Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A21P0069

LOSS OF CONTROL AT LIFTOFF AND OVERTURN

Atleo River Air Service Ltd.
Cessna A185F, C-GYJX
Tofino Harbour Water Aerodrome, British Columbia
26 July 2021

Canada

ABOUT THIS INVESTIGATION REPORT

This report is the result of an investigation into a class 3 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.

TERMS OF USE

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Summary

On 26 July 2021, the Atleo River Air Service Ltd. Cessna A185F seaplane (registration C-GYJX, serial number 18503187) was conducting a flight from Tofino Harbour Water Aerodrome, British Columbia, to the Hesquiaht First Nation community located at Hot Springs Cove, British Columbia, with 1 pilot and 4 passengers on board. During takeoff at approximately 1138 Pacific Daylight Time, the aircraft momentarily became airborne before control was lost and the aircraft cartwheeled and came to rest inverted in shallow water. The pilot and passengers were able to exit the aircraft onto a sandbar. One passenger received serious injuries; the remaining 3 passengers and the pilot received minor injuries. The aircraft was substantially damaged. No signal was received from the 406 MHz emergency locator transmitter.

1.0 FACTUAL INFORMATION

1.1 History of the flight

On 26 July 2021, the Atleo River Air Service Ltd. Cessna A185F seaplane (registration C-GYJX, serial number 18503187) was scheduled for multiple flights departing from Tofino Harbour Water Aerodrome (CAB4), British Columbia (BC). The first flight of the day was delayed due to fog in the morning.

The pilot arrived at the company base at 0845,[1] reviewed the aircraft journey logbook for defects, and checked the weather conditions from the dock, noting that the winds were calm and the fog was lifting. The pilot completed a pre-flight inspection on the aircraft and confirmed that the floats did not contain any water. He then fuelled the aircraft and confirmed the fuel quantity in the tank using a dipstick.

The flight follower completed the operational flight plan (OFP) for the first flight using volunteered passenger weights and fitted each passenger with a personal flotation device (PFD). The pilot signed off on the OFP and took the passengers down to the dock.

At 0946, after the pre-takeoff checks had been successfully completed, shortly after low tide,[2] and approximately 16 minutes behind schedule due to the fog, the aircraft lined up for a northbound takeoff from CAB4 towards a known sandbar. The local scenic flight had a brief stopover at Megin Lake, BC, located 21 nautical miles (NM) north-northwest of CAB4, and then returned to CAB4 and landed in an east-southeast direction at 1116.

The occurrence flight, which was the second passenger flight of the day, was scheduled for 1100 to transport 4 passengers from CAB4 to the Hesquiaht First Nation community located at Hot Springs Cove, BC. This departure time was also delayed. The flight follower completed the OFP for the second flight using estimated passenger weights and the remaining fuel, as communicated by the pilot. The pilot reviewed and signed off on the OFP before taking the passengers down to the dock. The passengers donned PFDs as the pilot conducted a safety briefing on their correct use, as well as on the aircraft's exits. The pilot loaded the luggage and then allowed the passengers to board, paying close attention to the seat allocation for each person.

At 1136, the aircraft taxied from the company dock and lined up for a northwestbound departure, similar to that of the first flight. The aircraft was configured for a normal takeoff with a flap setting of 20°.[3] The takeoff was temporarily delayed due to boat traffic along the

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1 All times are Pacific Daylight Time (Coordinated Universal Time minus 7 hours).

2 Canadian Hydrographic Service tide tables for Tofino Station 8615 on 26 July 2021 indicate a low tide of 0.2 m at 0917. (Source: Fisheries and Oceans Canada, Tides, Currents, and Water Levels, Tofino - 08615, at https://www.waterlevels.gc.ca/en/stations/08615/2021-07-26?tz=PDT [last accessed 13 September 2022]).

3 Robertson Aircraft Corporation, Pilot's Operating Handbook 10-6, *Robertson Aircraft Corporation Pilot's Operating Handbook Supplement For Cessna Model A185F Skywagon Serial Numbers 18502839 and Up* (18 July 1977), section 4: Normal Procedures, p. 3.

chosen take-off path and, once the path was clear of boat traffic, the pilot started the take-off run.

