Raising the bar on safety: Reducing the risks associated with air-taxi operations in Canada (A15H0001)

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Abstract: Safety in the air-taxi sector has been the subject of concern, as well as numerous studies and reviews, for over 27 years. The air-taxi sector, in simple terms, is comprised of smaller aircraft, both helicopters and airplanes, having 9 passenger seats or less providing scheduled and non-scheduled service. It is a challenging sector of commercial aviation, given its complex operating context, and it experiences a high number of accidents, especially fatal ones. In the 15 years between 2000 and 2014, the Canadian air-taxi sector experienced 716 accidents resulting in 227 deaths. These accidents represent 56% of all commercial aviation accidents in Canada and account for 64% of commercial aviation fatalities.

This paper summarizes the results of a recent safety issues investigation conducted by the Transportation Safety Board of Canada (TSB). The investigation examined in detail the state of safety in the air-taxi sector and identified where the safety bar can be raised to reduce the number of accidents, particularly fatal ones. Data were collected, analysed and combined from accident summaries, investigation reports and interviews with industry participants. The highest number of fatalities in both airplane and helicopter air-taxi accidents resulted from flights that started in visual meteorological conditions and continued to a point where the pilot lost visual reference with the ground. There were two key categories of underlying factors: the acceptance of unsafe practices and the inadequate management of operational hazards. Nineteen safety themes were identified from the large dataset. All results were further analysed within a model called the safe operating envelope. Recommendations to address the safety risks in the air-taxi sector are presented.

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Background

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. In 2015 , approximately 550 companies in Canada held an air operator certificate for air-taxi operations.

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:

"…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

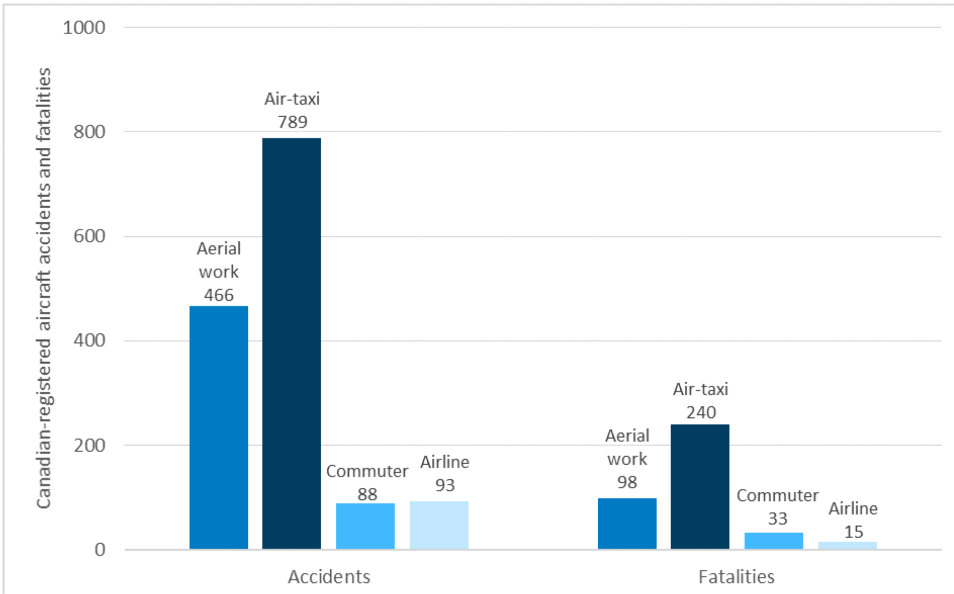
- airline operations (Subpart 705), involving aircraft built to carry 20 or more passengers, generally used for commercial passenger flights;
- commuter operations (Subpart 704), involving aircraft built to carry 10 to 19 passengers, generally used for commercial passenger flights and on-demand charter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

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.

Compared to those who fly for other commercial purposes, air-taxi 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 more severe weather because they are flown 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.

The air-taxi sector has had 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 1).

Figure 1: 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 93 accidents (6% of the total) and 15 fatalities (4% of the total).

The safety issues underlying air-taxi 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.(3)

And yet the air-taxi sector continues to experience a high number of accidents and fatalities. Why these accidents keep happening, and how safety in the sector can be improved is what the TSB's Safety Issue Investigation (SII) into the safety of the air-taxi sector sought to explain. This paper presents a condensed summary of the results of the larger SII.(4)

Method and Results

In the first phase 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. Because activity data in Canada are reported only for commercial aviation as a whole, it is not possible to calculate an accident rate specific to the air-taxi sector.

