, maintaining air-taxi aircraft (i.e., the time and labour required to maintain them), and operational pressures in the flight operation. These safety themes include activities that push operations away from the unacceptable workload boundary and toward the safety boundary: for example, flying overweight, not having adequate rest and choosing to fly fatigued, not recording defects in aircraft logs, or "pushing the weather."

The yellow arrow represents sector pressures that push the operation away from the economic failure boundary and toward the safety boundary. These pressures are aerodromes and infrastructure, availability of qualified personnel, airborne collision avoidance, interruptions and distractions, medical evacuation (MEDEVAC) operations, night operations, on-board technology, survivability, and weather information. These safety themes include activities that push operations away from the economic failure boundary: for example, upgrading older aircraft with new avionics or installing night vision goggles for night MEDEVAC operations.

The blue dot represents a flight operation, and it is shown as a constantly moving point within the safe operating envelope (the space defined by the 3 boundaries), moving toward or away from the boundaries in response to the competing pressures. The model shows how the sector pressures and the operating pressures both push the operating point toward the safety boundary, increasing the risk of an accident. Therefore, the safety pressures are positive mitigations that counteract the other 2 pressures. They keep the operating point within the boundaries of the safe operating envelope. It is important to note, that the competing pressures in this model are areas where the TSB has made multiple recommendations in the past.

The model also links the 2 main underlying factors contributing to air-taxi accidents (**acceptance of unsafe practices** and **inadequate management of operational hazards**) to the 19 safety themes that emerged from consultations with industry. Finally, the model, when mapped with the SII results, suggests where and what safety improvements will be most effective.

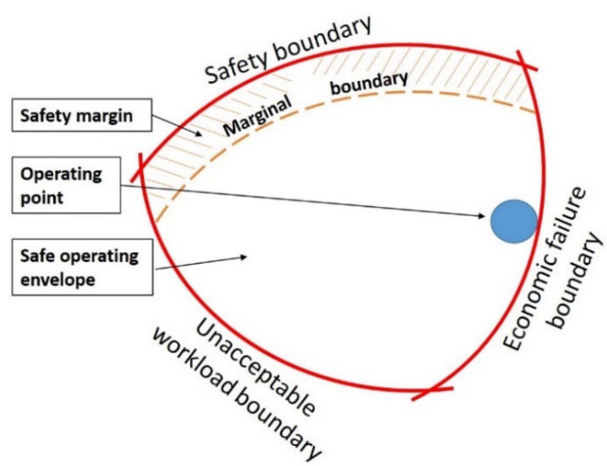
5.5.1 The safe operating envelope model in action

The safe operating envelope model and how it explains the hazards and risk factors in the air-taxi sector can be better understood with the use of an example. TSB Air Transportation Occurrence A10Q0132 (see sidebar) shows how the model increases understanding of this accident.

In a 2010 helicopter accident (TSB Air Transportation Occurrence A10Q0132), a client requested a flight that the company accepted, even though it could not be performed by the available aircraft without the aircraft taking off over the maximum allowable takeoff weight. The weather conditions were marginal with low ceilings and visibility. The passengers arrived with more than double the weight of baggage that was indicated on the client's original request with the company. Instead of reducing the baggage load, the pilot chose to reduce the additional fuel he had planned to take due to the marginal weather. When circumstances and weather dictated the use of an alternate route, the alternate route was also hampered by marginal weather. The pilot lost visual reference with the ground and lost control of the helicopter. The helicopter struck the ground, and the pilot and 3 passengers on board were fatally injured.

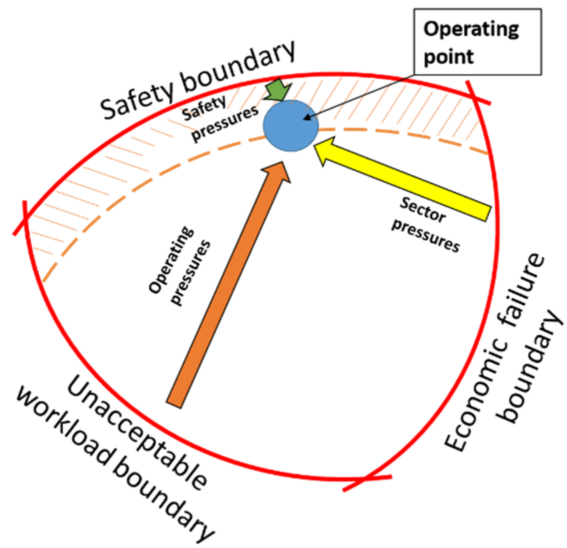
Before the client requested the flight, the aircraft was parked waiting. A flight operation has costs even when the aircraft are not flying. In the model, the operating point is next to the economic failure boundary, because the cost of the aircraft, the personnel to operate it, the costs of the aerodromes and infrastructure, survivability training and equipment, on-board technology, weather information, etc., are not being balanced by revenue (Figure 19).

Figure 19. Operating point of the flight when the aircraft is parked



A flight was booked by a client and the company accepted the flight. This influx of revenue moved the operating point away from the economic failure boundary. The client asked to carry 3 passengers and baggage, which was determined to be overweight for the helicopter that was available. However, the company accepted the flight anyway. This introduced an operational pressure, specifically the acceptance of unsafe practices and operating pressure. The operational pressure to fly an aircraft over the maximum allowable take-off weight (a safety pressure exerted by the regulatory framework) pushed the operating point for the flight over the marginal boundary (Figure 20).

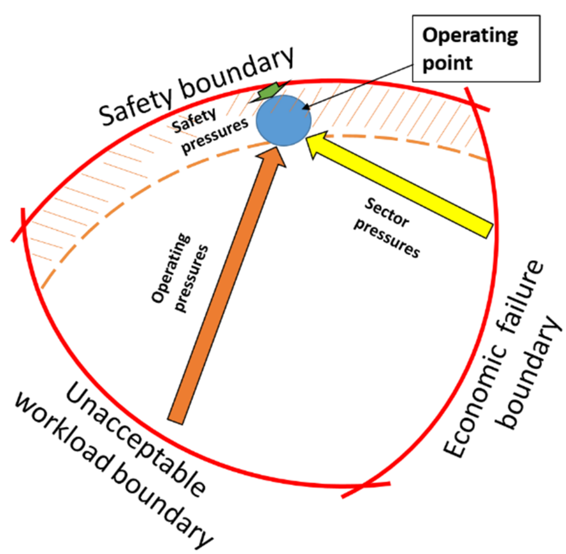
Figure 20. Operating point of the flight when at the beginning of the flight



On the day of the flight, the weather was marginal and visibility poor. To mitigate the risks associated with poor weather, the pilot planned to bring additional fuel, to give himself more flexibility to take alternate routes. This decision moved the operating point away from the safety boundary, but not by much, because of the helicopter being over the maximum allowable take-off weight.

Safety pressure is influenced by the strength of the operator's safety investments (for example, in the implementation of PDM/CRM training and support of its use by peers and supervisors) and the pilot's use of PDM/CRM to manage and counteract any additional operating pressures that may arise during the flight. If the safety pressure imposed by the pilot is not strong enough to counteract additional pressures, the operating point will move further into the safety margin.

Figure 21. Operating point of the flight when the aircraft is en route

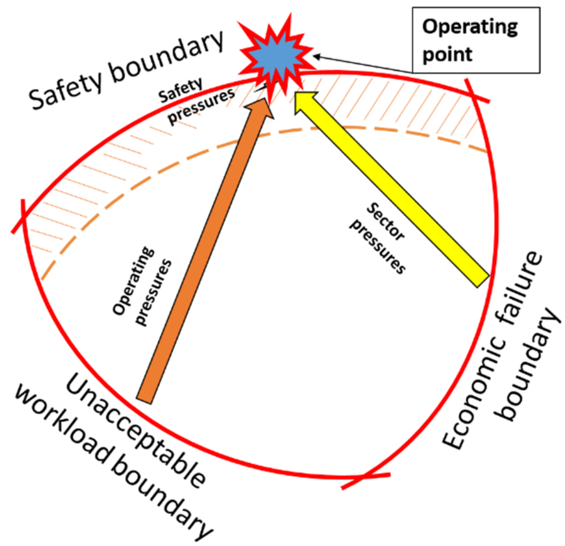


When the passengers and baggage arrived for the flight, the total weight was double the amount of weight on the original request. To manage this situation, the pilot reduced the amount of fuel on board to account for the additional weight. However, doing this also gave him less flexibility in the choice of alternate routes. These events and decisions moved the operating point further into the safety margin and closer to the safety boundary, due to the increased acceptance of unsafe practices and operating pressure (Figure 21).

When the pilot encountered low visibility and clouds in a mountain pass along the route initially chosen, he elected to turn back a considerable distance to return to a valley where he thought the weather conditions would be more favourable for him to fly to the destination. This diversion and additional flight time (fuel consumption) increased the operating pressure on the pilot while the safety pressure was already very low. In the face of this increased pressure, the pilot cut across a plateau to reach the desired valley more quickly. However, the top of the plateau was in cloud, and the pilot lost visual reference with the ground and lost control of the helicopter. This is where the operating point crossed the safety boundary. The helicopter struck the ground at a steep angle, and none of the occupants survived the impact (Figure 22).

The model illustrates how the erosion of the safety margin was influenced by the 2 main factors contributing to air-taxi accidents (**acceptance of unsafe practices** and **inadequate management of operational hazards**) and the complex ways in which these factors continuously change and influence safe flight operations.

Figure 22. Operating point when the aircraft crashes



When the operating point is very close to the safety boundary, any unforeseen event during a flight can push it over the safety boundary, resulting in an accident, as in TSB Air Transportation Occurrence A10Q0132. This is why in aviation, having a wide safety margin is important. However, the model also illustrates that, when unsafe practices are used to carry out flights and the wide safety margin allows flights operated with unsafe practices to be frequently successful, these unsafe practices may become the norm, making it difficult for stakeholders to realize how much the safety margin has eroded.

Effective PDM/CRM by pilots and operators, safety management, up-to-date regulations, and effective regulatory oversight, can actively add safety pressure to counteract the operating and sector pressures in air-taxi operations. At the core of effective safety management, regulations and standards, and effective oversight is safety culture. Safety culture[244] needs to be more than just a written policy: it has to be demonstrated through the operational and economic decisions made at the top of an organization as well as how those decisions and actions flow through the levels of an organization, especially before a flight is initiated. It also shows how the clients' safety culture and knowledge of safe practices and operational hazards can support the operator's safety culture, which in turn will support the operator's safety management and use of PDM/CRM. In this specific example, passengers with more knowledge of the weight limitations of air-taxi aircraft have the potential to reduce operating pressure.

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[244] Safety culture is discussed in **Section 5.6.1 Safety pressure**.

5.5.2 Structure of the air-taxi sector

The air-taxi sector is made up of a large number of stakeholders who all influence flight operations (Figure 23). The nature of the air-taxi sector, the persistence of the operational hazards, and the acceptance of unsafe practices, demand a different approach to improving safety. In the approach identified by the safe operating envelope model, where competing pressures are proactively identified and managed, all stakeholders collectively need to take action. Actions taken by stakeholders include supporting and integrating the communication of decisions down through the layers and feedback up through the layers, to identify and control risks. The model shows that increasing safety pressure while also reducing sector and operating pressures will improve the safety of air-taxi operations.

Figure 23. Stakeholders that have a role to play in the air-taxi sector

For the purposes of this report, the stakeholders are defined as follows:

Clients: This includes corporate clients (e.g., mining or power companies) that charter air-taxi operations for their personnel, as well as individual passengers on board a particular flight. They can have a negative influence on safety (exerting tacit or overt pressure to complete a flight) or a positive influence (being informed consumers who do not accept unsafe practices). Clients are at the top or blunt-end of the vertical organization of the air-taxi sector.

Regulator: TC, as the regulator, makes the regulations and establishes the standards to which all operators are held and for which they are accountable. TC is also responsible for monitoring companies' compliance with and enforcing regulations and standards.

Associations: Industry associations represent the interests of their members: lobbying for regulatory changes, sharing best practices with operators and clients, and providing educational materials.

Service providers: These include air navigation services (air traffic control [ATC], navigational aids, maps and charts) and aerodrome operators (de-icing, snow removal, runway maintenance). Costs are associated with the services provided, and these costs influence the sector pressures (economic boundary).

Operators: The companies that hold air operator certificates for air-taxi operations. The operator is the main influence on managing the safety of flight operations.

Individuals: Operational personnel (pilots, AMEs, dispatchers, etc.). Individuals are the front-line managers of risk, particularly in air-taxi operations, where they frequently operate with fewer resources and less support than in other aviation sectors, such as commercial airlines. Individuals are at the bottom or sharp-end of the vertical integration of the air-taxi sector in a given operation.

5.5.3 Competing pressures in the air-taxi sector

The first 9 safety themes are sector pressures (yellow). The next 4 safety themes are operating pressures (orange). The last 6 safety themes are safety pressures (green), as developed using the constant comparative method of data analysis with the 19 safety themes generated in Phase 2 of the SII and supplemented by the data from Phase 1. These safety themes illustrate the day-to-day challenges of operating in the air-taxi industry and how dynamic an operation is in its efforts to conduct safe flight operations.

The tables below summarize these safety themes, which are grouped into the 3 pressures. The tables provide a high-level description of risk and conclusion associated with each theme,[245] and a list of actions suggested by operators or TC inspectors during the industry consultations. Also included are any actions that have already been taken, as well as relevant active TSB recommendations.

Table 27. Safety themes related to sector pressures

Safety theme	Risk and conclusion	Actions suggested by operators or TC inspectors and relevant active TSB recommendations

Aerodromes and infrastructure	**Description of risk**
	Operations into some remote areas and/or northern communities with limited aerodrome infrastructure may be carried out with a reduced level of safety.
	Conclusion
	Remote and northern communities of Canada require appropriate aerodrome facilities and infrastructure to ensure that air-taxi operators can provide safe air services for those communities.
		Actions suggested by operators or TC inspectors
		• TC and industry review the status of the aerodromes that are used by air-taxi operators to ensure that the facilities and infrastructure are adequate to effectively manage safety.
		  ◦ More area navigation (RNAV) approaches at remote airports.
		  ◦ More automated weather observation system stations and weather cameras.
		  ◦ More accurate reporting of runway conditions.
		  ◦ Better maintenance of runways at remote and northern aerodromes.
		• TC mandate effective, contemporary PDM training to mitigate infrastructure issues. (This item will be addressed by the implementation of the new CRM training standard by 30 September 2019.)
		• Operators have systems in place to identify and manage issues at locations where there is limited aerodrome and infrastructure.
		  ◦ De-icing equipment being required at away bases.
		Relevant active TSB recommendation
		• TSB Recommendation A18-02

[245] The hazards associated with the descriptions of risk can be found in the summary tables for each safety theme in **Section 4.2 Information from consultations with industry**.

Safety theme	Risk and conclusion	Actions suggested by operators or TC inspectors and relevant active TSB recommendations
Availability of qualified personnel	**Description of risk** There is a risk that there will be a shortage of qualified personnel for air-taxi operators to conduct business safely. **Conclusion** The availability of qualified personnel is critical to safety; competent personnel are a key component in managing risk.	**Actions suggested by operators or TC inspectors** • More mentoring should be provided for pilots and AMEs, possibly an industry-wide mentorship program. • TC should develop a mentoring program for its inspectors. • Operators should have systems in place to ensure that they have an adequate number of qualified personnel to conduct business safely. • Industry should examine and modify compensation practices in the air-taxi sector. • Pay should be fair for the type of work being done. • Requirements for experienced personnel should be revisited. Customers should be educated that requiring a minimum number of hours of flight time (e.g., 2000 hours) is not necessarily a good approach to risk mitigation. • The flight time required to obtain an airline transport pilot licence (ATPL) could be increased, to prevent the drain of experienced pilots. Training • Aviation training institutions should prepare pilots and AMEs for the types of jobs they could expect when entering the air-taxi sector. • Training standards among different flight schools and colleges need to be made consistent. • Better training is needed for pilots in coastal flying and in decision making specific to weather-related issues. • Trade schools need to prepare apprentice AMEs for the challenges of northern or remote work, because most new AMEs are unaware of what to expect when working in such locations. • Procedures should be reviewed and pilots trained throughout the year to maintain a high level of competency. • Training should be competency- or performance-based. • Training should be given in PDM and CRM, instrument flight rules (IFR) approaches, risk management, and a special qualification for floatplanes beyond the seaplane rating. • Training pilots should be paid better. • Pilot competencies for single-pilot, high-performance aircraft should be regulated. • Policies to prevent “green-on-green” crew pairing should be required. • TC inspectors should conduct more check rides.
Airborne collision avoidance	**Description of risk** The absence of air navigation services in some areas and non-adherence to established communication	**Actions suggested by operators or TC inspectors** • Implement automatic dependent surveillance–broadcast (ADS-B) systems. • More frequencies are needed for uncontrolled airspace. • Areas of mixed IFR/VFR traffic; develop new procedures and review existing ones for congested areas.