During the take-off run, the aircraft crossed a boat wake on the water that slowed the aircraft's acceleration. The pilot recognized that a longer take-off run may be required and he initiated an arcing right step-turn in an attempt to reach the deepwater channel marked with 2 marine buoys. At 1138:01, the left float lifted up from the water first followed by the right float and the aircraft became airborne at a low speed while maintaining the right turn. The investigation was unable to determine what initiated the liftoff: a second boat wake or a control input.

The pilot pushed the control column forward and increased flap setting from 20° to 30°. Approximately 5 seconds later, the aircraft abruptly yawed and rolled to the left while simultaneously losing altitude. The floats contacted the water, followed immediately by the left wing tip. The aircraft bounced back to the right, and the right wing tip contacted the water, causing the aircraft to yaw to the right and to skid on the surface of the water. The left float dug into the water, and the aircraft cartwheeled once before coming to rest inverted on the sandbar in approximately 1 foot of water at 1138:10 (Figure 1).

Figure 1. Occurrence aircraft resting inverted on the sandbar approximately 3100 feet northwest of the company dock (Source: Royal Canadian Mounted Police)

The pilot and the 4 passengers were able to egress the aircraft through the left and right cabin doors. The pilot reached back into the aircraft to turn off the master power switch.

Immediately following the occurrence, emergency assistance arrived from a nearby boater, followed by the Canadian Coast Guard. The pilot and passengers were assessed and transported to the Tofino shoreline, where they were taken to the local hospital for further treatment. The passenger seated in the front right seat sustained serious injuries, while the injuries to the remaining 3 passengers and the pilot were minor.

The aircraft was substantially damaged and the remaining fuel was released into the water. No signal was received from the 406 MHz emergency locator transmitter (ELT).

1.2 Injuries to persons

The pilot and 4 passengers were on board the occurrence aircraft. Table 1 presents the summary of injuries.

Table 1. Injuries to persons

Degree of injury	Crew	Passengers	Persons not on board the aircraft	Total by injury
Fatal	0	0	–	0
Serious	0	1	–	1
Minor	1	3	–	4
Total injured	1	4	–	5

1.3 Damage to aircraft

The aircraft was substantially damaged as a result of the impact forces.

1.4 Other damage

Approximately 250 pounds (42 US gallons) of fuel was released into the water.

1.5 Personnel information

The occurrence pilot held the appropriate licence and met the recency requirements for the flight in accordance with existing regulations.

The pilot held an airline transport pilot licence–aeroplane with a seaplane rating and a valid Category 1 medical certificate. The pilot's company and regulatory training were up to date, and a pilot competency check had been completed with a different operator on 15 January 2021 using a Cessna 180 aircraft.

The pilot had previously flown for 2 summer seasons with Atleo River Air Service Ltd. until October 2019. He returned to the operator on 23 July 2021 and flew the occurrence aircraft for a total of 10.7 hours in the 3 days before the occurrence flight. This included the flight conducted earlier the same day.

The pilot had completed underwater egress training prior to the occurrence.

Table 2. Personnel information

Pilot licence	Airline transport pilot licence (ATPL)
Medical expiry date	01 August 2021
Total flying hours	17 010.8

Flight hours on type	8000 (approximately)
Flight hours in the 7 days before the occurrence	10.7
Flight hours in the 30 days before the occurrence	14.7
Flight hours in the 90 days before the occurrence	35.9
Flight hours on type in the 90 days before the occurrence	10.7
Hours on duty before the occurrence	3
Hours off duty before the work period	13

1.6 Aircraft information

The Cessna A185F aircraft is a single-engine, high-wing, all-metal monoplane with an upgraded engine and improved wing profile compared to the original Cessna 185 model. The aircraft is certified to carry 1 pilot and 5 passengers.

The occurrence aircraft was equipped with a Teledyne Continental IO-550-D[4] engine, a 3-bladed McCauley constant-speed propeller measuring 86 inches in diameter, and Aerocet 3500L floats.

The aircraft was maintained in accordance with the company maintenance schedule, which was approved by Transport Canada (TC), and was equipped for the intended flight in accordance with the existing regulations. The last 100-hour inspection had been completed on 14 July 2021 and, at the time of the occurrence, the aircraft had accumulated 47.8 hours since that inspection. There were no known outstanding mechanical defects.

The investigation found no indication of a mechanical issue that would have limited the performance of the aircraft at the time of the occurrence.

The aircraft take-off weight recorded on the OFP was 3374 pounds and within the centre-of-gravity limitations.