More insightful was reviewing the TSB investigation reports for 167 (5) of the occurrences from the study period. Using the grounded theory qualitative method (6), investigators categorized accident types based on the circumstances described in the reports. The analysis provided a more precise understanding of how these accidents were happening, andrevealed that the highest number of fatalities in both airplane and helicopter air-taxi 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 between was how the flight ended: in a **loss of control** or a **controlled flight into terrain (CFIT)**.

Figure 2 shows summary statistics for accident types and pilot experience (hours flown) for air-taxi **airplane** occurrences. Of the 476 airplane accidents, the most common 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 by VFR + loss of visual reference + CFIT accidents (26 deaths) for airplanes other than floatplanes.

A pilot's level of experience can affect the risk of being involved in an accident. Pilots who were involved in maintenance-related accidents had an average total flight time of 8657 hours, the highest flight-time average of all accident types. The lowest flight-time average (912 hours) was held by pilots who had been involved in fuel-related accidents.

Figure 2: 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

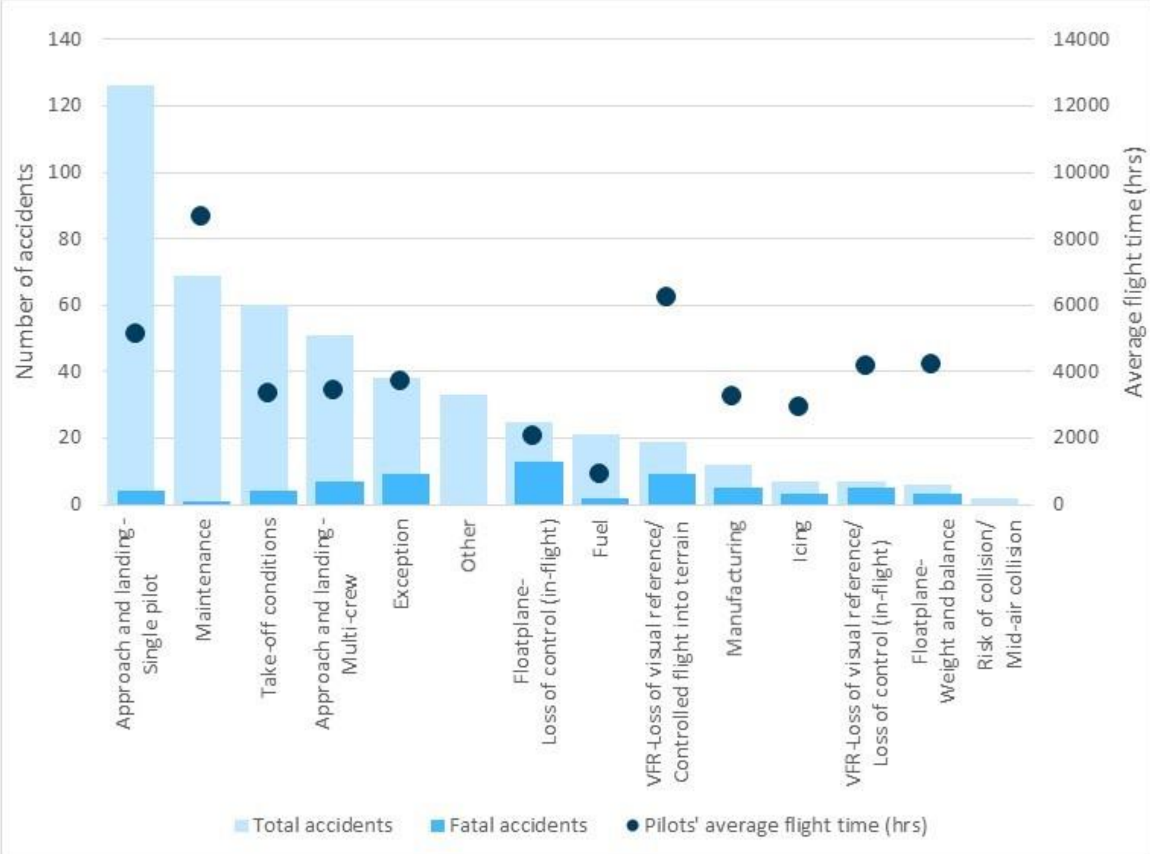


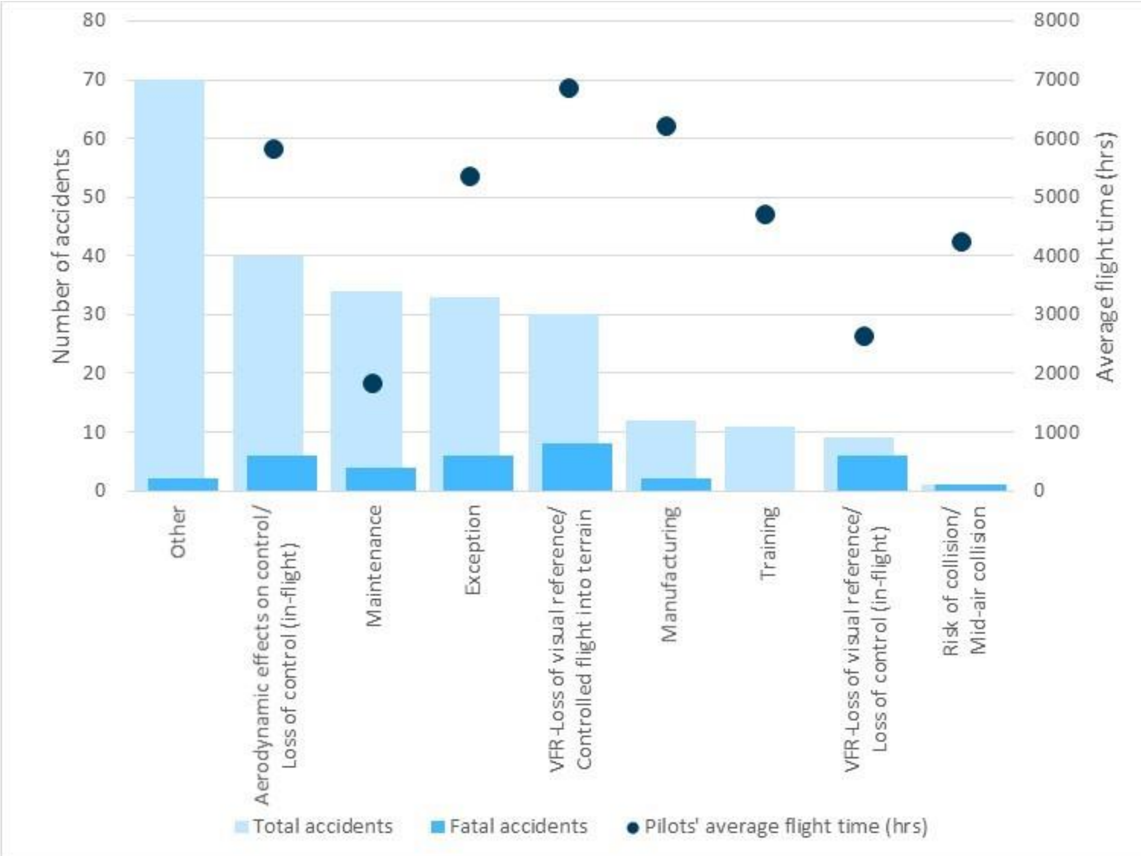
Figure 3 shows summary statistics for accident type and pilot experience (hours flown) for air-taxi **helicopter** occurrences. Of the 240 helicopter accidents, the most common accident types were

- 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 helicopter 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) of all helicopter accident types. Pilots involved in maintenance-related accidents had the lowest average total flight time (1800 hours).

Figure 3: 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



Finally, analysis of the all of the accident data, airplanes and helicopters combined, revealed that the factors contributing to air-taxi accidents fell into 2 key categories:

- **acceptance of unsafe practices** (e.g., flying overweight, flying into forecast 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 pilots involved in these accidents had a combined overall average of **5000** hours of experience. Therefore, it would appear that pilot experience is not necessarily mitigating against these types of accidents. In the air-taxi sector in the past, it was generally believed that the greatest risk of an accident came from inexperienced pilots pushing the limits; however, what emerged from the SII was that accidents involved both inexperienced and highly experienced pilots alike.

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 only for commercial aviation as a whole. Furthermore, movement data are not captured for locations where air-taxi operators are more likely, such as uncontrolled airports, remote locations with unprepared landing sites, or lakes.