Safety theme	Risk and conclusion	Actions suggested by operators or TC inspectors and relevant active TSB recommendations
	procedures may result in a reduced level of safety. **Conclusion** Traffic avoidance services and procedures are critical elements to mitigate the risk of collision.	• Many of the mitigations suggested for infrastructure issues would also contribute to collision avoidance. • Ensure pilots report on the applicable mandatory frequency.
Interruptions and distractions	**Description of risk** Interruptions and distractions can result in an increase in workload: as a result, personnel focus on one or a few tasks while ignoring others. **Conclusion** Well-developed company policies and standard operating procedures are critical to reduce the likelihood and effects of personnel being interrupted and/or distracted.	**Actions suggested by operators or TC inspectors** • Operators should develop and apply systems to identify and minimize the risk of interruption and/or distractions such as implementing a cellphone policy or strategy to deal with cellphone use (both business and personal) on the maintenance floor and during flights.
MEDEVAC operations	**Description of risk** Operational decision making is more complex and may be degraded when a pilot or a flight crew takes into consideration a patient's condition. **Conclusion** The unique nature of conducting MEDEVAC operations can place a great deal of stress on pilots, which may have a negative influence on their decision making.	**Actions suggested by operators or TC inspectors** • Duty day for MEDEVAC flight crews should include the time on call. • A dedicated radio frequency is required so that MEDEVAC flight crews can communicate directly with first responders on scene.
Night operations	**Description of risk** Conducting night operations with limited visual references may result in a reduced level of safety. **Conclusion** Adequate visual references during night operations are critical to ensuring the safety of the flight.	**Actions suggested by operators or TC inspectors** • Remote airports should be equipped with global positioning system (GPS) approaches. • The quality and timeliness of weather reporting and reporting on airport conditions at remote airports should be improved. • A standard minimum runway length should be defined for remote northern aerodromes. • Night-vision goggles should be used for helicopter operations.

Safety theme	Risk and conclusion	Actions suggested by operators or TC inspectors and relevant active TSB recommendations
		Relevant active TSB recommendation • TSB Recommendation A16-08
On-board technology	**Description of risk** The absence of on-board technology may result in some operators not receiving the safety benefits of this technology. If this technology is installed, over-reliance on it may lead to a degradation of basic piloting skills. **Conclusion** Improved technology, if incorporated into an operation, has significant potential to enhance safety in air-taxi operations.	**Actions suggested by operators or TC inspectors** • Regulations should require mandatory traffic collision avoidance systems (TCAS), transponders, and ADS-B systems. • TC should provide updated guidance for implementation and operation of night-vision goggles. • There needs to be an emphasis on basic manual flying and navigation/map-reading skills, from initial training to required recurrent training. • Cockpit layouts in a given model of aircraft should be standardized. **Relevant active TSB recommendation** • TSB Recommendation A16-10
Survivability	**Description of risk** The context of air-taxi operations, combined with ineffective safety briefings and improper use of safety equipment, reduces the likelihood of surviving an accident. **Conclusion** Aircraft crashworthiness, safety information, and safety equipment are key components to improve occupant survival in the event of an accident.	**Actions suggested by operators or TC inspectors** • Pop-out windows should be installed. • Passengers should receive more thorough safety briefings. • Establish clear requirements to ensure that all personal flotation devices (PFDs) remain certified after continuous use. • More research is required before the new PFD regulation is implemented. • Make helmet use mandatory for helicopter flight crew. **Relevant active TSB recommendations** • TSB recommendations A13-03, A15-02, A16-01, A16-02, A16-03, A16-04, A16-05, A16-06, and A16-07
Weather information	**Description of risk** Inaccurate or incomplete weather information negatively impacts safety. **Conclusion** Accurate weather information is a critical component of flight planning and allows pilots to make effective weather-related decisions.	**Actions suggested by operators or TC inspectors** • More reporting stations are needed in areas where weather is less predictable. Existing weather-reporting stations should have extended hours. • Additional automated weather observations system stations and weather cameras would augment safety. • Educating crews and clients. Such education would help pilots make better weather-related decisions.

Table 28. Safety themes related to operating pressures

Safety theme	Risk and conclusion	Actions suggested by operators or TC inspectors and relevant active TSB recommendations
Acceptance of unsafe practices	**Description of risk** Accidents and/or incidents may result when organizations do not recognize and mitigate unsafe practices. **Conclusion** If unsafe practices are not recognized and mitigated, or if they are accepted over time as the "normal" way to conduct business, there is an increased risk of an accident.	**Actions suggested by operators or TC inspectors** • Increased enforcement of current regulations governing weather minima. • Educating crews and customers. Such education should emphasize helping pilots make better weather decisions and helping clients understand the risks associated with operating in poor weather. **Relevant active TSB recommendation** • A18-02

Fatigue	**Description of risk**
	Ineffective management of fatigue may result in a reduced level of safety in all aspects of an operation.
	Conclusion
	Fatigue-related impairment has a detrimental effect on aviation safety.
		Actions suggested by operators or TC inspectors
		• TC and industry work together to implement duty-time regulations for maintenance personnel.
		• More limits to duty-day hours.
		• Regulations should be tailored to the type of operations.
		• Regulations should not be changed.
		• Regulations and crew scheduling do not provide sufficient mitigation of fatigue.
		• Operators suggested mitigations beyond duty-day limits:
		  ◦ Scheduling that takes into account the time of day and the type of work.
		  ◦ Reviewing the pay structure for helicopter operators to avoid the financial incentive to work extra hours.
		  ◦ Providing fatigue related training and methods of self-assessment for fatigue.
		• The sector needs to adopt fatigue risk management systems.
		• The issue is broader than air-taxi; there should be national discussion about fatigue and scheduling for all commuting pilots, regardless of sector.

Maintaining air-taxi aircraft	**Description of risk** The challenges of maintaining and/or replacing air-taxi aircraft may lead to decisions that result in a reduced level of safety. **Conclusion** Maintaining aircraft in a serviceable condition is fundamental to ensuring the safety of flight.	**Actions suggested by operators or TC inspectors** • TC and industry review the process for implementing advances in technology to ensure that the process is timely and effective (i.e., streamline the regulatory process). • TC should provide a single source for all aircraft maintenance manuals and a means for operators to access them. • Operators require better product support from the type certificate holder for aircraft that are no longer in production. • Overhaul facilities should have sufficient aircraft maintenance engineers on staff to ensure quality.

Safety theme	Risk and conclusion	Actions suggested by operators or TC inspectors and relevant active TSB recommendations
		• Better logistics are needed for obtaining parts on short notice.

Operational pressure	**Description of risk**
	The impact of operational pressures may lead to decisions that result in the acceptance of unsafe practices.
	Conclusion
	Internal and external pressures, including pressure to get the job done, can negatively impact safety.
		Actions suggested by operators or TC inspectors
		• TC treat all operators equally to ensure that everyone conducts operations to the same standard.
		• Clients should pay for safety. More should be done to educate clients about the risks associated with selecting contract aviation operators solely on the basis of price.
		• Standards and costs should be consistent across the industry in order to level the playing field.
		• Pressure on flight crew and maintenance personnel should be reduced by
		  • implementing duty-day regulations for maintenance staff
		  • paying pilots a salary
		  • providing adequate resources (maintenance and training staff)

Table 29. Safety themes related to safety pressures

Safety theme	Risk and conclusion	Actions suggested by operators or TC inspectors and relevant active TSB recommendations
PDM/CRM	**Description of risk** Operational risks may be higher when pilots do not have critical competencies to make safe decisions that manage the risks effectively. Operational risks may be higher when PDM/CRM practices are not supported and reinforced by managers, supervisors, and peers. **Conclusion** PDM and CRM are critical competencies that help flight crew manage the risks associated with aircraft operations.	**Actions suggested by operators or TC inspectors** • TC mandate effective, contemporary PDM/CRM training. (This will be addressed by implementation of the new CRM training standard by 30 September 2019.) • TC provide updated CRM training materials. • Offer structured classroom learning to supplement online CRM training. • Institute a requirement for a flight following and operational control centre, and using satellite tracking.

Training of pilots and other flight operations personnel	**Description of risk**
	Operational personnel who do not have the necessary skills and knowledge may not be able to manage operational risks effectively.
	Conclusion
	Providing training for pilots and other flight operations
		Actions suggested by operators or TC inspectors
		• Additional time allotted for training RNAV and localizer performance with vertical guidance (LPV) approaches.
		• Additional training required:
		  • CRM and PDM training (this will be addressed by implementation of the new CRM training standard by 30 September 2019)
		  • Line-indoctrination training

<table>
<tr><th>Safety theme</th><th>Risk and conclusion</th><th>Actions suggested by operators or TC inspectors and relevant active TSB recommendations</th></tr>
<tr><td></td><td>personnel is essential for them to develop the skills and knowledge they need to effectively manage the diverse risks associated with air-taxi operations.</td><td>Underwater egress training
CFIT training
Training materials for the following:
Guidance on how to train pilots in conducting stabilized constant descent angle approaches
Updated GPS guidance materials for training and development purposes
Updated TC icing examination for operators to use in developing training
General mitigations required:
Training programs to provide local area knowledge
Better training on mandatory frequency procedures
Seaplane rating qualification training needs to be increased
Operators need to share training requirements with flight schools for new pilots entering the air-taxi industry.
Relevant active TSB recommendation
TSB Recommendation A16-09</td></tr>
<tr><td>Training of AMEs</td><td>Description of risk
Inadequate initial and/or recurrent training may result in a reduced level of safety during operations.
Conclusion
AMEs working in air-taxi operations require extensive technical knowledge to ensure that the wide variety of aircraft types and models used in this sector are maintained in airworthy condition.</td><td>Actions suggested by operators or TC inspectors
Colleges and training facilities spend more time training on all aspects of maintenance documentation.
Human factors guidelines need to specify trainers’ experience and how to measure the effectiveness of the training.
More structured recurrent training for AMEs, similar to that for flight crew.</td></tr>
<tr><td>Safety management</td><td>Description of risk
Operators’ safety management may not have kept up with advances in the aviation industry.
Conclusion
Effective safety management is important for operators to be able to proactively identify hazards and mitigate risks to a level as low as reasonably practicable.</td><td>Actions suggested by operators or TC inspectors
Safety management systems (SMS) should be required for air-taxi operators.
SMS need to be designed for small companies.
SMS should be required only for companies that have a minimum number of employees or aircraft.
SMS should be based on shared data for the overall air-taxi industry rather than for a specific company.
Training should be provided in safety management, investigating safety issues, and conducting root-cause analysis.
Training in risk assessment and root-cause analysis should be provided to managers.
Training in developing a corrective action plan.
College programs should include SMS training.</td></tr>
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<table>
<tr><th>Safety theme</th><th>Risk and conclusion</th><th>Actions suggested by operators or TC inspectors and relevant active TSB recommendations</th></tr>
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Support for safety training, better guidance from TC and a manual containing examples of SMS and other safety initiatives.
Sharing safety information among smaller operators.
Regional Aviation Safety Councils should be reinstated.
Operators called for more effective oversight from TC.

Relevant active TSB recommendations

TSB recommendations A16-12 and A16-13

</td></tr>
<tr><td>Regulatory framework</td><td>Description of risk
Regulations that are ineffective or outdated, and/or the absence of regulations, may result in a reduced level of safety.
Conclusion
Regulations must keep pace with advances in the aviation industry to help achieve an acceptable level of safety.</td><td>
Suggested actions

Regulations for air-taxi operations are inadequate and should be closer to the regulations governing commuter airline operations (CARs Subpart 704).
Regulations should contain sub-categories for different types of operations, such as floatplanes, MEDEVAC, helicopters, and single- and multi-engine aircraft operating under IFR.
Regulations need to be updated to reflect new technology.
Greater regulation in areas covered in other parts of the SII, including:

SMS
operations in adverse weather conditions
use of and training in new technology

Other regulatory changes needed include:

crew fitness
alcohol consumption for AMEs
maximum hours on duty for maintenance personnel
credentials, qualifications, and operational requirements being required for key positions in a company

Visibility and VFR operations

Visibility requirements should be easier to understand.
Eliminate the reduced visibility operations specification.
Update regulations for night flights under VFR or prohibit night operations under VFR.
Improve VFR and IFR procedures for operations in uncontrolled airspace.

Training

Make more types of training mandatory.
Increase hours for training.
Require line-indoctrination training and line checks.
Require CRM training. (TC has published the new standard, Advisory Circular AC 700-042, “Crew Resources [sic] Management,” which became effective on 31 July 2017 with a full implementation date of 30 September 2019.)

</td></tr>
</table>

Safety theme	Risk and conclusion	Actions suggested by operators or TC inspectors and relevant active TSB recommendations

		• Increase the flight time required for seaplane rating.
		  • Introduce recurrent training for AMEs.
		• Equipment
		  • Require use of high-intensity strobe lights.
		  • Require TCAS for all air-taxi operations.
		  • Simplify approval method for modifications to older aircraft.
		• Dispatch
		  • Require a licensed dispatcher for all air-taxi operations.

Regulatory oversight	**Description of risk**
	Ineffective and/or inefficient regulatory oversight may result in a reduced level of safety.
	Conclusion
	A robust system of regulatory oversight that includes safety promotion, monitoring, and enforcement is critical to ensuring that operators are provided with the support they need to effectively manage the risks associated with their operation and that they are complying with the regulations.
		Suggested actions
		• TC to ensure that it employs sufficient industry-competent personnel to effectively carry out oversight activities.
		• More frequent oversight and oversight that is broader in scope.
		• More traditional oversight, with more hands-on activities, including check rides, ramp checks, and line checks.
		• More frequent contact between operators and TC inspectors which includes greater support from TC.
		• A positive relationship with TC inspectors in order for a company to improve safety.
		• Additional or improved guidance material in several areas, including
		  • process inspection, program validation inspection and corrective action plan processes;
		  • guidance for new operations managers; and
		  • updated approved check pilot manuals.
		• Improved timeliness and consistency of responses from TC.
		• Greater knowledge and training required among TC inspectors. TC inspectors should have specific knowledge and experience in the operations for which they are providing oversight.
		Relevant active TSB recommendation
		• TSB Recommendation A16-14

5.6 Raising the bar on safety in air-taxi operations in Canada

5.6.1 Safety pressure

Some actions taken to increase safety pressures also have the potential to decrease sector pressures and operating pressures. Taking these actions will be most efficient overall because they act on all 3 pressures at once, increasing safety pressure against the operating point while reducing the operating and sector pressures pushing against a safe operating point. For example, implementing safety management in air-taxi operations provides processes and knowledge to identify hazards and risks proactively (increasing safety pressure) and to use corrective action planning and implementation to mitigate the risk (decreasing operating pressure, such as fatigue, or sector pressure, such as making weather information more readily available). The dynamics of the safe operating envelope model highlight that the most effective pressure to influence change is the safety pressure, and the structure of the model illustrates that all stakeholders have a role to contribute to influence this change, given the complexity of the sector, and that they must work together to ensure that decisions and feedback flow effectively to all stakeholders.

An organization's culture is established by what its members believe to be important and valuable; it is a critical determinant of how people behave day to day. Culture tacitly communicates expectations to new and existing members of the organization, affecting both how the work is accomplished and how fully members participate in company processes. Culture is deeply ingrained, and its impact on safety may not be readily apparent to individuals working within those sub-cultures.

Safety culture is the way safety is perceived, valued, and prioritized in an organization. A positive and active safety culture reflects the actual commitment to safe operations at all levels (i.e., the vertical integration of information) in the organization. It has also been described as "how an organization behaves when no one is watching."[246] The organization's safety culture is influenced by the values, attitudes and behaviours of the stakeholders.

A positive safety culture is paramount to effective safety management, which is where management style and commitment have a significant influence on the safety culture. Management sets the tone as to how things are done and how decisions are made, and whether they reinforce or undermine a positive safety culture. To this end, prioritizing safety considerations in all decisions made throughout the organization is crucial. This is the first step toward achieving a system of safety management in which everyone participates.