Table 3. Aircraft information

Manufacturer	Cessna Aircraft Company[5]
Type, model and registration	Cessna A185F Skywagon, C-GYJX
Year of manufacture	1976
Serial number	18503187
Certificate of airworthiness/flight permit issue date	23 September 1985
Total airframe time	16 907.7 hours
Engine type (number of engines)	Teledyne Continental IO-550-D (1)
Propeller (number of propellers)	McCauley D3A34C401/90DFA-4 (1)
Maximum allowable take-off weight	3525 pounds (1599 kg)

4 Continental Aerospace Technologies Inc. is the current type certificate holder for the Continental IO-550-D engine.

5 Textron Aviation Inc. is the current type certificate holder for the Cessna A185F aircraft.

Recommended fuel types	100LL, 100
Fuel type used	100LL

1.6.1 Aircraft modifications

The aircraft was modified multiple times with certified design changes approved by supplemental type certificates (STC). The modifications increased the maximum gross take-off weight from 3350 pounds to 3525 pounds, improved the short take-off and landing (STOL) performance, and permitted operation on the water.

1.6.1.1 Wing modifications

1.6.1.1.1 STC SA93-136: Air Research Technology Inc. wing extension

The wing reinforcement and wing extension modification reinforces the spar of the wing and extends the wingspan by 37.75 inches, increasing the wing surface area and the resultant lift. Combined with a 300-hp engine and sufficient float buoyancy, the modification permits the maximum certified take-off weight to increase by 175 pounds for a total of 3525 pounds. The airplane flight manual supplement (AFMS) for the modification provides the following pertinent information:

- Never-exceed speed (V_{ne}) reduced to 165 knots
- Weight and centre-of-gravity limits for increased maximum take-off weight of 3525 pounds[6]

The AFMS reverts to the Cessna 185 pilot's operating handbook (POH)[7] for the remaining aircraft performance data.

1.6.1.1.2 STC SA2256WE: Stene Aviation, Inc. leading edge cuff

The leading edge cuff, commonly known as the Sportsman STOL kit, modifies the airfoil shape of the wing to provide increased aerodynamic efficiency and resistance to aerodynamic stalls. The modification did not include an AFMS.

1.6.1.1.3 STC SA1441WE: Sierra Industries, Ltd. Robertson/short take-off and landing high-lift system

The Robertson/STOL high-lift system modifies the wing control surfaces by connecting the flap and aileron systems to increase the wing camber from root to tip when the flaps are extended. The STC also recontours the leading edge to improve the airfoil shape, but given that the Cessna A185F is manufactured with an improved leading edge, this model of

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6 Air Research Technology Inc., *Flight/Operating Manual Supplement: Cessna 185 Series aircraft Fitted with ART "Wing Extensions"*, Revision 2 (17 January 2001), section 2: Limitations, p. 4.

7 Cessna Aircraft Company, *Pilot's Operating Handbook Cessna 185 Skywagon 1977 Model A185F*, Change 1 (01 February 1977), section 5: Performance, p. 5-1.

aircraft is exempt from the leading edge addition. The result is an improved STOL performance with better slow-speed handling and lower aerodynamic stall speeds.

In 2003, the Safety Investigation Authority, Finland conducted test flights[8] on a Cessna A185E seaplane equipped with the Robertson/STOL high-lift system to verify the aerodynamic performance of the modified wing. The test flights simulated the takeoff phase with the engine set at maximum power and the flaps set at 20°, which corresponds to an aileron deflection of 13° due to the flap-aileron interconnect. The tests revealed the 13° aileron setting initiated an airflow separation at the aileron hinge point that periodically resulted in a sudden wing tip stall when the aircraft was pitched up 10 degrees at a speed of 50-55 knots. The wing tip stall was contrary to the normal Cessna 185 stall in which airflow separation begins from the root of the wing[9] and prolongs aileron control for lateral stability.