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

Using the grounded theory qualitative method, the information from these interviews was analyzed and organized into 19 safety themes . Further analysis within each theme (using accident data, previous studies, and TSB safety recommendations) yielded the conclusions presented in Table 1.

Table 1. Safety themes identified from interviews with air-taxi industry, and corresponding conclusions

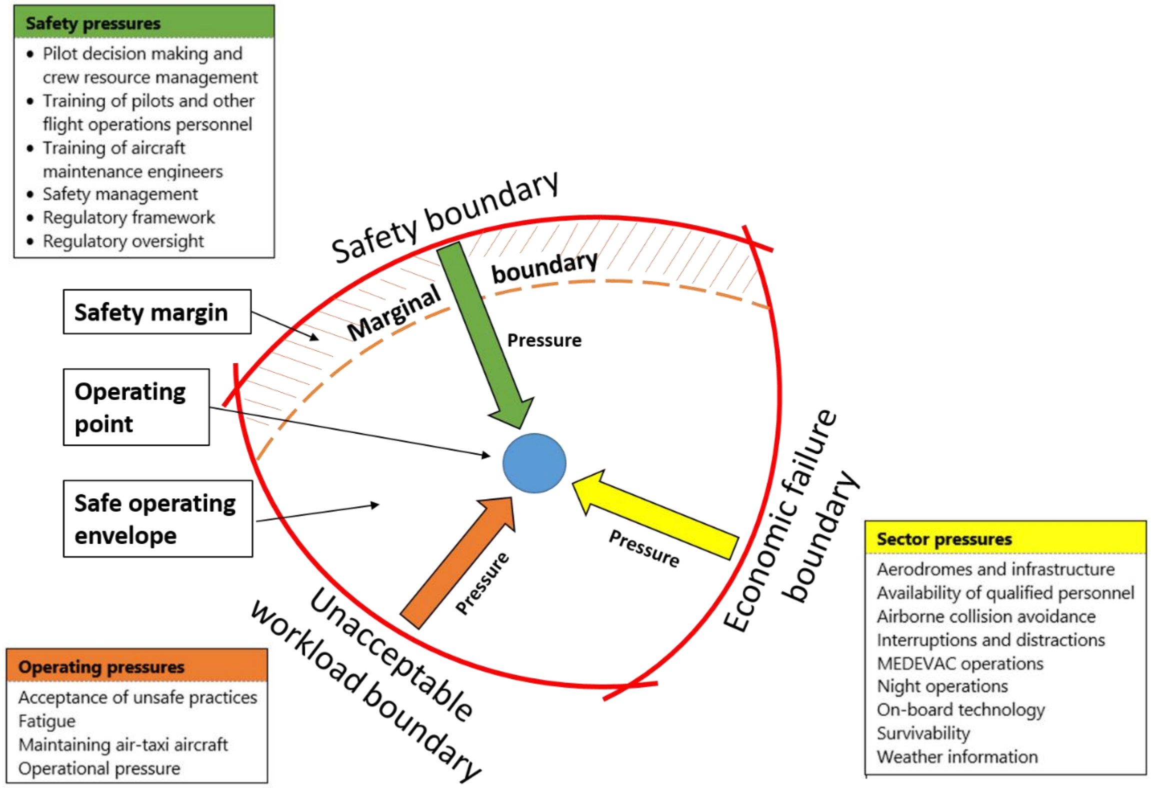
Safety theme	Conclusion
1. Aerodromes and infrastructure	Remote and northern communities of Canada require appropriate aerodrome facilities and infrastructure to ensure that air-taxi operators can provide safe air services for those communities.
2. Availability of qualified personnel	The availability 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, and 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 so it is important to manage it in the air-taxi sector.
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.
14. Pilot decision making (PDM) and crew resource management (CRM)	PDM and CRM are critical competencies that help air-taxi 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.

Safety theme	Conclusion
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 air-taxi 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 air-taxi 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.

Discussion

To understand how these 19 safety themes interact with each other as well as how they connect to the underlying factors of the accident analysis, namely the acceptance of unsafe practices in air-taxi operations and the inadequate management of operational hazards, the investigation team analyzed the safety themes within a model called the **safe operating envelope**. The resultant visual representation (see Figure 4) can be used to help explain the persistence and complexity of the factors contributing to air-taxi accidents.