One of the challenges in establishing the desired positive safety culture is that people within the organization cannot always see how effective their safety culture actually is. This is where having outside organizations (clients or industry associations) assess the safety culture may be helpful: they can provide objective feedback that can be used to improve the safety culture. Similarly, hands-on TC oversight performed on a regular basis would give the regulator a better sense of the company's safety culture and help it allocate limited resources based on direct observations rather than on document and paper reviews and evaluations.

Establishing a positive safety culture has many challenges; however, it is a necessary first step in creating the values, attitudes and behaviours required for operators to effectively manage the risks associated with their operations. These efforts and investments will eventually lead to a positive safety culture where unsafe practices are seen as *un*acceptable

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246 Skybrary, "Safety Culture," available at https://www.skybrary.aero/index.php/Safety_Culture#Definition (last accessed on 07 October 2019).

by all stakeholders and risks are managed to a level as low as reasonably practicable, improving the management of operational hazards.

The SII results and the safe operating envelope as adapted by the investigation team illustrate that the most effective way of improving safety in the air-taxi sector is to increase the safety pressure through the influence and participation of all stakeholders. The SII identified 6 safety themes that exert safety pressure in air-taxi operations:

- training of pilots
- training of other flight operations personnel and AMEs
- training in PDM/CRM
- safety management
- regulatory framework
- regulatory oversight

Possible safety actions to address each of these themes are discussed below.

5.6.1.1 Training of pilots, other flight operations personnel and aircraft maintenance engineers

The purpose of providing training for pilots, other flight operations personnel, and AMEs is to ensure that they have the knowledge and skills necessary to perform their duties and responsibilities, and to help them develop the skills they need to make decisions that will manage the risks in their work effectively.

Although training requirements for all types of commercial aviation operations have many similarities, these requirements are less stringent for pilots flying in air-taxi operations than for pilots flying in commuter or airline operations. The SII identified training issues across a broad range of accident scenarios, such as aircraft- or equipment-specific training; PDM/CRM training; and operation-specific training.

Although Subpart 703 of the CARs, which governs air-taxi operations, has mandatory training requirements for certain specialized operations (e.g., night flying), there are no such requirements for many other specialized operations (e.g., mountain flying and coastal flying). Mandatory training requirements may therefore be inadequate to meet the many unique aspects of air-taxi operations. Without the requirement for specialty training for high-risk operations, pilots may lack the knowledge and skills to ensure safe flight operations.

Operators stated that the current training requirements for air-taxi operations should be improved. Many said that the minimum training times stipulated in the regulations and standards are insufficient; as a result, training may be compressed, and the subjects may not be covered as thoroughly as they need to be. Training must be adapted to the needs of the operation and to the experience levels of personnel. Newer, less experienced pilots may require additional training in map reading and manual flying, for example, to reduce overreliance on GPS or automation, while more experienced pilots may need additional training to help them use new technology in older aircraft.

All pilots conducting MEDEVAC operations would benefit from critical incident stress management training to help them manage the psychological and traumatic challenges of this type of operation.

Interruptions and distractions are serious safety issues that have been identified repeatedly in the past. All flight operations personnel would benefit from training on how to manage interruptions and distractions. Other company personnel and passengers could also receive education on managing interruptions and distractions. For maintenance personnel, the same interruptions and distractions during critical maintenance tasks are also a serious safety issue: hence, these personnel and surrounding personnel should receive training on the impact of these interruptions and distractions.

At the same time, individual pilots must take responsibility for continuously improving their knowledge and skills: for example, maintaining or improving manual flying skills.

Similarly, education for clients needs to be created and promoted to help them become informed consumers of air-taxi services.

Attitude influences actions and decisions within an organization, and will therefore influence how training is conducted as well as how it is received. In the case of PDM, the training will be ineffective unless it is conducted with an attitude that includes the safety component when making decisions. This means not always using the most efficient way, but considering safer courses of action as having a higher priority, even when they cost more in time and money.

5.6.1.2 Pilot decision making and crew resource management

When asked which issues led to highest overall risk to safety, operators identified 2 issues related to PDM/CRM that make unsafe decisions more likely:

- insufficient PDM/CRM skills and training
- the inability to apply PDM/CRM effectively in the operating environment (safety culture within the operation)

Operators cited insufficient or ineffective training and crew inexperience as contributing to ineffective PDM skills, while the absence of CRM training was cited as contributing to weak CRM in multi-crew environments.

Operators suggested training as the way forward to improve PDM/CRM. However, they questioned the effectiveness of online PDM or CRM courses, which were thought to be missing the discussion component of classroom-based training that provides practical application of PDM or CRM concepts and the learning from the experience of others. But training alone will not improve PDM/CRM; it must be supported by a company culture in which safe operating decisions and actions are the norm.

On 31 July 2017, TC Advisory Circular AC 700-042, “Crew Resources [*sic*] Management,” came into effect. The new PDM/CRM requirements indicated in this advisory circular must be fully implemented by 31 January 2019. TC has since published an exemption to delay the implementation date of this standard until 30 September 2019.[247]

5.6.1.3 Safety management

The traditional approach to safety management is based on compliance with regulations and a reactive response to incidents and accidents. Although compliance with safety regulations is fundamental, operators that simply comply with the standards set by the regulations are not well situated to identify emerging safety problems. According to the International Civil Aviation Organization *Safety Management Manual*:

> As global aviation activity and complexity continue to grow, […] traditional methods of managing safety to an acceptable level [become] less effective and efficient. Different, evolved methods of understanding and managing safety are necessary.[248]

One of the patterns through which accidents occur in complex systems, such as air-taxi operations, is the drift into failure: the components of these systems interact, evolve, and adapt to new situations in ways that are not always visible or controllable, but that may cause the operating point to drift into the safety margin, increasing the level of risk of the operation. The traditional approach to safety is ineffective to deal with this drift.

Modern safety management principles promote a proactive search for hazards, identification of risks, and instituting the best defences to reduce risk to an acceptable level. These activities allow the drift away from safe operating practices to be detected. These principles must be embedded within an organization's management system so that safety policies, planning, procedures, and performance measurement are integrated into day-to-day operations. This is possible with a culture that supports people speaking up, asking questions, and making decisions that prioritize safety.

In a system as complex as the air-taxi sector, individual actions control almost nothing, but influence almost everything.[249] In such complex systems, an individual action is one small influence on the overall pressure acting on the operating point. Combined actions or influences of stakeholders are needed to impact a significant change in the system, hence the need to address the influences acting on air-taxi operations. Regulations alone cannot control all the risks and make air-taxi operations safe.

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[247] Transport Canada, Exemption from subsections 722.76 (24), 723.98(33) – Aeroplanes, 723.98(25) - Helicopters, 724.115(38) - Aeroplanes, 724.115(28) - Helicopters and 725.124(39) of the Commercial Air Service Standards made pursuant to subsection 702.76(1), subparagraph 702.76(2)(d)(vi), subsection 703.98(1), paragraph 703.98(2)(d), subsection 704.115(1), paragraph 704.115(2)(e), subsection 705.124(1) and paragraph 705.124(2)(e) of the *Canadian Aviation Regulations* (effective 31 January 2019).

[248] International Civil Aviation Organization, Document 9859, *Safety Management Manual (SMM)*, Second Edition (2009), Chapter 3, paragraph 3.6.1.

[249] S. Dekker, Drift into Failure: From Hunting Broken Components to Understanding Complex Systems (CRC Press, 2011), pp. 169–171.

A safety management system (SMS) is generally defined as a formalized framework for integrating safety into an organization's daily operations, including the necessary organizational structures, accountabilities, policies and procedures, so that "it becomes part of that organization's culture, and of the way people go about their work."[250] An SMS provides a framework for this system-wide, proactive search for hazards and management of risk. SMS focuses on organizational risk management, yet includes and respects the decision makers who routinely make decisions about risk at the sharp end.

SMS is mandatory for airline operations and their related aircraft maintenance organizations as well as airports and air navigation service providers, but not for air-taxi operations. The current regulations therefore still do not require approximately 90% of all Canadian aviation certificate holders to have an SMS.[251] In 2016, the TSB recommended that TC require all commercial aviation operators in Canada to implement a formal safety management system.[252]

Over 10 years after the introduction of the first SMS regulations for airline operations and aircraft maintenance companies working for these operators, SMS implementation for aerial work, air-taxi, and commuter operations has stagnated. The TSB has repeatedly emphasized the advantages of SMS (see **Section 4.2.17 Safety theme: Safety management**). The issue of SMS has been on the TSB Watchlist since 2010. Since then, there has been no progress on expanding the application of SMS to air-taxi operations. TC had previously committed to doing this, but has not followed through with that commitment.

The industry consultation phase of the SII has shown that some operators fully support the idea that all air-taxi operators should be required by regulation to have an SMS; however, other operators felt that informal measures worked well and that implementing a full SMS would be a burden to small air-taxi operators. This is where the context and diversity of air-taxi operations highlight the need for an SMS that is appropriately scaled for the type of operation (e.g., a small floatplane operator vs. a multi-engine IFR operator), because a one-size-fits-all SMS approach cannot work.

This SII found that operators are capable of adopting modern safety management principles: some are using scaled-down measures, while others are using a voluntarily implemented SMS, and all of these measures are adapted to the needs of their operations. However, TC neither evaluates nor verifies a voluntarily implemented SMS. As a result, an air-taxi operator's SMS is not evaluated nor subject to surveillance or oversight by TC.

Implementing an SMS is a challenging process, requiring a company to transform its culture of compliance into one of proactive safety management: identifying hazards and how to mitigate them before an accident can occur. Company-wide commitment and training will help employees through this transition, where safe decision making is encouraged and

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250 J. Reason, Managing the Risks of Organizational Accidents (Ashgate Publishing, 1997).

251 TSB Aviation Investigation Report A13H0001.

252 TSB Recommendation A16-12.

unsafe practices are not accepted. This transformation is all the more difficult for small operators with neither the personnel nor the organizational structure of larger operators. Education on safety culture, safety management tools and practices, and risk management will help operators develop proactive safety management. Furthermore, adopting a culture of learning where incidents and near misses are used as sources of risk information and where peers learn from the experience of others will also contribute to proactive safety management.

Some operators are proactively identifying and mitigating risk, and taking measures that exceed regulatory requirements. For example, some operators provide line-indoctrination training, although there is no requirement for this training under Subpart 703 of the CARs. Another example is that operators who conduct operations under Subparts 703 and 704 are carrying out Subpart 703 operations to meet the higher requirements of Subpart 704.

For this reason, TC, which advocates the use of an SMS for the entire aviation industry, could reasonably be expected to provide these organizations with information on the concept of safety management, to provide guidance, and to facilitate the implementation of an SMS. Furthermore, unless an SMS is required, assessed, and monitored by TC in order to ensure continuous improvement, there is an increased risk that companies will not be able to effectively identify and mitigate the hazards involved in their operations.

With an SMS framework, a positive safety culture, and appropriate regulatory support and oversight, operators will be better able to develop a mature, continuously improving SMS. Such an SMS will increase safety pressure, while also reducing sector and operational pressure. However, even an appropriately scaled and mature SMS can only go so far: operators need support from the other stakeholders involved to make it work in eliminating the acceptance of unsafe practices and improve the management of operational hazards.

5.6.1.4 Regulatory framework

Regulations establish minimum requirements to address the most common risks. The air-taxi sector needs regulations and standards that reflect its difference from other types of commercial air services and accommodate the diversity of its operations, even within the sector (i.e., airplanes, helicopters, floatplanes, MEDEVAC). However, the complex nature of air-taxi operations is such that it limits the extent to which one-size-fits-all regulations and standards can be applied. Most of all, the actions that regulations and standards prescribe need to build the capacity of crews, companies, and clients to proactively identify and mitigate risks, recognizing their resource limitations and competing pressures.

A review of the 167 occurrences with published TSB investigation reports during the study period revealed 30 findings from 19 investigations that identified regulatory issues that led to a reduced level of safety in air-taxi operations. Some of the findings from these investigations (such as competence of key personnel, training, and equipment) are corroborated by industry consultations during this investigation.

Operators reported that existing regulations and standards for air-taxi operations have not kept pace with advances in the sector. The process for amending regulations and standards can take many years, by which point the regulations are outdated before they come into force. Regulations and standards must evolve with advances in the aviation industry to continuously apply safety pressure.

5.6.1.5 Regulatory oversight

In Phase 2 of the SII, regulatory oversight issues were described by some operators as the most significant risk associated with air-taxi operations. These issues included insufficient TC inspectors and other resources, the frequency and focus of surveillance, inspectors having inadequate training to carry out surveillance activities, and inconsistent interpretation and application of regulations.

Previous TSB investigations and safety studies have emphasized TC's role in ensuring that operators are capable of managing the risks inherent in their operations. The approach to regulatory oversight has changed over the last 10 years from a compliance-based to a systems-based approach, which includes some compliance and enforcement activities. However, the operators consulted repeatedly highlighted that the emphasis of current oversight activities is on document review. In addition, TC has scaled back on the safety promotion and education activities that went along with traditional regulatory oversight activities in the past.

Given the importance of safety culture for effective safety management, TC regulatory oversight should include evaluation of the operator's safety culture. This can best be accomplished by periodically conducting a range of surveillance activities, both planned and unplanned. Oversight activities also need to be supported by regulatory enforcement activities that are proportionate to the findings of non-compliance.

A robust system of regulatory oversight that includes safety promotion and education, monitoring, and enforcement is critical to ensure that operators are provided with the support they need to effectively manage the risks associated with their operation and that they are operating in compliance with the CARs.

~~5.6.2~~ Stakeholder influence

For stakeholders to manage risk and implement mitigations that will work, it is critical to understand the operational context (i.e., the operating pressures and the sector pressures) faced by operators and the challenges of regulating such a diverse sector. In a system as complex as the air-taxi sector, stakeholders have the ability to influence operations at all levels to be conducted safely, where risks are managed to a level as low as reasonably practicable. The following section outlines safety actions that have the potential to influence safer operations with an emphasis on the different organizational levels.

5.6.2.1 Influences on the sector pressures

Themes related to sector pressures
• Aerodromes and infrastructure • Availability of qualified personnel • Airborne collision avoidance • Interruptions and distractions • MEDEVAC operations • Night operations • On-board technology • Survivability • Weather information

The safety themes that fall under the sector pressures group are discussed in detail in sections 4.2.1 to 4.2.9 of this report. Many of the operators consulted in Phase 2 of the SII identified these as operational hazards. Sector pressures increase the risk within the air-taxi sector and are tied to the operational context. There are many ways to manage sector pressures.

Clients chartering aircraft to fly to their own work sites can help flight crews make sound safety decisions by providing information about available infrastructure and local hazards at the destination, and by installing more infrastructure (e.g., lighting, weather cameras) as necessary. Clients can provide their employees with training on personal protective equipment (e.g., PFDs, immersion suits, helmets), underwater egress, or other survivability aspects. They can also provide training on expected behaviour during flight, including the importance of not interrupting or distracting the flight crew and of paying attention to safety briefings. In light of the challenges regarding availability of qualified personnel, clients can also review their requirements with regard to flight crew experience.

The **regulator** promulgates regulations and establishes the standards required for air-taxi operations. Some operators are already exceeding the standards and would like more regulations and higher standards to level the playing field in this competitive sector, where profit margins are narrow. Existing regulations are not keeping pace with advances in technology (e.g., ADS-B for collision avoidance, lightweight recorders) and the process makes it difficult for operators who want to incorporate new technology into their existing fleet. Regulations and standards need to be reviewed to ensure that they are adequate, sufficient, and current: for example, “adequate visual reference” for night operations needs to be clearly defined, as called for in TSB Recommendation A16-08. The TSB has made recommendations to TC to address a number of safety issues in the air-taxi sector. Several are still active, including ones relating to terrain awareness warning systems for night operations and for flights in instrument meteorological conditions[253] and to survivability.[254] Addressing these recommendations will reduce sector pressures by mitigating specific hazards.

The regulator and service providers need to review the status of aerodromes used by air-taxi operators to ensure that the facilities and infrastructure are adequate: for example, the runway length is appropriate for the intended aircraft, and RNAV approaches, automated weather observation systems (AWOS), weather cameras, runway surface condition reports, and de-icing/anti-icing equipment are available. Technology can also help service providers mitigate sector pressures, for example, weather-reporting technology such as AWOS or

[253] TSB Recommendation A16-10.