The AFMS provides updated stall speeds[10] for the modified wing, but the test flights conducted by the Safety Investigation Authority, Finland concluded the following:

> The calculations and test flights performed during the investigation proved that the STOL take off speeds are slightly too slow and there is a risk of stalling. […]. It seems to be very important to increase speed near ground or water to over 65 knots before starting to climb. One should not turn during the initial climb.[11]

The AFMS also provides the following 2 takeoff procedures:

- normal takeoff procedure with 20° flap setting
- maximum performance takeoff procedure with 30° flap setting[12]

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8 Safety Investigation Authority, Finland, Investigation report B 2/2003 L, Aircraft Accident at Enontekiö, Finland, 25 June 2003, at https://turvallisuustutkinta.fi/material/attachments/otkes/tutkintaselostukset/en/ilmailuonnettomuuksientutkinta/2003/b22003l_tutkintaselostus/b22003l_tutkintaselostus.pdf (last accessed 16 September 2022).

9 Ibid., Section 2.12.2, p. 30.

10 Robertson Aircraft Corporation, Pilot's Operating Handbook 10-6, *Robertson Aircraft Corporation Pilot's Operating Handbook Supplement For Cessna Model A185F Skywagon Serial Numbers 18502839 and Up* (18 July 1977), section 4: Normal Procedures, p. 7.

11 Safety Investigation Authority, Finland, Investigation report B 2/2003 L, Aircraft Accident at Enontekiö, Finland, 25 June 2003, Section 2.10, p. 29, at https://turvallisuustutkinta.fi/material/attachments/otkes/tutkintaselostukset/en/ilmailuonnettomuuksientutkinta/2003/b22003l_tutkintaselostus/b22003l_tutkintaselostus.pdf, (last accessed 16 September 2022).

12 Robertson Aircraft Corporation, Pilot's Operating Handbook 10-6, *Robertson Aircraft Corporation Pilot's Operating Handbook Supplement For Cessna Model A185F Skywagon Serial Numbers 18502839 and Up* (18 July 1977), section 4: Normal Procedures, p. 3.

The Cessna 185 POH recommends a takeoff flap setting of only 20°; flap settings of 30° and 40° are not approved.[13]

All information and procedures contained in the AFMS for the Robertson/STOL high-lift system are based on the aircraft being on wheels with no additional modifications and a maximum take-off weight of 3350 pounds. The AFMS provides no caution or warning to the pilot about the potential change in the aircraft stall characteristics.

1.6.1.2 Powerplant modifications

1.6.1.2.1 STC SA2933SO: Davis Aviation Services engine upgrade

The Teledyne Continental Motors IO-550-D engine upgrade provides a 15-hp increase in the maximum continuous power, to 300 hp. The AFMS[14] for the engine upgrade provides pertinent information specific to engine operation and performance.

1.6.1.2.2 STC SA00412WI : Air Plains Services Corporation 3-bladed propeller

The installation of the 86-inch McCauley 3-bladed propeller provides performance and noise-attenuation improvements. The propeller STC approval requires a placard that indicates to the pilot the restrictions for continuous operation, but there is no AFMS included with the modification.

1.6.1.3 Landing gear modifications

1.6.1.3.1 STC SA5908NM: Aerocet Inc. floats

The Aerocet 3500L floats are of composite construction and permit aircraft operations on water. Floats are designed to produce some lift in flight, but the net aerodynamic result on the aircraft is increased drag. Based on a maximum take-off weight of 3350 pounds with no additional modifications, the AFMS for the floats provides slightly different aircraft limitations for the following:

- forward center of gravity limit
- maneuvering speed
- stall speeds[15]

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13 Cessna Aircraft Company, *Pilot's Operating Handbook Cessna 185 Skywagon 1977 Model A185F*, Change 1 (01 February 1977), section 4: Wing Flap Settings, p. 4-15.

14 Bonaire Aviation Company, *"Pilot's Operating Handbook and FAA Approved Airplane Flight Manual" Supplement for Cessna,* Revision D (07 December 1998).

15 Aerocet Inc., Document A-10010, *FAA Approved Supplemental Airplane Flight Manual for Cessna 185 Series Floatplanes Equipped with Aerocet 3500 or 3500L Seaplane Floats,* Revision A (15 March 1995), sections 1 and 2, pp. 3–5.

1.6.2 Multiple modifications

The performance data in all of the AFMSs of the occurrence aircraft did not reflect the combined interaction of all the installed modifications, nor was this required by regulation.