Figure 4. 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 in Figure 4), 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 (red lines in Figure 4), 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).(7)

The marginal boundary (yellow hatched area in Figure 4) depicts the depth of the safety margin: the fewer or weaker the defences in place, the narrower 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 model, and are influenced by many stakeholders in the air-taxi sector (see Figure 5). In addition to the stakeholders close to the "sharp"-end of the operation, namely the operator and individuals, the regulator and the manufacturers, two other key stakeholders, have very important roles in the safety of air-taxi operations, clients and passengers. Clients, those who pay for air-taxi services or need them for their communities or cities, can influence how air-taxi services are delivered and overseen. As well, passengers on air-taxi flights are much more involved in front-line safety than those on other commercial flights. Safety knowledge imparted to air-taxi passengers can have an important influence in the safe operation of a flight.

The model in Figure 4 shows the interaction among 3 kinds of pressures observed in the data and provides direction for their management on an ongoing basis.

- **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** 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.

In order to raise the bar on safety in air-taxi operations, all stakeholders need to change to a culture where unsafe practices are not accepted. Operating safely has to become the norm.

Figure 5: Stakeholders that have a role to play in the air-taxi sector (Source: TSB)

Increasing the safety pressures has the potential to influence safety in a meaningful way in this sector in Canada. Working with safety as a balancing pressure, rather than merely a cost, can elevate safety in day-to-day operational decisions and risk management.

Recommendations

Practially speaking, the SII concluded that the 22 active TSB recommendations (see full report) 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 PDM and CRM, including single-pilot 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., provide better weather information) and **operating pressures** (e.g., manage fatigue); and
- improve how activity (rate) data are obtained to better evaluate how well safety measures are working.

The TSB issued 4 new recommendations as a result of the SII. These are described next.

An important step in raising the bar on safety in air-taxi operations is getting clients, passengers, crews, and operators to not accept unsafe practices even when there seems to be a sufficient safety margin, and to speak up to prevent unsafe practices from happening.

This requires strategies, promotion, and education tailored to the air-taxi 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**

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**

Some operators interviewed for the SII identified gaps in the existing regulations and standards. Others 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 IFR, 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 specific to 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**

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**

Conclusion

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. Supportive influences from all stakeholders 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**.

In practice, this culture looks like weighing baggage or estimating conservatively, respecting visibility and wind limitations, routinely briefing passengers as if they will have to exit the aircraft in an emergency in water or remote terrain, considering hazards and associated risks during route planning , and asking advice of others. At another level it involves convincing clients, operators, and passengers to not accept unsafe practices, and to speak up if any are observed. This ability requires knowledge and a change of attitude and actions, which will contribute to the needed change in culture.

Another step is making it routine for effective PDM/CRM practices by line pilots to be supported by managers, supervisors, and peers, as well as by a positive safety pressure from clients and passengers. The cultural shift created would spread to other operational personnel, including fellow pilots, maintenance, dispatch, and ground operations. This is a longer-term process that could provide numerous additional defences. Peers have the potential to drive this positive pressure; ask the question "who is the pilot you want to send your family to fly with?". This type of culture is not new: many operators have already developed this culture or operating safely, in the knowledge that it was necessary for their success.

How does a small air-taxi operator practice effective and efficient safety management? Cost, time and pressures for air-taxi flights like MEDEVAC, food supply, transportation of workers, including fire-fighting are always present. 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." (8) It is not necessary for an air-taxi operation to have all of the components of an airline SMS; in fact, this would not be appropriate for the air-taxi context. An SMS, if it is appropriately scaled and designed to support risk management in air-taxi operations, while retaining its core components, can be a proactive means to identify and mitigate hazards on a continuous basis.

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. Additionally, there are many new light-weight recording devices becoming available to air-taxi aircraft that would permit basic flight data monitoring.

The in-depth SII honed the understanding that the complexity of the air-taxi sector and its associated operations means that change must happen from the inside, and from all stakeholders. The ultimate goal is to attain an operational environment where **operational hazards are effectively and proactively managed and unsafe practices are considered unacceptable.**

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

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

3 For the full report, see: https://www.tsb.gc.ca/eng/enquetes-investigations/aviation/2015/a15h0001/a15h0001.html.

4 For the full report, see: https://www.tsb.gc.ca/eng/enquetes-investigations/aviation/2015/a15h0001/a15h0001.html.

5 TSB Aviation Investigation Report A15H0001

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

7 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.

8 J. Reason, Managing the Risks of Organizational Accidents (Ashgate Publishing, 1997).