[254] TSB recommendations A15-02, A16-01, A16-02, A16-03, A16-04, A16-05, A16-06, and A16-07.

weather cameras, or runway surface condition reports. The structure of air navigation services and air traffic services can reduce sector pressures by using ADS-B technology to use actual aircraft positions to monitor traffic and prevent collisions and in turn increase the safety of the service provided. Furthermore, ADS-B has the potential to improve survivability by providing accurate position information to search and rescue resources so that they can find and rescue survivors in a timely manner. Similarly, RNAV arrival and departure procedures can separate traffic, reducing the risk of collisions, and make traffic flow more efficient, particularly at aerodromes with mixed traffic (IFR aircraft and VFR aircraft).

Service providers (aerodrome operators) can reduce sector pressures and mitigate the risks associated with night operations by ensuring that their facilities have adequate approach and runway lighting, GPS approaches, and up-to-date and readily available information on weather and runway conditions. Weather-related risks can be mitigated with more and better weather-reporting technology (e.g., AWOS and weather cameras). However, mitigation strategies implemented by service providers are directly linked to the economic boundary of the safe operating envelope: technology costs money, and service providers must balance financial considerations against usage, while also balancing safety and efficiency of operations.

Associations can help reduce sector pressures through industry consultations related to infrastructure improvements and regulatory changes. They can also share best practices with their members and provide educational materials to the travelling public.

Operators have an obligation to manage the specific risks associated with their operations and use mitigation strategies to reduce sector pressures. Many operators are proactive in taking measures that go beyond existing regulations (e.g., imposing higher weather minima than the regulations do). They also address other safety issues not covered by regulations, in order to reduce the level of risk to their specific operations (e.g., line indoctrination, which is not mandatory under the subpart of the CARs that governs air-taxi operations). Operators can influence clients through education in order to manage sector pressures, for example, by providing information about weather minima, infrastructure limitations, or equipment limitations. The regulator can also educate the public (including potential clients) directly through awareness campaigns about issues related to sector pressures, such as survivability.

Company policies can provide a solid foundation to support individuals making operational decisions and many companies go beyond existing regulation: for example, by implementing policies that can be used to manage crew fatigue while on standby. Other policies can serve as mitigations, for example, policies to manage interruptions and distractions from cellphones. A policy, procedure, or checklist on what information needs to be included in passenger safety briefings will help individual flight crews perform these to the regulatory standard.

Individual crew members (pilots, AMEs, and other flight operations personnel), being at the sharp end of operations, are the stakeholders that are most influenced by the sector pressures. Many of these pressures can be mitigated with tools, procedures, and policies that have been established beforehand. For example, to manage interruptions and distractions, checklists can be used to perform critical tasks, with a standard procedure of using safety flags or other memory devices to mark where the task has been interrupted. Standard procedures can also include guidance on prioritization and task sharing in multi-crew operations. Pilots, crew members, and support and management personnel have a responsibility to use the safest course of action or take action to stop unsafe work practices.

PDM is a primary tool that pilots can use to mitigate sector pressures. PDM can include gathering information about remote or unfamiliar aerodromes (e.g., runway conditions, short-runway performance limitations, obstacles and topography) beforehand, and it can include building the safety component into all decisions (to counteract psychological or emotional influences that might override safety concerns, such as in MEDEVAC operations). But most important are PDM/CRM practices that can be used to mitigate many kinds of operational issues, such as infrastructure issues and the challenges associated with flying into remote or unfamiliar aerodromes. Training must be comprehensive, sufficient, and modern, and it must prepare pilots, AMEs, and other flight operations personnel for the operating context in which they will be working. While pilots and other flight operations personnel working in these operations may have received training, operators expressed concern that the training may not be effective, because it is difficult for any training program to address all higher-risk operational scenarios. Additionally, personnel at all levels must be supported to make such decisions and take such actions by all stakeholders (managers, supervisors, peers and passengers).

Sector pressures are part of the context of air-taxi operations; they can and should be planned for and managed before departure.

5.6.2.2 Influences on the operating pressures

The safety themes that fall under the operating pressures group are discussed in detail in sections 4.2.10 to 4.2.13 of this report. These pressures significantly increase the risks within the air-taxi sector and are tied to the day-to-day demands of efficiency.

Themes related to operating pressures
• Acceptance of unsafe practices • Fatigue • Maintaining air-taxi aircraft • Operational pressure

Clients have a role to play as informed consumers of aviation services. An example is the Federal Aviation Administration's "Circle of Safety" program in Alaska, which was developed to inform passengers of their rights and responsibilities. Passengers are encouraged not to assume that everything is as it should be, and to speak up and question the pilot about operating the aircraft in accordance with regulatory requirements, for example, weather, visibility, and weight and balance.[255] With regard to clients' responsibilities as passengers, the TSB has previously raised the issue of clients making requests for flights that cannot be performed legally, and the pressure on operators to accept such unreasonable requests.[256] Examples of these requests include pressuring pilots to deviate from standard operating procedures, overloading the aircraft, or rushing aircraft maintenance to meet the client's schedule. If operators accept such requests, there is additional pressure on AMEs and pilots to accept unsafe practices.

The **regulator**'s role in mitigating operating pressures includes developing policies, guidelines, regulations, standards, and educational materials.[257] Regulations need to be updated to keep pace with advances in technology and to take into consideration modifications and updates to older aircraft: for example, aircraft whose original manufacturer no longer exists, making it difficult or impossible to find replacement parts. The regulatory update process can be reviewed to ensure that it is timely and not onerous for operators to fit older aircraft with new technology. New regulations are required for AMEs, for example: while the CARs have provisions for flight crew hours of work and rest periods, no such regulations exist for maintenance personnel. PDM/CRM training will become mandatory on 30 September 2019.

The regulator can also create guidelines and educational materials for the public on the dangers of unsafe practices, such as overloading the aircraft or flying below visibility requirements, to help them become informed consumers.

Service providers' influence on operating pressures relates to time: services may be delayed or unavailable when operators need them. Examples of these services include weather briefings, filing flight plans, ATC clearances in a non-radar environment, refuelling, snow removal, aircraft de-icing/anti-icing, and runway maintenance.

Associations can mitigate operating pressures through education and lobbying. They can educate operators and clients on the dangers of accepting unsafe practices, on fatigue, and on operational pressures. They can help level the playing field for operators by creating incentives for their members to meet certain safety standards. One association that does this is the Tour Operators Program of Safety. Associations can also lobby the regulator for changes to regulations as well as participate in the Canadian Aviation Regulation Advisory Council to propose new regulations or changes to existing regulations.

Operators set the tone within their operation to create and promote the culture associated with safety management, to say that unsafe practices are unacceptable and to eliminate conditions in the operations that could give rise to these unsafe practices (for example,

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255 Federal Aviation Administration, "Circle of Safety Consumer Safety Education: Training the Traveler Guide" (30 August 2002), at https://www.faa.gov/about/office_org/headquarters_offices/arc/programs/fly_alaska/docs/TrainerHB.pdf (last accessed on 07 October 2019).

256 TSB Aviation Investigation Report A10Q0132.

257 Transport Canada, "Civil Aviation – What we do," at https://www.tc.gc.ca/eng/civilaviation/menu.htm (last accessed on 07 October 2019).

pressuring AMEs to finish maintenance tasks quickly). Operators need to provide appropriate, operations-specific PDM/CRM training and support for safe operating decisions in the form of a company culture that prioritizes safety. This culture should also extend to decision making associated with maintenance of aircraft. Policies can be put in place to identify and mitigate fatigue-related risks, and compensation regimes (such as paying by the hour) can be reviewed to make sure crews are not being motivated to fly more than they should. Operators can build safety into decision making at the beginning, when bidding on or accepting a contract, to make sure that the contract can be fulfilled safely.

Individuals are in an important position to influence the acceptance of and/or drift into unsafe practices, but they are also at the greatest risk of not seeing them for what they are. Because unsafe practices may be part of the existing culture, it is not always easy to recognize that they are unsafe, particularly if they have resulted in successful flights on many other occasions. This is why it is important to create a company culture in which safety is built into decision making, giving all individuals an opportunity to question practices without fear of repercussions. This culture, with a solid foundation of procedures that have been developed with safety in mind, will give individuals the knowledge and skills they need to determine their fitness for duty (for example, fatigue) and use PDM to mitigate operational pressure. Operators need to accept the decisions made using PDM that help the company *and* the ones that may lead to additional financial costs (e.g., delayed or cancelled flights due to weather).

Peer influence is also a significant factor in the transition from a compliance-based approach to safety to a proactive approach to safety that includes company-wide safety-based decision making. Peers have the potential to lead a cultural change through day-to-day work where unsafe practices are no longer acceptable. Sharing information and experience within peer groups is a key way to bring about change.

Sector pressures and operating pressures have an influence on day-to-day operations (individual flights) and the operation as a whole. Safety pressures also counteract these pressures.

5.6.2.3 Influences on the safety pressures

The safety themes that fall under the safety pressures group are discussed in sections 4.2.14 to 4.2.19 of this report. All of these themes can positively influence the manner in which hazards and risks are effectively managed within the air-taxi sector. Safety pressures counteract the sector and operating pressures based on actions carried out beforehand: training, PDM/CRM, SMS, and regulatory framework and oversight. Training and regulatory framework and oversight are the foundation for safe decision making.

Themes related to safety pressures

- Pilot decision making and crew resource management
- Training of pilots and other flight operations personnel
- Training of aircraft maintenance engineers
- Safety management
- Regulatory framework
- Regulatory oversight

Clients can increase the safety pressure by fostering a culture in which additional safety measures are required (e.g., having their employees wear PFDs, conducting safety audits, requiring SMS) and supporting safe decision making. As informed consumers, clients can identify unsafe practices and speak up.

TC, as the **regulator**, establishes regulations and standards that act as part of the foundation for managing safety in air-taxi operations, but regulations alone cannot ensure an acceptable level of safety, especially in this sector. Individual actions are a small part of the overall pressure acting on the operating point; in the air-taxi sector specifically, the combined efforts of all stakeholders are what will keep the operating point within the safe operating envelope. This includes regulation and oversight, but is not limited to these.

The ability to update regulations and standards in a timely manner will have a positive influence on safety. This was raised repeatedly during industry consultations. For example, on-board technology, modifications to older aircraft, operations-specific sub-categories (floatplanes, MEDEVAC operations, helicopters, IFR operations), duty time and alcohol/drug consumption limits for AMEs, and training, regulations and standards. Additionally, it was raised that the credentials, qualifications, and operational requirements for key operational personnel (e.g., director of flight operations, chief pilot) need to be reviewed to ensure that these personnel are capable of assuming the duties and responsibilities of those positions. The regulations and standards also need to be reviewed to ensure that, if personnel are not capable, the requirements include provisions to remove them from their position.

The SII has highlighted that some training requirements need to be improved (e.g., line indoctrination) and that the training time in the regulatory standard is insufficient. As a result, training time may be compressed and the topics may not be covered as thoroughly as they need to be. The industry consultation phase of the SII also found that there may be a need for more clearly defined aircraft-specific training for AMEs, along the same lines as aircraft-specific training for pilots.

The regulator also has a role to play in training, safety promotion and education. New PDM/CRM requirements must be fully implemented by operators by 30 September 2019; however, for PDM/CRM training to be effective, it is not enough to require only that this training be taken. The standards regarding how the training will be conducted and by whom will greatly influence how effective is the training. The training also has to incorporate positive safety attitudes, and the importance of building safety and risk management into all decision making, supporting the practice of good PDM/CRM in all aspects of flight operations by all stakeholders. Some examples include supporting go/no-go decisions, operating aircraft within weight limits, having weigh scales and weight and balance forms and calculations available at all departure points.

PDM/CRM training also needs to be assessed and monitored to ensure that it is effective and being delivered to standard by trainers with the appropriate qualifications. Ultimately, the effectiveness of a contemporary PDM/CRM training program depends upon the extent to which the operator incorporates PDM/CRM as an integral part of its culture;[258] its day-to-day operations. PDM/CRM practices need to be supported and reinforced by managers, supervisors, and most importantly peers in day-to-day operations and actions.

An SMS provides the necessary framework (policies, procedures, tools) for a proactive approach to managing safety. TC currently requires an SMS for airline operations, but not for air-taxi operations. Many air-taxi operators are introducing the principles of SMS into their operations in the absence of a regulation. However, because SMS is not mandatory, it is not assessed against a recognized standard and is an added cost assumed by the proactive operators. This is where TC can facilitate the implementation of SMS by providing appropriate guidance, explicitly in the context of air-taxi operations, where a one-size-fits-all approach is not effective.

An SMS is a tool that can be scaled to suit the size and complexity of the operation while still covering the core components of an SMS. TC inspectors need to be trained and empowered to provide the necessary guidance for implementing a scaled-down SMS in the air-taxi sector. TC inspectors also need the training and the appropriate tools to monitor SMS performance in the field, for example, by attending an operator's training or doing check rides, line checks, or ramp checks to directly observe how the operator works on a day-to-day basis, rather than just evaluating policies and procedures on paper.

TC inspectors need to be qualified and experienced to perform oversight of specialized operations (e.g., having a float endorsement and experience to assess and monitor floatplane operations) and be familiar with the technology in use in the air-taxi sector (or the part of the sector they are overseeing). Given that an effective SMS requires a positive safety culture, TC oversight should include an assessment of the operator's safety culture. This oversight should share best practices used by other operators and provide feedback that goes beyond focusing on errors and issuing findings of non-compliance. Furthermore, regardless of the regulatory oversight activity being performed, TC inspectors must have the authority to immediately address any unsafe practices that are identified and the factors underlying these practices. Oversight activities also need to be supported by regulatory enforcement that is proportionate to the findings of non-compliance. The maximum surveillance window of up to 5 years may not be enough to monitor safety performance of this sector. The TSB has issued recommendations on the implementation of SMS and oversight activities.[259] Addressing these recommendations would increase safety pressure.

Another way of increasing safety pressure is to have **operators** and **industry associations** work together to develop a mechanism for sharing safety data, best practices, and lessons learned. Industry associations can also provide seminars, training and tools, as well as documentation and guides. Appendix D contains examples of how associations have increased the safety pressure in their sector.

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[258] Transport Canada, Advisory Circular AC 700-042: Crew Resources [*sic*] Management (Issue 01: 31 January 2019), at https://www.tc.gc.ca/en/services/aviation/reference-centre/advisory-circulars/ac-700-042.html (last accessed on 07 October 2019).

[259] TSB recommendations A16-12, A16-13, and A16-14.

Many **operators** use proactive safety management to identify hazards and mitigate the risks associated with their operations to increase the safety pressure. To further increase the safety pressure, operators also need to provide training and the equipment and tools necessary, whereby a culture of operating safely is built and maintained that will foster the effective use of PDM/CRM in day-to-day operations. Operators can use these proactive mitigations in advance of TC regulations to incorporate the safety component in all decisions within the operation.

Also identified by the SII is that providing operational support for pilot decision making (e.g., flight dispatch, operational control) and establishing policies and procedures to balance crew experience (e.g., “no green-on-green”, avoid pairing 2 less-experienced crew members) will also increase the safety pressure. However, this comes with a cost. Operational personnel (pilots, AMEs, dispatchers, etc.) are the front-line managers of risk, particularly in air-taxi operations, where they frequently operate with fewer resources (e.g., no dispatch) and less support (e.g., ground support) than in other aviation sectors, such as commercial airlines.

Individuals also have a role to play in influencing safety pressure by ensuring that they are fit for duty, have the knowledge and skills to perform their duties, are competent to manage the risks associated with their operations, and include safety in their daily decision making. Individuals have other roles to play in influencing safety pressure when interacting with their peers. For example, check pilots, instructors, and senior pilots can serve as positive role models for safe practices (e.g. continuous use of standard operating procedures and checklists) by not accepting unsafe practices. New pilots can also influence those performing unsafe practices by speaking up. However, the influence new pilots and their fresh observations have will depend on the support they receive from all stakeholders.

6.0 CONCLUSION

This safety issue investigation (SII) builds on the experiences of those who have been operating in this sector for decades, on the results of previous safety studies, and on previous Transportation Safety Board of Canada (TSB) investigations in order to understand the hazards and risk factors associated with air-taxi operations in Canada and to identify underlying systemic safety issues where action needs to be taken.

Using a grounded theory study to analyze the data gathered in phases 1 and 2 of the SII was a novel approach that yielded reliable information and a solid understanding of the hazards and risk factors affecting the safety of operations in this sector, and it did this in a way that would not be possible with more standard, quantitative approaches (see **Section 3.0 Methods**).