Each of these STC modifications was evaluated individually and approved by regulators after testing on an otherwise unmodified aircraft. Consequently, most TC and Federal Aviation Administration-issued STC include a compatibility statement which states, in part:

> Conditions: Prior to incorporating this modification, the installer shall establish that the interrelationship between this change and any other modification(s) incorporated will not adversely affect the airworthiness of the modified product.[16]

In addition to this statement, TC has issued Airworthiness Notices B045 - *Compatibility of Multiple Modifications*. The regulator requires the installer to ensure the modification(s) will not affect the airworthiness of the modified product and, if necessary, a new flight manual supplement may be required with the installation to prescribe the operating envelope.

A review of the aircraft's technical records did not indicate that any of the installed modifications had undergone a compatibility assessment by the installer. Despite the above-mentioned conditions, TC does not require proof that this assessment has been done.

1.6.2.1 TSB safety concern

Following its investigation of an October 2013 aerodynamic stall and collision with terrain of a Cessna A185E,[17] the TSB noted that TC requires the installer to evaluate all STC combinations and determine whether the combination of STC maintains the aircraft's airworthiness.[18] However, there are no regulatory guidelines to determine the scope or extent of this evaluation or the manner in which it must be performed and documented.

Most light aircraft in Canada, including commercially operated light aircraft, are maintained by smaller approved maintenance organizations with limited capability for aerodynamic testing or engineering evaluations. As a result, the compatibility and interaction between STC is often accepted with limited evaluation.

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16 Transport Canada, Airworthiness Notices (AN) – B045*: Compatibility of Multiple Modifications*, Edition 1 (15 May 1998), at https://tc.canada.ca/en/aviation/reference-centre/airworthiness-notices/airwothiness-notices-b045-edition-1-15-may-1998 (last accessed 16 September 2022).

17 TSB Aviation Investigation Report A13P0278.

18 Transport Canada, Airworthiness Notices (AN) – B045: *Compatibility of Multiple Modifications*, Edition 1 (15 May 1998), at https://tc.canada.ca/en/aviation/reference-centre/airworthiness-notices/airwothiness-notices-b045-edition-1-15-may-1998 (last accessed 16 September 2022).

In conclusion, the Board issued the following safety concern:

> The Board is concerned that, if multiple STCs are installed without adequate guidance on how to evaluate and document the effects on aircraft handling, pilots may lose control of the aircraft due to unknown aircraft performance.[19]

Since 2013, the TSB has investigated at least 2 other occurrences,[20] the reports of which have reiterated this concern.

1.7 Meteorological information

The closest aviation weather reporting station is Tofino/Long Beach Airport (CYAZ), BC, (7 NM southeast of CAB4). It is approximately 900 feet north of the coastline and 80 feet above mean sea level. The weather at 1100 was as follows:

- Winds from 160° true, variable in direction from 140° to 210° true at 7 knots
- Visibility 15 statute miles
- Scattered cloud layers at 2000 feet and 10 000 feet above ground level
- Temperature 17 °C and dew point 14 °C
- Altimeter setting 30.05 inches of mercury

Due to the different locations of the two aerodromes, the south wind recorded at CYAZ was not representative of the conditions at CAB4. As a result, wind conditions for the harbour are determined by observing flags in the vicinity of the harbour and the condition of the water surface.

At the time of the occurrence, local observations reported the wind as calm with no wind chop on the surface of the water. Additional data collected from a wireless weather station, located on the Canadian Coast Guard dock in the harbour, reported 2 knots of wind in a west-northwest direction.

Weather was not considered a factor in this occurrence.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

CAB4 is located approximately 7 NM northwest of CYAZ and is a registered water aerodrome operated by Tofino Airlines. Atleo River Air Services Ltd. operates from a

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19 TSB Aviation Investigation Report A13P0278.

20 TSB aviation investigation reports A15O0188 and A16Q0119.

separate private dock located approximately 820 feet east of the designated water aerodrome dock.

The water aerodrome is uncontrolled and, in addition to seaplane operations, the harbour hosts “kayaks, pleasure craft, whale watching vessels, tour boats, [and] water taxis.”[21] The harbour provides no designated take-off or landing area for seaplanes.

The harbour is surrounded by islands along with rocks and sandbars. The depth of the rocks and sandbars change with ocean tide levels. The harbour has a designated water channel to the north that allows safe passage in and out of the harbour for vessels at low tide. This deepwater channel—named Deadman Passage—is approximately 90 metres wide[22] and runs in a north-northeast direction from the harbour. At both the north and south entry points, the channel is marked by 2 staggered buoys, 1 red and 1 green, that identify the safe route for vessels into the channel along with the eastern and western edges. At the southern entry point, the green buoy is located 178 m north-northwest of the red buoy and closest to the sandbar. The investigation found that the green buoy can be difficult to see from the pilot’s perspective given the background of the dark ocean water and the forested mountains.

The occurrence flight was the pilot’s second takeoff of the day from CAB4 in the occurrence aircraft. The pilot’s first takeoff was completed approximately 2 hours prior and was in a similar north-northwest direction with similar wind conditions (Figure 2).

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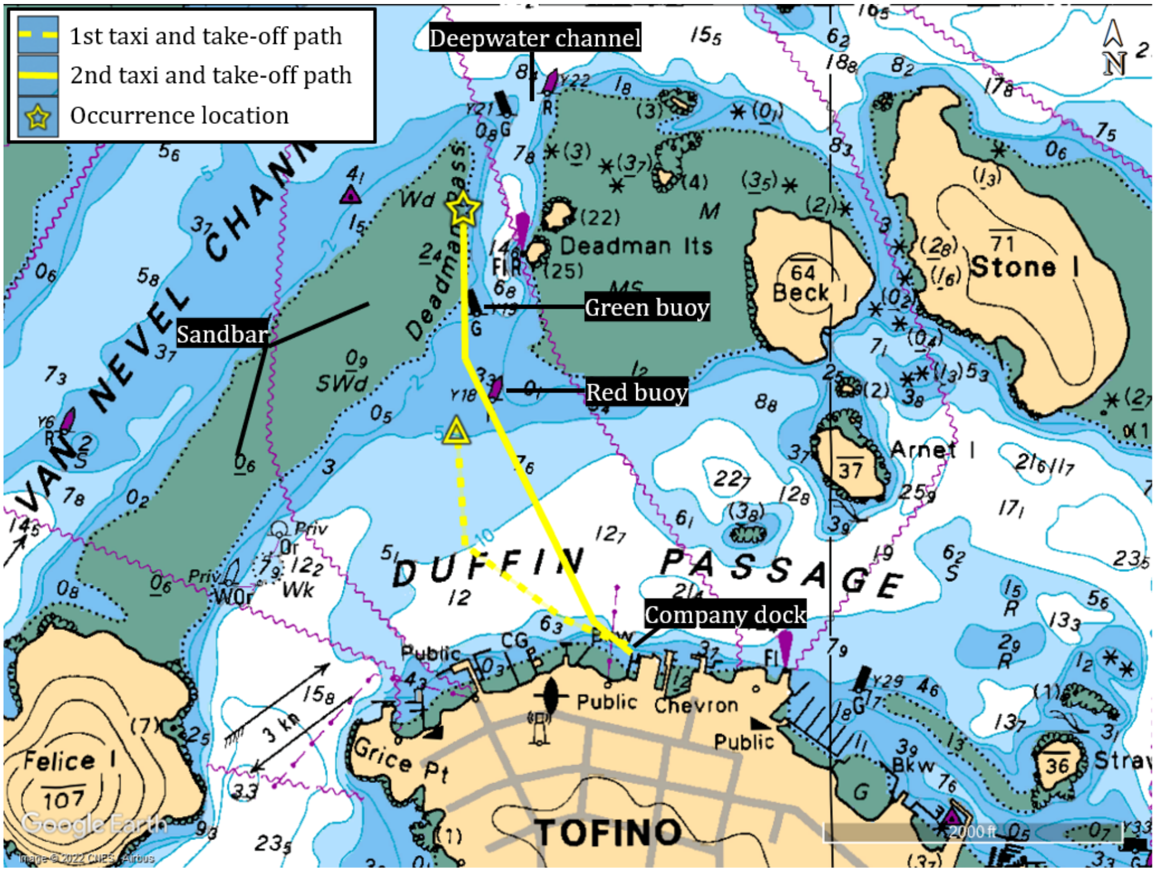
[21] Fisheries and Oceans Canada, Canadian Hydrographic Service, PAC 202E, *Sailing Directions: Discovery Passage to Queen Charlotte Strait and West Coast of Vancouver Island* (corrected to December 2021), chapter 5-22, paragraph 451.

[22] Ibid., chapter 5-24, paragraph 472.