The results of the grounded theory study made it possible to model the air-taxi sector as a complex system, using the safe operating envelope model (see **Section 5.4 A dynamic model of safety: The safe operating envelope**). This model illustrated the competing pressures within the air-taxi sector and how they interact at the systems level. It also highlighted where stakeholder influence can be applied most effectively to make safety improvements in this sector.

6.1 The air-taxi sector is different, and this demands a different approach to safety

The air-taxi sector is different from other sectors of commercial aviation, and this context must be taken into account in order to make safety improvements. The need to manage competing pressures—balancing sector, operational, and safety pressures in the context of air taxi operations—must be taken into consideration.

Most operators in the air-taxi sector have moved beyond improving aircraft reliability and safety and modernizing pilot selection and basic training. The next level is to focus on organizational and management factors where competing pressures interact. Operational and sector pressures still need to be addressed; however, the emphasis now needs to be on using culture and proactive safety management to increase safety pressure.

The SII studied the sector and its accidents in depth and outlines a way ahead that respects the nature of the sector and addresses the 2 main underlying factors of **acceptance of unsafe practices** and **inadequate management of operational hazards**. It demonstrates that change needs to happen from within the sector and requires the participation of all stakeholders, including clients and passengers, who have the potential to greatly influence safety. The approach to managing safety shown by the SII is new and different from the traditional approach to safety applied in this sector.

6.2 What we learned from the accident data

Air-taxi operators are exposed to diverse hazards and risk factors and are subject to operational pressures that are unique to the sector. Therefore, understanding the operating context is critical to managing the risks associated with this sector.

Many new pilots enter this complex, varied, and challenging environment having to operate sometimes with older aircraft, less training, less guidance, less mentoring, less robust policies, few or no standard operating procedures, less stringent regulations, and possibly less oversight, all while operating in the highest-risk environment compared to other sectors of commercial aviation.

The analysis of the accident data provided an understanding of how these accidents were happening (through precise descriptions). This analysis revealed that the highest number of fatalities in both airplane and helicopter accidents resulted from flights that started in visual meteorological conditions (VMC) and continued to a point where the pilot lost visual reference with the ground. The main difference was how the flight ended: in a loss of control or in a controlled flight into terrain. The pilots-in-command involved in these accidents had a combined overall average of 5000 hours of experience. Therefore, it would appear that pilot experience is not mitigating against these types of accidents.

The analysis of the accident data also revealed that the factors contributing to air-taxi accidents that occurred during the study period fall into 2 broad areas:

- **acceptance of unsafe practices** (e.g., flying overweight, flying into forecasted icing, not recording defects in the aircraft log, flying with unserviceable equipment, "pushing the weather," and flying with inadequate fuel reserves); and
- **inadequate management of operational hazards** (e.g., inadequate response to aircraft emergencies, inadequate crew coordination contributing to unstable approach, visual flight rules [VFR] flight at night, loss of visual reference in marginal weather conditions, scales not available for weight and balance calculations).

The acceptance of unsafe practices is incremental and largely invisible to operators and pilots, making it difficult to realize how much the safety margin has been eroded. The accident data revealed many examples of pilots who had previously completed successful flights in marginal conditions and, over time, as they continued to fly using these unsafe practices, these practices became the norm.

The inadequate management of operational hazards is linked to the conflict between short-term production goals and long-term safety goals within the sector. Further analysis of the accident data identified weak or missing defences that, if improved or added, have the potential to enhance safety. The fact that these defences are insufficient, and have been this way in many accidents for many years, speaks to the persistence of the hazards and risk factors in the air-taxi sector. The persistence of these hazards and risk factors also indicates that a different view and approach is needed to provide a better understanding of the pressures and influences on safe air-taxi operations, and how to raise the bar on safety.

6.3 What we learned from industry consultations

The information gathered from the interviews with air-taxi operators was analyzed, and 19 safety themes emerged from this analysis. The hazards in 11 of these themes were also identified in 17 previous studies, including the Transport Canada (TC) Safety of Air Taxi Operations Task Force (SATOPS) study in 1998. This validated that these previously identified hazards and safety issues are not new, and are still contributing to air-taxi accidents.

The information gathered also provided insight into how these hazards were being managed by operators, and what actions operators believed should be taken by various stakeholders.

6.4 The safe operating envelope

The safety themes that emerged from the industry consultations were fitted into a model adapted from the safe operating envelope initially developed by Cook and Rasmussen.[260] This model was selected as a way to illustrate how the safety themes, the context, and the competing pressures inherent in the air taxi sector interact.

The model showed the interaction between the 3 kinds of pressures observed in the data:

- **Sector pressures** are operational hazards that increase the level of risk and are part of the context of air-taxi operations. They can and should be planned for and managed before a flight takes off.
- **Operating pressures** significantly increase the risks within the air-taxi sector and are tied to the day-to-day demands of efficiency in a financial and a workload sense.
- **Safety pressures** counteract the sector and operating pressures, mainly based on actions carried out before a flight.

The advantages to this model were as follows:

- It showed a good qualitative fit with both the accident data and the industry consultation data.
- It illustrated the structure of the sector and the vertical flow of information through the layers.
- It illustrated the interrelationships among the competing pressures in air-taxi operations.
- It provided a system-wide view and understanding of the competing pressures and influences that stakeholders deal with every day.
- It demonstrated which of the pressures would be most effective to target with safety improvements.

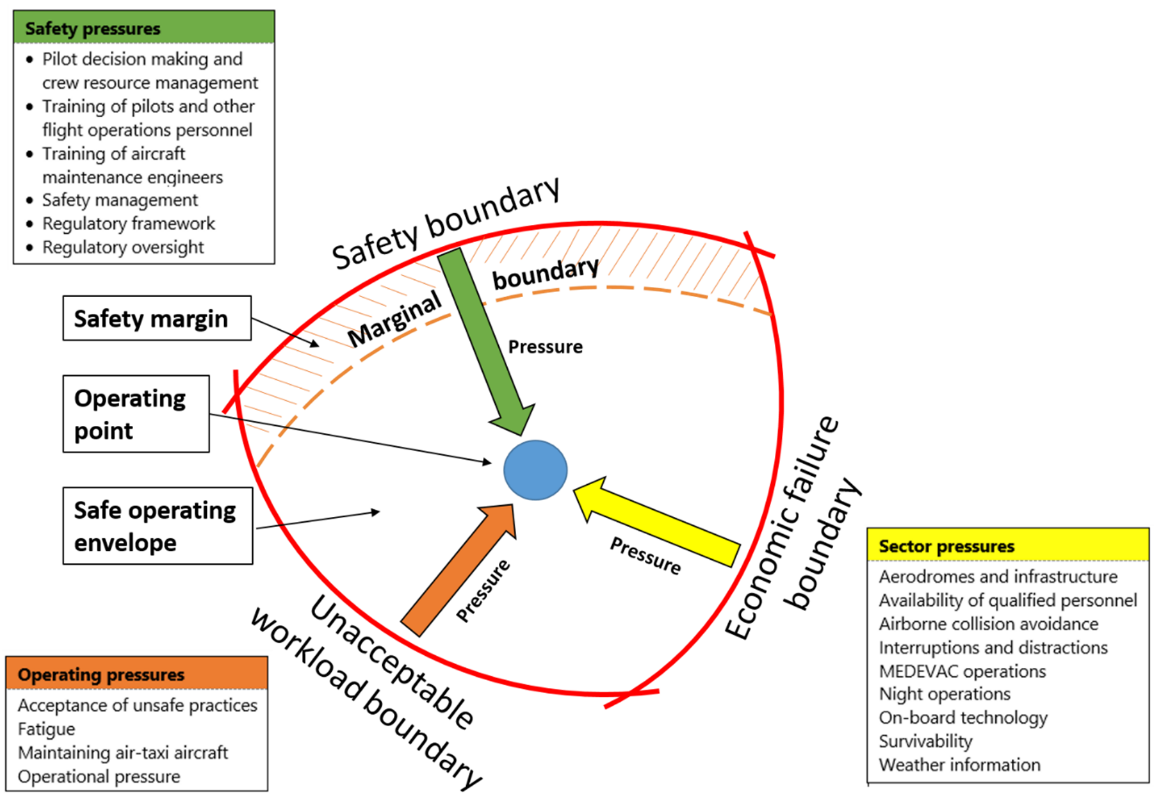
260 D.D. Woods, J. Schenk, and T.T. Allen, "An Initial Comparison of Selected Models of System Resilience," in: C.P. Nemeth, E. Hollnagel and S. Dekker (eds.), *Resilience Engineering Perspectives, Volume 2: Preparation and Restoration* (CRC Press, 2009), p. 78.

The safety themes grouped in the pressures in this model are some areas where the TSB has made multiple findings and recommendations related to air-taxi operations in the past. Of these recommendations, 22 are currently active as of the publication of this report.

This model illustrates the competing pressures that act on an operation as a result of goal conflicts (e.g., balancing safety and financial viability). The model shows the operation as a constantly moving point within the safe operating envelope, moving toward or away from the economic failure, unacceptable workload, and safety boundaries.

Figure 24 shows this model in conjunction with the 19 safety themes that emerged from the industry consultations in Phase 2 of the SII (see **Section 4.2 Information from consultations with industry**).

Figure 24. The safe operating envelope model illustrating how sector pressures, operating pressures, and safety pressures affect the position of the operating point within the envelope



The safe operating envelope model shows how the sector pressures and the operating pressures both push the operating point toward the safety boundary, increasing the risk of an accident (see **Section 5.5.1 The safe operating envelope model in action**). The safety pressures are positive mitigations that counteract the other 2 pressures to keep the operating point within the boundaries of the safe operating envelope. All of this effort has the potential to reduce the acceptance of unsafe practices and improve the management of operational hazards.

The system-wide competing pressures illustrate how the clients, the individuals, the operator, the service providers, the regulator, and industry associations can influence each of these pressures together to improve the safety of air-taxi operations:

- Increase the safety pressures
- Decrease the sector pressures
- Decrease the operating pressures

Making investments to increase the safety pressure may be the most effective strategy, because these investments can at the same time decrease the sector pressures and operating pressures.

What this means for operators is incorporating safety into all aspects of decision making and flight operations. For all stakeholders, it means investing time and resources before the flight, to develop and support a culture of operating safely.

Referring to the safety themes, the following measures will help increase the safety pressure to keep the operating point within the safe operating envelope:

- **Pilot decision making (PDM) and crew resource management (CRM)** competencies that help flight crew manage the risks associated with aircraft operations.
- **Training for pilots and other flight operations personnel** to develop the skills and knowledge they need to manage the diverse risks associated with air-taxi operations effectively.
- **Training of aircraft maintenance engineers** working in air-taxi operations to ensure that the wide variety of aircraft types and models used in this sector are maintained in airworthy condition.
- Effective **safety management** of operational hazards to proactively identify hazards and mitigate risks to a level as low as reasonably practicable, thus mitigating the sector pressures and operating pressures.
- Up-to-date **regulations** with a robust system of **regulatory oversight** that includes safety promotion, monitoring, and enforcement.

6.5 Raising the bar on safety

To improve safety in the air-taxi sector, the 2 main underlying factors contributing to air-taxi accidents (**acceptance of unsafe practices** and **inadequate management of operational hazards**) must be addressed differently than in the past. A system-wide, combined effort by all stakeholders is necessary.

Supportive influences from all stakeholders with a positive safety attitude can help operators plan safer flights and support pilots' use of PDM/CRM practices that prioritize safety. This will lead to a culture where unsafe practices are considered unacceptable.

Therefore, one step to improving safety in the air-taxi sector is convincing clients, operators, and passengers not to accept unsafe practices, and to speak up to prevent them from happening. This requires knowledge and a change of attitude and actions, which will contribute to a change in culture.

Another step is making it routine for effective PDM/CRM practices to be supported by managers, supervisors, and peers, as well as by a positive safety pressure from clients and passengers. The cultural shift created by this change of attitude and actions will spread to all other operational personnel, including pilots, maintenance, dispatch, and ground operations. This is a longer-term process that will provide numerous additional defences. Establishing a positive safety culture[261] has many challenges; however, it is a necessary step in creating the attitude and actions required for operators to manage the risks associated with their operations effectively. This type of culture is not new: many operators have already implemented this culture, in the knowledge that it was necessary for their success.

A third step is widely promoting and implementing proactive safety management in air-taxi operations that is based on an understanding of the operating context and the risks specific to an operation. A safety management system (SMS) provides a framework for this systematic, proactive search for hazards and management of risk that "becomes part of that organization's culture, and of the way people go about their work."[262] It is not necessary for an air-taxi operation to have all of the components of an airline SMS. An SMS, if it is appropriately scaled to air-taxi operations, while retaining its core components, can be a proactive means to identify and mitigate hazards on a continuous basis.

The TSB has repeatedly emphasized the advantages of SMS through its Watchlist since 2010. Some operators have voluntarily implemented an SMS that is adapted to their needs, but there has been no progress toward requiring SMS for all air-taxi operations.

Introducing measures of safety performance that can help operators recognize where they are within the safe operating envelope is another important aspect of safety management. Some industry initiatives have established higher standards to distinguish operators who exceed the regulatory requirements (e.g., the Tour Operators Program of Safety). If these steps are taken, they will address the 2 main underlying factors contributing to air-taxi accidents. The risks will be mitigated by the investments made as part of increasing safety pressures through training and education, company-wide safe decision making, PDM/CRM, and safety management that includes a culture of operating safely.

Finally, for stakeholders to better evaluate the efficacy of the safety measures implemented, hours-flown and movement data need to be collected for the air-taxi sector. If these data are not categorized by *Canadian Aviation Regulations* (CARs) subpart, it will be more difficult to assess the effectiveness of any safety improvements initiated within the air-taxi sector.

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261 Safety culture is the way safety is perceived, valued, and prioritized in an organization.

262 J. Reason, Managing the Risks of Organizational Accidents (Ashgate Publishing, 1997).

6.6 Safety action required

To mitigate the hazards and risk factors associated with air-taxi operations in Canada and raise the bar on safety, all stakeholders need to understand the operating context and work together to invest in measures to increase the safety pressure and to decrease the sector and operating pressures. This approach will address the underlying factors present in air-taxi accidents: **acceptance of unsafe practices** and **inadequate management of operational hazards**.

The following TSB recommendations must be addressed to mitigate the persistent safety deficiencies associated with air-taxi operations:

- 22 active recommendations from previous investigations
- 4 new recommendations arising from this SII:
    - eliminating the acceptance of unsafe practices
    - promoting proactive safety management processes and a positive safety culture
    - closing gaps in the air-taxi regulatory framework
    - collecting activity data that is specific to the air-taxi sector

6.6.1 Active TSB recommendations

The TSB has 22 active recommendations that, if addressed, could mitigate the persistent safety deficiencies associated with air-taxi operations to address the 2 main underlying factors contributing to accidents in the air-taxi sector:

- acceptance of unsafe practices (3 active recommendations)
- inadequate management of operational hazards (19 active recommendations)

Addressing the active recommendations related to the acceptance of unsafe practices will increase safety pressure while at the same time reducing or counteracting sector and operating pressures. Addressing the active recommendations related to the inadequate management of operational hazards will reduce sector pressure.

6.6.1.1 Eliminating the acceptance of unsafe practices

Air-taxi operators are exposed to diverse hazards and risk factors and are subject to operational pressures that are unique to the sector. Fifteen years of accident data revealed many examples of flights in marginal conditions resulting in an accident, even though flights undertaken in similar conditions had been successfully completed in the past. Unsafe practices

Active TSB recommendations related to acceptance of unsafe practices (at September 2019)

A16-12: the Department of Transport require all commercial aviation operators in Canada to implement a formal safety management system.

A16-13: the Department of Transport conduct regular SMS assessments to evaluate the capability of operators to effectively manage safety.

A16-14: the Department of Transport enhance its oversight policies, procedures and training to ensure the frequency and focus of surveillance, as well as post-surveillance oversight activities, including enforcement, are commensurate with the capability of the operator to effectively manage risk.

identified in air-taxi accidents included flying overweight, flying into forecasted icing, not recording defects in the aircraft log, flying with unserviceable equipment, “pushing the weather,” and flying with inadequate fuel reserves. As operators continued to fly using these unsafe practices, over time these practices became the norm.

The acceptance of unsafe practices is incremental and largely invisible to operators, making it difficult for operators to realize how much the safety margin has been eroded. The traditional approach to safety is ineffective at dealing with this incremental shift, elements of which are captured by the theory of drift into failure.[263] A formal SMS provides the necessary policies, procedures, and tools to formalize a proactive approach to operating safely, and, when implemented properly, makes it possible to detect and manage aspects of drift into failure and manage risk more effectively. An SMS makes operations safer than traditional approaches to safety.

The SII emphasized the need for operators to be able to manage safety effectively. More than 10 years after the first SMS regulations were introduced for airline operators and the companies that perform maintenance on their aircraft, SMS implementation has stagnated in the rest of the commercial aviation industry. Although many companies have recognized the benefits of SMS and have voluntarily begun implementing it within their organizations, approximately 90% of all Canadian aviation certificate holders are still not required by regulation to have an SMS.

Operators have a responsibility to manage safety risks in their operations. Compliance with regulations can only provide a baseline level of safety for all operators in a given sector. Because the air-taxi sector is so diverse, regulatory requirements cannot address all risks associated with a specific operation. As a result, companies need to be able to identify and address the hazards specific to their operation. Regulatory requirements for companies to implement SMS are the first step in ensuring that operators are capable of meeting their safety responsibility. It is for this reason that the TSB has echoed calls from the International Civil Aviation Organization and the worldwide civil aviation industry emphasizing the advantages of SMS.

Even with SMS requirements, companies will vary in their ability or commitment to manage risk effectively. Less frequent surveillance that is focused on an operator's safety management processes may be sufficient for some companies. However, the regulator must be able to vary the type, frequency, and focus of its surveillance activities to provide effective oversight to companies that are unwilling or unable to meet regulatory requirements or manage risk effectively. Furthermore, the regulator must be able to take appropriate enforcement action in such cases.

The documentation provided to TC inspectors has evolved considerably in recent years, and TC continues to provide new training to its inspectors; however, given the complex nature

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263 S. Dekker, Drift into Failure: From Hunting Broken Components to Understanding Complex Systems (Ashgate Publishing. 2011), pp. 87-123.

of the air-taxi sector and the variety of air-taxi operators, SMS regulations and associated regulatory oversight must be adapted to meet the needs of the sector.

Therefore, to ensure that air-taxi operators have effective safety management systems in their operations and that air taxi operators continue operating in compliance with regulations, the Board reiterates the need to address these active TSB recommendations. Addressing these recommendations will increase the safety pressure, also reducing or mitigating sector and operating pressures throughout the air-taxi sector.

6.6.1.2 Management of operational hazards

The SII demonstrated how the varied and complex nature of the air-taxi sector and the extent of the competing pressures introduce hazards and risk factors that are different from those in other aviation sectors. It showed that these risks have persisted for decades and are resistant to more traditional safety mitigations.

The study also demonstrated that many of the hazards and risk factors identified in the TC SATOPS study in 1998, as well as in other studies conducted between 1998 and 2015, continue to persist. In addition, the analysis of the TSB occurrence data in Phase 1 of the SII showed that the same types of accidents— particularly the same types of fatal accidents— occurred throughout the study period.

The industry consultations in Phase 2 of the SII further validated that these previously identified hazards and safety issues are still contributing to air-taxi accidents. Both phases of the study also highlighted weak or missing defences that contributed to these accidents. The fact that these defences are insufficient, and have been identified in many accidents for many years, speaks to the persistence of the hazards and risk factors in the air-taxi sector.

The air-taxi sector, as a safety-critical industry,[264] must manage risk to a level that is as low as reasonably practicable. Operators need to balance many competing pressures that ultimately come from the need to be efficient and safe. This results in goal conflicts that require trade-offs, which may increase risk and reduce safety. Sector pressures are part of the context of air-taxi operations; they can and should be planned for and managed in advance or proactively. The inadequate management of operational hazards is linked to the conflict between acute production goals and ongoing safety goals within the sector. Therefore, mitigations need to address the system as a whole, taking into account the nature of air taxi operations as well as the influences exerted on operational activities by the sector pressures. Further analysis of the accident data also identified weak or missing defences that, if improved or added, have the potential to enhance safety.

The SII has illustrated systemic safety deficiencies, including those previously identified by 19 active TSB recommendations. The Board reiterates the need to address these

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264 A safety-critical industry is one in which safety is of paramount importance and where the consequences of failure or malfunction may be loss of life or serious injury, serious environmental damage, or harm to plant or property. (Source: F. Saunders, "Safety–critical industries: definitions, tensions and trade-offs" [11 January 2015], at http://fionasaunders.co.uk/safety-critical-industries-definitions-tensions-and-tradeoffs/ [last accessed on 07 October 2019].)

recommendations: doing so will ensure that a number of persistent, inadequately managed operational hazards, including those related to survivability, night operations, and the lack of on-board technology, are being managed effectively.

Stakeholders can go beyond existing regulations to address active TSB recommendations—there is no need to wait for TC to make regulatory changes in order to improve safety in the air-taxi sector.

Active TSB recommendations related to the inadequate management of operational hazards (September 2019)

A90-84: the Department of Transport require all commercially-operated helicopters to be equipped with appropriate instrumentation for the conduct of basic instrument flying.

A13-03: the Department of Transport require that all seaplanes in commercial service certificated for 9 or fewer passengers be fitted with seatbelts that include shoulder harnesses on all passenger seats.

A15-01: the Department of Transport require commercial air carriers to collect and report, on a routine basis, the number of infants (under 2 years old), including lap-held, and young children (2 to 12 years old) travelling.

A15-02: the Department of Transport work with industry to develop age- and size-appropriate child restraint systems for infants and young children travelling on commercial aircraft, and mandate their use to provide an equivalent level of safety compared to adults.

A16-01: the Department of Transport require all Canadian-registered aircraft and foreign aircraft operating in Canada that require installation of an emergency locator transmitter (ELT) to be equipped with a 406 MHz ELT in accordance with International Civil Aviation Organization Standards.*

A16-02: The International Civil Aviation Organization establish rigorous emergency locator transmitter (ELT) system crash survivability standards that reduce the likelihood that an ELT system will be rendered inoperative as a result of impact forces sustained during an aviation occurrence.

A16-03: The Radio Technical Commission for Aeronautics establish rigorous emergency locator transmitter (ELT) system crash survivability specifications that reduce the likelihood that an ELT system will be rendered inoperative as a result of impact forces sustained during an aviation occurrence.

A16-04: The European Organisation for Civil Aviation Equipment establish rigorous emergency locator transmitter (ELT) system crash survivability specifications that reduce the likelihood that an ELT system will be rendered inoperative as a result of impact forces sustained during an aviation occurrence.

A16-05: the Department of Transport establish rigorous emergency locator transmitter (ELT) system crash survivability requirements that reduce the likelihood that an ELT system will be rendered inoperative as a result of impact forces sustained during an aviation occurrence.

A16-06: Cospas-Sarsat amend the 406-megahertz emergency locator transmitter first-burst delay specifications to the lowest possible timeframe to increase the likelihood that a distress signal will be transmitted and received by search-and-rescue agencies following an occurrence.

A16-07: the Department of Transport prohibit the use of hook-and-loop fasteners as a means of securing an emergency locator transmitter to an airframe.

A16-08: the Department of Transport amend the regulations to clearly define the visual references (including lighting considerations and/or alternate means) required to reduce the risks associated with night visual flight rules flight.

A16-09: The Department of Transport establish instrument currency requirements that ensure instrument flying proficiency is maintained by instrument-rated pilots, who may operate in conditions requiring instrument proficiency.

A16-10: The Department of Transport require terrain awareness and warning systems for commercial helicopters that operate at night or in instrument meteorological conditions.

A17-01: The Department of Transport require all commercially operated DHC-2 aircraft in Canada to be equipped with a stall warning system.

A17-02: The Department of Transport, in collaboration with the Canadian aviation industry and employee representatives, develop and implement requirements for a comprehensive substance abuse program, including drug and alcohol testing, to reduce the risk of impairment of persons while engaged in safety-sensitive functions. These requirements should consider and balance the need to incorporate human rights principles in the Canadian Human Rights Act with the responsibility to protect public safety**.**

A18-01: The Department of Transport require the mandatory installation of lightweight flight recording systems by commercial operators and private operators not currently required to carry these systems.

A18-02: The Department of Transport collaborate with air operators and airport authorities to identify locations where there is inadequate de-icing and anti-icing equipment and take urgent action to ensure that the proper equipment is available to reduce the likelihood of aircraft taking off with contaminated critical surfaces.

A18-03: The Department of Transport and air operators take action to increase compliance with Canadian Aviation Regulations subsection 602.11(2) and reduce the likelihood of aircraft taking off with contaminated critical surfaces.

* On 01 June 2019, regulations amending the *Canadian Aviation Regulations* (Parts I, V, and VI – ELT) were published in the *Canada Gazette*, Part I, Volume 153, Number 22.

6.6.2 New TSB recommendations

6.6.2.1 Eliminating the acceptance of unsafe practices

This SII highlights what types of unsafe practices have been happening for years and continue to happen: from flying overweight to flying in marginal weather to flying with inadequate fuel reserves. Deviations from standard operating procedures, company policy, procedures, regulations, or safe practices can result in outcomes similar to those that have contributed to numerous accidents and incidents over the years.

At the same time, though, the safety margin built into these operations may allow an unsafe flight to be completed successfully. When operations are conducted successfully with a reduced safety margin, this may lead to an acceptance of unsafe practices and make it difficult to know how much of the safety margin has been eroded.

An important step in raising the bar on safety in air-taxi operations is getting clients, passengers, and operators not to accept unsafe practices even when there seems to be a sufficient safety margin, and to speak up to prevent them from happening. This requires strategies, promotion and education to change values, attitudes and behaviours, which will eventually result in a change of culture.

Safety culture is defined as the way safety is perceived, valued, and prioritized in an organization. Establishing a positive safety culture has many challenges; however, it is a necessary first step in creating the values, attitudes and behaviours required for operators to effectively manage the risks associated with their operations. In practical terms, a positive safety culture can in part be built or supported by proactive safety management.

The evidence of this change in culture will be an operation that supports and reinforces PDM/CRM practices through a strong company culture, including support for decision making by managers, supervisors, and peers. Supportive influences and actions from all stakeholders can help operators prioritize safety and manage risks to an acceptable level. But to do this, time and resources must be invested *before* the flight, and investments must be made as part of increasing safety pressures through training and education, company-wide safe decision making, the use and support of PDM/CRM practices, and safety management that includes a culture of operating safely. To be effective, all this must be done with the knowledge of the operating context of air-taxi operations and the hazards and risk factors specific to this sector.

The emphasis now needs to be on using a positive safety culture and proactive safety management to increase safety pressure that will eventually lead to a culture where unsafe practices are considered unacceptable.

Therefore, the Board recommends that

> the Department of Transport collaborate with industry associations to develop strategies, education products, and tools to help air-taxi operators and their clients eliminate the acceptance of unsafe practices.
>
> **TSB Recommendation A19-02**

6.6.2.2 Promoting proactive safety management processes and a positive safety culture

In recent years, organizations such as the Floatplane Operators Association, the Air Transport Association of Canada (ATAC), the Helicopter Association of Canada (HAC), , the Medallion Foundation, the Federal Aviation Administration (through its Circle of Safety program), and the Tour Operators Program of Safety have come together to improve safety in sectors with a high number of accidents. The initiatives they have organized go beyond the regulations and set high standards for members. These initiatives can provide a roadmap for improving safety in the air-taxi sector in Canada (Appendix D), and participation by operators can also provide confidence and incentives for clients and passengers.

As these initiatives show, associations within the air-taxi sector are well positioned to influence safety within the sector. They have a responsibility to their members and the industry and can play a role in positively influencing the 3 competing pressures described in this SII. Industry associations can provide seminars, training and tools, as well as documentation and guides. As an example, industry associations have worked together successfully in the past to address a critical shortage of skilled personnel in the Canadian aviation maintenance industry.[265]

In 2016, the TSB recommended that TC require all commercial aviation operators in Canada to implement a formal safety management system (SMS).[266]

An SMS is generally defined as a formalized framework for integrating safety into an organization's daily operations, including the necessary organizational structures, accountabilities, policies and procedures, so that "it becomes part of that organization's culture, and of the way people go about their work." While individual employees routinely make decisions about risk, SMS focuses on organizational risk management, yet includes and supports the decision makers at the sharp end. An SMS is scalable and can be designed to meet the needs of a given operation in a way that respects the nature of the sector.

In advance of an SMS regulation, associations can play an important role in making available and accessible to operators, modern promotion and education products and tools on safety culture and proactive safety management that will advance safety in their operations. This

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[265] The Canadian Aviation Maintenance Council was formed in 1991 to undertake this work. The Council changed its name to the Canadian Council for Aviation & Aerospace in 2010 to reflect the fact that its work has expanded to other areas of the aviation and aerospace industry. (Source: Canadian Council for Aviation & Aerospace, "CCAA History", at https://www.avaerocouncil.ca/en/about/ccaa-history (last accessed 07 October 2019).

[266] TSB Recommendation A16-12.

will foster the development of a culture of operating safely that is supported by all stakeholders.

Many operators belong to a variety of associations, such as the Air Transport Association of Canada (ATAC), the Helicopter Association of Canada (HAC), the Association Québécoise du Transport Aérien (AQTA), the Floatplane Operators Association (FOA), and the Northern Air Transport Association (NATA). Such associations could provide a venue for sharing best practices, tools, and safety data specific to air-taxi operations. They could also provide assistance and training in implementing proactive safety management that incorporates a positive safety culture.

Therefore, the Board recommends that

> Industry associations (e.g., ATAC, HAC, AQTA, FOA, NATA) promote proactive safety management processes and safety culture with air-taxi operators to address the safety deficiencies identified in this safety issue investigation through training and sharing of best practices, tools, and safety data specific to air-taxi operations.
>
> **TSB Recommendation A19-03**

6.6.2.3 Closing gaps in the air-taxi regulatory framework

The hazards and risks in air-taxi operations have persisted over many years, with data directly showing the persistence of operational hazards from 1998 to 2015. The SII has illustrated that regulations and standards alone cannot guarantee safety in the sector, but they do provide necessary controls that contribute to safety in the sector. That said, there are gaps in this regulatory framework, namely with regard to training and qualifications, improvements to older aircraft, and fatigue in aircraft maintenance engineers (AMEs).

6.6.2.3.1 Training and qualifications

The CARs set out the required training for operators, but the actual training provided can vary widely, as operators observed. While some operators provide training only to a level that meets the requirements in the regulations, others provide extra training beyond the requirements to address needs and/or to derive benefits that mitigate risk in their operation. However, several operators mentioned that without updated regulations and standards forcing all operators to work under the same rules, the playing field is not level.

Although Subpart 703 of the CARs has mandatory training requirements for certain specialized operations, such as night flying, there are no such requirements for many other specialized operations such as mountain flying and coastal flying. There is also no regulation addressing line indoctrination for air-taxi operations. Mandatory training requirements may therefore be inadequate to meet the many unique aspects of air-taxi operations. Without the requirement for specialty training for high-risk operations, pilots may lack the knowledge and skills to ensure safe flight operations.

Furthermore, pilots conducting medical evacuation operations would benefit from specialized training to help them manage the psychological and traumatic challenges of this type of operation.

The qualifications of key personnel within an air-taxi operation were also identified in the SII as a potential issue. TSB investigations from the study period showed that key positions (e.g., operations manager or chief pilot) do not appear to be given sufficient attention when the regulator approves the appointment of individuals to these positions. More attention needs to be given to an individual's credentials and qualifications, as well as the operational requirements for the key positions at the operator. Furthermore, although there are regulatory requirements relating to the roles and responsibilities that these key positions must fulfill, there are no training requirements for individuals appointed to these positions.

6.6.2.3.2 Improvements to older aircraft

The SII also identified the difficulty in making improvements to older aircraft such as installing new avionics because it would require a change to the original aircraft type design. The approval process required by TC requires a supplemental type certificate to be developed, which can be a costly and burdensome process; for some smaller operators, the costs may be prohibitive.

6.6.2.3.3 Fatigue in aircraft maintenance engineers

The industry consultations revealed that AMEs often experience fatigue when working, especially when they are working in a remote location or away from their main base. Duty days can be long, and duty-day hours for AMEs are not subject to TC's regulations. Some operators stated that duty days for AMEs are often not defined by operators and that AME duty-day regulations are required.

6.6.2.3.4 Closing the gaps

Some operators have identified gaps in the existing regulations and standards. Some operators' recommended practices go beyond the current regulatory requirements or include concepts that are not yet addressed by regulations, for example

- carrying out all flights under instrument flight rules
- using 2 pilots for all operations
- establishing their own minimum requirements for pilot flight experience

However, in the face of the competing pressures illustrated by the safe operating envelope model, operators may choose to simply comply with the regulations even though exceeding them would increase safety pressure (e.g., limiting training expenses by providing only the training required by regulation, even when specialized mountain or survivability training would mitigate risks associated with the operation). As long as gaps, such as the ones identified in the SII exist in the regulatory framework, there will be an uneven level of safety in the air-taxi sector.

Therefore, the Board recommends that

> the Department of Transport review the gaps identified in this safety issue investigation regarding Subpart 703 of the *Canadian Aviation Regulations* and associated standards, and update the relevant regulations and standards.
>
> **TSB Recommendation A19-04**

6.6.2.4 Collecting activity data specific to the air-taxi sector

A key indicator of aviation safety is the aircraft accident rate, which is calculated as the number of accidents per hours flown or per number of movements (a movement can be a takeoff or a landing). Performing a trend analysis of accident rates for different types of operators can detect emerging safety issues associated with specific operator types and activities. In addition, accident rate data makes it possible to compare accident risk for different operator types, in different countries or on different continents. For example, the U.S. Federal Aviation Administration (FAA) compiles scheduled and non-scheduled flight hours and departures under Title 14 *Code of Federal Regulations* (CFR). Operators governed by Part 135 of Title 14 CFR include on-demand carriers, which are similar to Canadian air-taxi operators. The U.S. National Transportation Safety Board (NTSB) uses these activity data to compute accident rates and fatal accident rates across sectors.

Activity data (e.g., flight hours) broken out by operator type[267] is required to calculate the accident rates that enable trend analysis of specific operator types over time, or comparisons across operator types or geographical regions.

Until 2010, TC provided activity data broken out by operator type, and the TSB used these data to calculate and publish accident rates across operator types. In 2010, however, TC informed the TSB that it would no longer provide hours-flown activity data breakouts by operator type, because it had concerns regarding the accuracy of those data. The data were reported to TC by the commercial operators who were allowed to report all hours under the most restrictive subpart of the CARs, even if they conducted operations under more than one subpart.

Reporting all hours for all subparts under a single total conflates and confounds airline and commuter activity, as well as the activity of many smaller aviation operators that may carry out operations under multiple subparts of the CARs (commuter, air taxi, and/or aerial work) and report their activity as a single total. Furthermore, the movement data as presently reported by Statistics Canada[268] come from a survey that covers all aircraft movements at Canadian airports, with or without NAV CANADA air traffic control towers and flight service stations. Air-taxi operations are conducted at these locations, as well as in

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[267] The operator types in the CARs are as follows: airline operations (Subpart 705), commuter operations (Subpart 704), air-taxi operations (Subpart 703), aerial work (Subpart 702), foreign air operations (Subpart 701), and private operators (Subpart 604).

[268] Statistics Canada, "Aircraft Movement Statistics," at http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=2715 (last accessed on 07 October 2019).

locations such as lakes, unprepared landing sites, remote locations, etc. where movements are not recorded by air traffic service providers.

Because hours-flown and movement data are currently not categorized by CARs subpart when collected by the government, the rate data calculated is for the commercial aviation sector as a whole; there is no differentiation between sectors (e.g., air-taxi operators versus airline operators) or between different types of aircraft (airplane, helicopter, floatplane). Therefore, the accident rate cannot be calculated for just the air-taxi sector.

Without hours-flown and movement data that are categorized by CARs subpart and aircraft type, it will be more difficult for sector stakeholders to assess risks and determine if mitigation strategies being carried out to improve safety are actually working.

Therefore, the Board recommends that

> the Department of Transport require all commercial operators to collect and report hours flown and movement data for their aircraft by *Canadian Aviation Regulations* subpart and aircraft type, and that the Department of Transport publish those data.
>
> **TSB Recommendation A19-05**

This report concludes the Transportation Safety Board of Canada's investigation into this safety issue. The Board authorized the release of this report on 18 September 2019. It was officially released on 07 November 2019.

Visit the Transportation Safety Board of Canada's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

APPENDICES

Appendix A – Table of air safety and air-taxi studies and reports reviewed

Study	Issue
Office of the Auditor General of Canada, 2017 Spring Reports of the Auditor General of Canada, Report 6: Civil Aviation Infrastructure in the North—Transport Canada (2017)	• Infrastructure and funding (includes northern airport infrastructure and lack of aerodrome support)
Transport Canada, Follow-up Audit of Civil Aviation (2016)	• Database systems • Inspector training
Office of the Auditor General of Canada, 2012 Spring Report of the Auditor General of Canada, Chapter 5: Oversight of Civil Aviation—Transport Canada (2012)	• Transition to SMS (includes regulatory framework) • TC oversight
Transport Canada Float Plane Safety Study (2010)	• Pilot and occupant survivability • Overturning of floatplanes • Inconsistent use of shoulder harnesses • Lack of PFDs • Stall accidents involving DHC-2 Beaver aircraft
Office of the Auditor General of Canada, 2008 May Report of the Auditor General of Canada, Chapter 3: Oversight of Air Transportation Safety—Transport Canada (2008)	• Transition to SMS (includes regulatory framework)
Transport Canada Safety Study on Risk Profiling the Air Taxi Sector in Canada (2007)	• Weather (includes deficiencies in weather briefing facilities, difficulty in obtaining weather information, serious shortcomings in the permissible weather minima for VFR flight, and industry practices) • Limitations in aircraft equipment (includes communication equipment) • Infrastructure and funding (includes northern airport infrastructure and lack of aerodrome support) • Operating pressures (includes competition, client pressures) • Inadequate management of pilot resources • The itinerant nature of employment in the air-taxi sector
Transport Canada Safety of Air Taxi Operations Task Force (1998)	• Decision making and human factors • Training (includes flight training units) • Weather (includes deficiencies in weather briefing facilities, difficulty in obtaining weather information, serious shortcomings in the permissible weather minima for VFR flight, and industry practices) • Operating pressures (includes competition, client pressures) • Airworthiness • Communication • Management • Navigation • Operating problems • Statistics • TC

TSB Lessons Learned from Investigations of Helicopter Accidents (2005)	• Decision making and human factors • Loss of visual reference (includes regulatory limits) • Mechanical causes
TSB Safety Study of Survivability in Seaplane Accidents (1994)	• Pilot and occupant survivability • Hazard of operating aircraft from water
TSB Safety Study of Piloting Skills, Abilities and Knowledge in Seaplane Operations (1993)	• Decision making and human factors • Pilot skills • Pilot knowledge • Pilot techniques
TSB Safety Study on VFR Flight into Adverse Weather (1990)	• Training (includes flight training units) • Weather (includes deficiencies in weather briefing facilities, difficulty in obtaining weather information, serious shortcomings in the permissible weather • minima for VFR flight, and industry practices) • Pilot skills • Limitations in aircraft equipment (includes communication equipment) • Serious shortcomings in pilot licence privileges
House of Commons Standing Committee on Transport, Infrastructure and Communities (SCOTIC), *Aviation Safety in Canada* , (2017)	• Training (includes flight training units) • Transition to SMS (includes regulatory framework) • TC oversight • Infrastructure and funding (includes northern airport infrastructure and lack of aerodrome support) • Fatigue • Responding to TSB recommendations • Air safety review of the entire system
Office of the Chief Coroner of British Columbia, *Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations On British Columbia's Coast, Report to the Chief Coroner of British Columbia* (2012)	• Decision making and human factors • Limitations in aircraft equipment (includes communication equipment) • Loss of visual reference (includes regulatory limits) • Pilot and occupant survivability • Flight following • Dissemination of safety information
N. A. Mode, M. B. O'Connor, G. A. Conway and R. D. Hill, "A Multifaceted Public Health Approach to Statewide Aviation Safety" (2012), a public health initiative for Alaska air-taxi and commuter operations (2012)	• Controlled flight into terrain
Federal Aviation Administration, Aviation Safety, Alaskan Region, *Fatal and Serious Injury Accidents in Alaska – A Retrospective of the years 2004 through 2009 with Special Emphasis on Post Crash survival* (2010)	• Decision making and human factors • Training (includes flight training units) • Pilot skills • Pilot and occupant survivability • Violations • Perceptual error • Technological solutions
D. M. Bensyl, K. Moran, and G. A. Conway, "Factors associated with pilot fatality in work-related aircraft crashes, Alaska, 1990–1999" (2001)	• Pilot and occupant survivability

Appendix B – List of active TSB recommendations that are applicable to the air-taxi sector

Number	The Transportation Safety Board of Canada recommends that…	Investigation report	Rating (at September 2019)
A90-84	the Department of Transport require all commercially-operated helicopters to be equipped with appropriate instrumentation for the conduct of basic instrument flying.	90-SP002	Unsatisfactory
A13-03	the Department of Transport require that all seaplanes in commercial service certificated for 9 or fewer passengers be fitted with seatbelts that include shoulder harnesses on all passenger seats.	A12O0071	Unsatisfactory
A15-01	the Department of Transport require commercial air carriers to collect and report, on a routine basis, the number of infants (under 2 years old), including lap-held, and young children (2 to 12 years old) travelling.	A12Q0216	Satisfactory intent
A15-02	the Department of Transport work with industry to develop age- and size-appropriate child restraint systems for infants and young children travelling on commercial aircraft, and mandate their use to provide an equivalent level of safety compared to adults.	A12Q0216	Satisfactory intent
A16-01	the Department of Transport require all Canadian-registered aircraft and foreign aircraft operating in Canada that require installation of an emergency locator transmitter (ELT) to be equipped with a 406 MHz ELT in accordance with International Civil Aviation Organization Standards.	A13H0001	Satisfactory intent
A16-02	the International Civil Aviation Organization establish rigorous emergency locator transmitter (ELT) system crash survivability standards that reduce the likelihood that an ELT system will be rendered inoperative as a result of impact forces sustained during an aviation occurrence.	A13H0001	Satisfactory intent
A16-03	the Radio Technical Commission for Aeronautics establish rigorous emergency locator transmitter (ELT) system crash survivability specifications that reduce the likelihood that an ELT system will be rendered inoperative as a result of impact forces sustained during an aviation occurrence.	A13H0001	Satisfactory intent
A16-04	the European Organisation for Civil Aviation Equipment establish rigorous emergency locator transmitter (ELT) system crash survivability specifications that reduce the likelihood that an ELT system will be rendered inoperative as a result of impact forces sustained during an aviation occurrence.	A13H0001	Satisfactory intent
A16-05	the Department of Transport establish rigorous emergency locator transmitter (ELT) system crash survivability requirements that reduce the likelihood that an ELT system will be rendered inoperative as a result of impact forces sustained during an aviation occurrence.	A13H0001	Satisfactory intent
A16-06	Cospas-Sarsat amend the 406-megahertz emergency locator transmitter first-burst delay specifications to the lowest possible time frame to increase the likelihood that a distress signal will be transmitted and received by search-and-rescue agencies following an occurrence.	A13H0001	Satisfactory intent

A16-07	the Department of Transport prohibit the use of hook-and-loop fasteners as a means of securing an emergency locator transmitter to an airframe.	A13H0001	Satisfactory intent
A16-08	the Department of Transport amend the regulations to clearly define the visual references (including lighting considerations and/or alternate means) required to reduce the risks associated with night visual flight rules flight.	A13H0001	Satisfactory intent
A16-09	the Department of Transport establish instrument currency requirements that ensure instrument flying proficiency is maintained by instrument-rated pilots, who may operate in conditions requiring instrument proficiency.	A13H0001	Satisfactory intent
A16-10	the Department of Transport require terrain awareness and warning systems for commercial helicopters that operate at night or in instrument meteorological conditions.	A13H0001	Unable to assess
A16-12	the Department of Transport require all commercial aviation operators in Canada to implement a formal safety management system.	A13H0001	Unable to assess
A16-13	the Department of Transport conduct regular SMS assessments to evaluate the capability of operators to effectively manage safety.	A13H0001	Satisfactory in part
A16-14	the Department of Transport enhance its oversight policies, procedures and training to ensure the frequency and focus of surveillance, as well as post-surveillance oversight activities, including enforcement, are commensurate with the capability of the operator to effectively manage risk.	A13H0001	Satisfactory in part
A17-01	the Department of Transport require all commercially operated DHC-2 aircraft in Canada to be equipped with a stall warning system	A15Q0120	Unable to assess
A17-02	the Department of Transport, in collaboration with the Canadian aviation industry and employee representatives, develop and implement requirements for a comprehensive substance abuse program, including drug and alcohol testing, to reduce the risk of impairment of persons while engaged in safety-sensitive functions. These requirements should consider and balance the need to incorporate human rights principles in the *Canadian Human Rights Act* with the responsibility to protect public safety.	A15P0081	Satisfactory in part
A18-01	the Department of Transport require the mandatory installation of lightweight flight recording systems by commercial operators and private operators not currently required to carry these systems.	A16P0186	Satisfactory in part
A18-02	the Department of Transport collaborate with air operators and airport authorities to identify locations where there is inadequate de-icing and anti-icing equipment and take urgent action to ensure that the proper equipment is available to reduce the likelihood of aircraft taking off with contaminated critical surfaces.	A17C0146	Satisfactory intent
A18-03	the Department of Transport and air operators take action to increase compliance with Canadian Aviation Regulations subsection 602.11(2) and reduce the likelihood of aircraft taking off with contaminated critical surfaces.	A17C0146	Satisfactory intent

Appendix C – Grounded theory study

Theoretical background and qualitative research

A qualitative research method was selected for this research project. Qualitative research, broadly defined, means "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification."[269] Qualitative methods allow phenomena to be studied in natural settings and can be used to gain new perspectives in areas where much is already known, or to provide additional information that would be difficult to convey quantitatively.[270] It is focused on the qualities of the phenomenon, rather than the quantities. There is no overarching goal to identify or isolate specific or certain causes; rather, it is well suited to describing and explaining interrelationships between many factors that cannot be experimentally isolated.

The qualitative method consists of a set of interpretive practices that make the world visible to others. This approach acknowledges the role that the researcher plays. It tends to make use of field studies, in naturalistic settings, where there is little control over variables, and where sampling is driven not by the need for a representative sample, but rather by a need to identify as many instances of a topic and their interrelationships as possible, with the aim of generating a description or theory. This process begins with a set of observations (i.e., description) and moves on to develop theories of these observations.[271] This is in contrast to more traditional research methods where the researcher begins with a theory, and using the theory, the research predicts how things will be in the real world and goes and tests that theory.

Grounded theory

Grounded theory is a general method of constant comparative analysis using a systematically applied set of research methods to generate a theory or description about an area. The aim of the research is to understand a substantive area from the point of view of the people involved. Theory or description is generated from the data and is then illustrated by using characteristic examples directly from the data.[272]

Data are analyzed using exploratory coding. As the theory begins to be generated, more data are analyzed until the theory "matures" and it appears that saturation of data (or near saturation) has been reached. At this point the theory is written up and presented.

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269 J. Corbin and A. Strauss, Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory, 4th edition (Sage Publications, 2015), pp. 4–5.

270 Ibid.

271 L. Donati, "Human Factors in the Field: A Field Study of Accident Investigation at the Transportation Safety Board of Canada," (PhD dissertation, University of Toronto, 2003), p. 9.

272 Ibid., p. 10.

Saturation of data is considered to be reached when similar instances are seen over and over again, and looking for new information to stretch the diversity of the data does not yield new properties.[273]

> While grounded theory is primarily an inductive method, it involves alternating between inductive and deductive logic as the research progresses. It begins as a theory is induced (emerges), after data collection and analysis begins. This initial analysis involves coding the collected information. Coding of data and comparison between cases allows the research to move from the specifics of each individual case, through coding, to a more general theory. Deductive logic is used to derive conceptual guidance as to where to go next in order to sample for more data to further develop the theory. The focus of deduction in grounded theory is more on deriving comparisons for discovery, rather than on deriving hypotheses for verification (though this may occur as a by-product). In essence, the coding scheme drives the development of theory through induction, and the developing theory in turn drives further sampling and coding through deduction.[274]

Sample and data collection

The primary data source for this analysis is the final documentary evidence (i.e., published class 2 and 3 TSB aviation investigation reports from the study period). The content of these reports was coded by a team of senior Air Branch investigators following a general protocol, and then further coded and themed by a team consisting of the investigator-in-charge (IIC) and a senior human factors investigator to develop a theory/description. The levels of coding and analysis followed an exploratory process that made use of the constant comparative method of data analysis. A theory/description was developed about the common hazard and risk factors and mitigations planned or employed in air-taxi accidents and incidents for a 15-year period (2000–2014).

Data analysis and theory generation

The following questions guided the constant comparison of cases (aviation accidents and incidents investigated as Class 2 or 3):

- What unsafe acts (errors) and unsafe conditions (threats) are causing and contributing to incidents and accidents?
- How are errors and threats being managed or mismanaged?
- What mitigations (recommended, actual, and new) are involved in managing these hazard and risk factors?
- Are there patterns of factors for given accident types?
- Are there patterns of factors for fatal accidents?
- Are there patterns of factors for reducing harm (e.g., regulations, technology, procedures, and training)?

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273 Ibid., pp. 11–12.

274 Ibid., p. 12.

- How do airline operations and commuter operations “as designed” and regulatory requirements compare to air-taxi operations “as designed” and regulatory requirements and how do these factors relate to the patterns for incidents and accidents and fatal accidents?
- How do air-taxi operations “as designed” and regulatory requirements compare to actual air-taxi operations?

Constant comparative process for safety issues investigation into air-taxi operations

Preparation Part 1: Develop database to manage occurrence SII summary information

1. Take hand-written table and enter into MS Excel
2. Take MS Excel table and enter into MS Access
3. Enter (4) test occurrences into MS Access database
4. Test table view and report view with IIC
5. Refine field list with IIC

Preparation Part 2: Examine interrater reliability of investigators assigned to summarize TSB reports

1. Assign 2 reports
2. Mark start time
3. Save Coding File GT Test1 xx.docx with initials in place of xx
4. Read the SUMMARY, FINDINGS as to CAUSAL and CONTRIBUTING FACTORS, FINDINGS as to RISK, and RECOMMENDATIONS (if available) for report
5. Code the first 8 columns
6. Read the rest of the report (Other Factual/Factual and Analysis)
7. Summarize the rest of the report in point form or highlight information you think is relevant to the study
8. List additional information succinctly in the last column
9. Mark end time
10. Repeat for second report
11. Compare results across investigators and refine protocol as necessary to obtain similar summaries

Actual Coding 1: Organize and summarize the content data for each occurrence number:

1. Assign first set of report numbers (10) to each investigator
2. Read SUMMARY AND FINDINGS AS TO CAUSAL AND CONTRIBUTING FACTORS and FINDINGS AS TO RISK

3. Enter data into database
    a. Summarize FINDINGS AS TO CAUSAL AND CONTRIBUTING FACTORS into either THREATS (CAUSAL AND CONTRIBUTING) or ERRORS (UNSAFE ACTS)
    b. Summarize FINDINGS AS TO RISK into THREATS (RISK)
    c. Summarize RECOMMENDATIONS/SAFETY ACTION TAKEN (if any) into MITIGATIONS
4. Read OTHER FACTUAL, ANALYSIS and any other parts of the report
5. Fill in all the other database fields
6. Classify the occurrence type with the International Civil Aviation Organization (ICAO) CATEGORY
7. Fill in OTHER INFO with summary of key information
    a. Please think about SHEL when doing this and ensure details are included about weather, technology onboard (e.g. TAWS), procedures, training, company management, clients, regulations, regulatory oversight, flight hours (e.g. total, on type, in conditions), decision making, coordination, dispatch, risk analysis)
8. Save record
9. Update IIC's master input list indicating record complete

Actual Coding Step 2: Code the occurrence study summaries for its major categories of information

1. Print and group occurrence summaries by:[275]
    - FW [fixed-wing, or aeroplane] and RW [rotor wing, or helicopter]
    - Within FW and RW groups by accident title
2. Code occurrence study summaries (use open coding and/or be guided by Glaser (1978)[276] codes referenced by Donati (2003) in appendix [Table B1])
    - Coding entails physically marking codes on the margins of hard copy occurrence study summaries
    - Initial codes will be marked by the researchers on the occurrence study summaries
    - While the starting points for coding are visible instances of a phenomenon, it is the exceptions to the rule which cue the research to probe further and understand the constraints acting on the system and the manner in which actors have adapted, through the strategies they have developed, thus providing a richer understanding of the phenomenon
3. Theme codes

[275] The data have already been preliminarily coded by hazard and risk factors ("Causal and Contributing Factors"), by operational context ("Summary") and by other information ("Other Factual"). This grouping activity is practical at this point, and group comparisons were made at a later step in the analysis.

[276] B. G. Glaser, Advances in the Methodology of Grounded Theory: Theoretical Sensitivity (The Sociology Press, 1978).

- The same data also give rise to themes, where themes are the bringing together of several codes. An attempt here is made to identify initial codes and themes relevant to the individuals involved, and not based on an a priori scheme
- The second level of comparison is to compare themes and field data. As the analysis progressed, new properties of the themes, and hypotheses were generated to further drive the data analysis and coding. At this point, Glaser's (1978) coding schemes were applied where appropriate to help organize themes and to generate new questions to explore the data further. A subset of Glaser's (1978) schemes are listed in the appendix

4. Use memos[277] (and diagrams of memos) to build an early theory (description) of the hazard and risk factors in air-taxi accidents
5. Compare memos in order to establish what the interrelationships were between the various themes
6. Refine the theory (description) of the hazard and risk factors in 703 air-taxi accidents

Actual Coding Step 3: Compare across sub-groups (i.e. FW/RW and accident title) to build a more general theory of hazard and risk factors

1. Compare the hazard and risk factors (theories/descriptions) across sub-groups
2. Refine again and strive for a more generalizable theory (if this makes sense)
3. Are any of the theories consistent with existing understanding of human and organizational performance?

Actual Coding Step 4: Validate the theory or theories of hazard and risk factors associated with 703 air-taxi operations with industry knowledge and experience

1. Document theory or theories in publicly accessible format
2. Present to industry
3. Obtain feedback
   a. Compare against near misses, non-reportable incidents, other events or activities
   b. Have operator safety programs or processes identified these hazard and risk factors?
   c. What other hazard and risk factors have operator safety programs or processes identified?
   d. How are operators mitigating these hazard and risk factors?
   e. What additional mitigations are needed?
4. Apply grounded theory method on data from industry consultation sessions
5. Refine theory or theories

[277] Memos are processes of themes or themes organized together into a description or process of the phenomenon being studied.

6. Write report
7. Publish report

Sampling error

The following elements relate to sampling error:

- Insufficient breadth in sampling and theoretical saturation
- Cases selected from within a subset of the larger population through the TSB's *Policy on Occurrence Classification*
- Distortions introduced by changes in the subject matter being studied over time
- Distortions caused by lack of depth in data collection, depending on the occurrence

Generalizability of results

Care has been taken to collect and document well the context of the operations that have involved accidents (e.g., aircraft type, weather, type of operation, location). The results should be generalizable where contextual factors are similar.

Table B1. Coding schemes, per Glaser (1978) and Donati (2003)

Title	Coding scheme
Process	An accident can be viewed as normal work, unfolding in an operational context. The passage of time is linked to the concept of process as process involves getting something done or something happening over a time period. As such, process refers to sequences undertaken at the organizational level, the team level, and the individual level. This can allow for the grouping of various temporal sequences of the phenomena under study.
Dimensions	Categorizing by dimension refers to classifying groups of items from smaller components and sub-components to the whole, or from the whole to its constituent parts, in essence a part-whole hierarchy. For example, a flight can be broken down by phase of flight or by information requirements by phase of flight. The dimension category may assist in building a picture of the work domain (context) and its elements.
Types	Types here refers to the types of hazard and risk factors (threats or unsafe conditions), including errors as the path between the hazard and the outcome, that are involved in occurrences. Type here also refers to the next to last and last events as another 'type'.
Strategies	We are particularly interested in the strategies employed by participants to manage (identify and control) hazard and risk factors (unsafe conditions or threats), errors and outcome events. For example, are we seeing patterns of behavior (strategies) used by some pilots in some contexts that are having negative consequences?
Cultural (Operation)	Are there differences in the occurrences that are related to the different operating contexts and the sub-culture of these groups? Are there similarities?
Goals	In order to further understand the actions of various participants, look at goals where possible. This may have to do with information, pressures, business, safety, etc.

Appendix D – Examples of initiatives to improve safety in the air-taxi sector

Floatplane Operators Association

The Floatplane Operators Association was established to implement a standard level of professionalism and share best practices in the British Columbia floatplane sector, which was perceived by the public to be unsafe. These best practices relate to the themes of survivability, weather, safety management, and training, among others. Examples include establishing policies on the use of personal flotation devices; offering training in underwater egress and in mountain flying; recommending flight only during daylight hours; prioritizing the use of scales at all times to weigh passengers, baggage, and cargo; and conducting line checks on all pilots annually on each type of aircraft.[278]

It is intended that member pilots adhere to both the *Canadian Aviation Regulations* and to FOA best practices, some of which go beyond the regulatory requirements or include concepts that are not yet addressed by regulations.[279]

Medallion Foundation

The Medallion Foundation was formed by the Alaska Air Carriers Association in 2001 to improve safety awareness among pilots and reduce insurance rates for air carriers. At the time the foundation was formed, the Alaska commercial aviation industry was experiencing an unacceptably high accident rate, and the accidents themselves followed a repeated pattern.[280]

The foundation helps members apply the principles of system safety and safety management systems by means of its Shield program. The program consists of 5 areas in which members can achieve certification (a Star rating) by meeting certain organizational, procedural, and training requirements. Members that have met the requirements of all 5 areas are eligible for the Medallion Shield rating.[281]

Benefits of membership in the Medallion Foundation include recognition from government departments such as the U.S. Department of Defense and the Federal Aviation

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278 A full list of the Floatplane Operators Association's best practices can be found at http://www.floatplaneoperators.org/best-practices/ (last accessed on 01 October 2019).

279 T. Parker, "Floatplane Operators Association (FOA) Best Practices," in: Transport Canada, TP 185, *Aviation Safety Letter* (Issue 2/2014), at http://www.tc.gc.ca/eng/civilaviation/publications/tp185-2-2014-6547.html#e (last accessed on 01 October 2019).

280 Medallion Foundation, "History," at http://medallionfoundation.org/title-page/about-medallion/about-us-2/ (last accessed on 05 July 2019).

281 Ibid., "Shield Program," at http://medallionfoundation.org/services-and-programs/five-starshield-program/ (last accessed on 08 July 2019).

Administration "as an operator who incorporates higher standards of safety than required by regulations."[282]

According to the foundation's website,[283] a Centers for Disease Control and Prevention and National Institute for Occupational Safety and Health report found a 57% reduction in controlled flight into terrain accidents between 2000 and 2009.[284] This reduction may be attributable to programs such as the Medallion Foundation's CFIT-Avoidance program, which is part of the Shield program.

Tour Operators Program of Safety

The Tour Operators Program of Safety (TOPS) was formed in 1996 by a group of helicopter air tour operators in the United States. The program was formed in response to a high accident rate and a public perception that the helicopter air tour industry was not concerned about safety.

The program covers 5 areas: company management, pilot qualifications and training, helicopter maintenance, ground support personnel, and aircraft equipment. Operators and contracting organizations are subject to an annual audit in order to remain a member in good standing.[285]

Members have access to materials they can use to improve passenger safety briefings, as well as to materials that can be used to provide human factors and crew resource management (CRM) training geared to tour operators with single-pilot operations. Additional benefits include insurance discounts, endorsements from industry and government organizations, and authorization to display a TOPS logo and plaque to indicate to clients that the operator has undertaken measures to achieve a higher level of safety.[286]

Since TOPS was incorporated in 1996, TOPS members have had a safety record better than that of general aviation.[287]

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282 Ibid.

283 Medallion Foundation, "History," at http://medallionfoundation.org/title-page/about-medallion/about-us-2/ (last accessed on 08 July 2019).

284 N. A. Mode, M. B. O'Connor, G. A. Conway, and R. D. Hill, "A Multifaceted Public Health Approach to Statewide Aviation Safety," *American Journal of Industrial Medicine*, Vol. 55, Issue 2 (February 2012).

285 Tour Operators Program of Safety, "Program Overview," at http://www.topssafety.org/program-overview/ (last accessed on 01 October 2019).

286 Ibid., "Benefits," at http://www.topssafety.org/benefits/ (last accessed on 01 October 2019).

287 Ibid., "TOPS Operator Standards Go Above and Beyond," at http://www.topssafety.org/tops-vs-non-tops-operators/ (last accessed on 01 October 2019).

Federal Aviation Administration

The Federal Aviation Administration's Fly Alaska Safely program has a consumer education component called the "Circle of Safety." The purpose of the Circle of Safety is to educate passengers about their rights and responsibilities, and with company support, arm them with knowledge to be proactive about their own safety when flying.[288]

Passengers' rights include knowing the location of survival equipment and emergency exits, asking questions about how the flight will be conducted, and understanding what bad weather conditions look like. Their responsibilities include paying attention to the safety briefing, accepting decisions to delay or cancel a flight, and not overloading the aircraft.[289]

Helicopter Association International

The Helicopter Association International (HAI) has been promoting Land and Live[290] program to its members. This program is targeted to both pilots and operators, and the aim is to encourage helicopter pilots to land the aircraft before circumstances become hazardous, rather than continuing to operate the aircraft in deteriorating weather, for example, or when fuel is running low. The program provides resources for pilots and operators and asking both pilots and operators to make a pledge to "…affirm that [their] highest priority is the safety of [their] passengers, [their] crew, [their] aircraft, and the people [they] fly over."[291]

Air Transport Association of Canada (ATAC)

ATAC, in collaboration with industry, has developed an SMS toolkit that has been reviewed by Transport Canada. According to ATAC, 70% of operator members have taken advantage of the SMS Toolkit.[292] In addition to the SMS toolkit, ATAC hosts a 3-day workshop, consisting of lectures and hands-on exercises, designed to help members use the SMS Toolkit to establish an SMS program within their operations, while minimizing time and expenses in the implementation process.

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288 Federal Aviation Administration, "What is the Circle of Safety Consumer Education Program?," at https://www.faa.gov/about/office_org/headquarters_offices/arc/programs/fly_alaska/docs/COSltr.pdf (last accessed on 01 October 2019).

289 Ibid., "Circle of Safety Consumer Safety Education," at https://www.faa.gov/about/office_org/headquarters_offices/arc/programs/fly_alaska/docs/brochure.pdf (last accessed on 01 October 2019).

290 Helicopter Association International, "Pledge to Land & Live – Stay Alive," at https://www.rotor.org/initiatives/land-and-live (last accessed 01 October 2019)

291 Ibid.

292 Air Transport Association of Canada, "SMS Toolkit and Workshops," at https://www.atac.ca/web/en/initiatives/sms-toolkit.html (last accessed 01 October 2019).

Helicopter Association of Canada (HAC)

Among the Helicopter Association of Canada's initiatives are publishing and sharing helicopter industry best practices on a variety of topics through its website. At February 2019, the following best practice guides were available:

- HAC Mountain Flying Training Best Practices
- HAC Heliski Training Best Practices
- Pilot Competencies for Helicopter Wildfire Operations
- Helicopter Guidelines for Onshore Seismic Operations
- Utility Flight Operations Guide

Appendix E – Glossary

ACAS	airborne collision avoidance system
ADS-B	automatic dependent surveillance – broadcast
AME	aircraft maintenance engineer
ASIS	Aviation Safety Information System
AWOS	automated weather observation system
CAIRS	Civil Aviation Issues Reporting System
CAP	corrective action plan
CARs	*Canadian Aviation Regulations*
CARAC	Canadian Aviation Regulation Advisory Council
CASS	*Commercial Air Service Standards*
CASO	Company Aviation Safety Officer
CFIT	controlled flight into terrain
CRM	crew resource management
ELT	emergency locator transmitter
FAA	Federal Aviation Administration
FRMS	fatigue risk management system
GPS	global positioning system
ICAO	International Civil Aviation Organization
IFR	instrument flight rules
ILS	instrument landing system
IMC	instrument meteorological conditions
LPV	localizer performance with vertical guidance
MDA	minimum descent altitude
MEDEVAC	medical evacuation
NDB	non-directional beacon
NPA	Notice of Proposed Amendment
PDM	pilot decision making
PFD	personal flotation device
PI	process inspection
PPC	pilot proficiency check
PVI	program validation inspection
RASC	Regional Aviation Safety Council
RNAV	area navigation

SATOPS	Safety of Air Taxi Operations Task Force
SB	service bulletin
SCDA	stabilized constant descent angle
SMS	safety management system
SOP	standard operating procedure
STC	supplemental type certificate
TAWS	terrain awareness and warning system
TC	Transport Canada
TC AIM	*Transport Canada Aeronautical Information Manual*
TCAS	traffic alert and collision avoidance system
TEM	threat and error management
VFR	visual flight rules
VMC	visual meteorological conditions