Figure 2. Approximate aircraft take-off paths superimposed on the hydrographic chart for CAB4 with indications of depths in metres at the lowest normal tide and identified markers and hazards (Source: Google Earth and Canadian Hydrographic Service Chart 3685, with TSB annotations)



1.11 Flight recorders

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, nor was either required by regulation.

The occurrence flight was recorded by 2 video cameras: a closed circuit television camera and a cell camera.

1.12 Wreckage and impact information

1.12.1 General

Following the accident, the aircraft was overturned on a sandbar approximately 4000 feet north-northwest of the company dock and the fuselage remained largely intact with both wings submerged in approximately 1 foot of water.

Approximately 2 hours after the occurrence, as the water depth increased with the incoming tide, the aircraft was salvaged from the sandbar, dismantled, and transported to CYAZ for storage.

The investigation was unable to confirm the flight control continuity and control surface position during the impact due to the damage incurred during the salvage and disassembly of the aircraft. The engine controls were found intact and operational.

1.12.2 Aircraft floats

The forward section of the left-hand float was severed from the forward spreader bar and deflected inboard approximately 45°, causing half of the outboard skin on the float to depart. The orientation and damage to the float was consistent with the airplane's right yaw and skid on the surface of the water being stopped abruptly by the left float digging into the water.

The right float was attached to both spreader bars with no significant damage.

1.12.3 Aircraft wings

The leading edge of the left wing tip was significantly damaged, and the wing root was separated from the fuselage with only the wing strut connected at both ends. The damage was consistent with an impact on the left wing tip from contact with the sandbar and the wing subsequently being overloaded as the aircraft flipped over to the left.

The right wing was attached to the fuselage with no significant leading edge impact damage.

1.12.4 Fuselage

The fuselage suffered minor compression damage, with 6 of the 7 windows found largely intact. The damage suggested that the majority of the energy had been dissipated during the accident sequence before landing on the roof, which enabled the fuselage to maintain a survivable space for the occupants.

The 2 cockpit doors were open at the accident site and were attached to the hinges with no significant distortion.

1.12.5 Propeller

All 3 propeller blades exhibited bending and abrasion damage that was consistent with the propeller rotating and the engine producing power at the time of impact.

1.13 Medical and pathological information

The investigation determined that there was nothing to indicate that the pilot's performance was degraded by medical or physiological factors including fatigue.

1.14 Fire

There was no fire.

1.15 Survival aspects

In this occurrence, the aircraft overturned on the sandbar, which prevented the fuselage from being submerged and provided time for the occupants to egress the aircraft. The pilot and 1 passenger had completed underwater egress training, and all occupants were wearing PFDs. The sea water temperature was approximately 15.3 °C.[23]

The fuselage suffered only minor deformation and maintained a survivable space for the occupants. All seats and safety belts remained anchored to the floor, and the baggage was retained in the aft baggage compartment. The occupants were able to egress the aircraft without external assistance.

Finding: Other

The aircraft was overturned in shallow water on the sandbar, which likely contributed to the survival of the occupants by reducing the risk of drowning and providing time for the occupants to egress the aircraft.

The aircraft was fitted with an automatic fixed ELT (Kannad 406 AF-compact) capable of transmitting on 406 MHz and 121.5 MHz. The ELT annual certification had been completed on 12 May 2021, and the ELT switch locking latches were found to be intact following the occurrence.[24] The ELT was mounted near the front of the baggage compartment on the left side of the fuselage. No ELT signal was received by Joint Rescue Coordination Centre Victoria; however, the investigation could not determine if this was due to insufficient impact forces to activate the g-switch, or due to the antenna being submerged.

Shortly after the occurrence, a nearby boater arrived at the crash site to offer assistance before the arrival of the local Canadian Coast Guard detachment. All occupants were assessed at the site and transported to the Tofino shoreline for treatment at the local hospital.

1.15.1 Safety belts

In this occurrence, all aircraft occupants were restrained by the safety belts.

The 2 forward seats were fitted with a lap belt and shoulder harness; the left seat had an inertia reel for the shoulder harness whereas the right seat had fixed adjustments. The middle and aft seats were fitted with lap belts only. The lap belt anchors and attaching hardware for all seating positions were found significantly corroded.

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23 Meteorological Services of Canada data from a buoy at La Perouse Bank (Station 46206), recorded at 1823 Universal Coordinated Time on 26 July 2021.

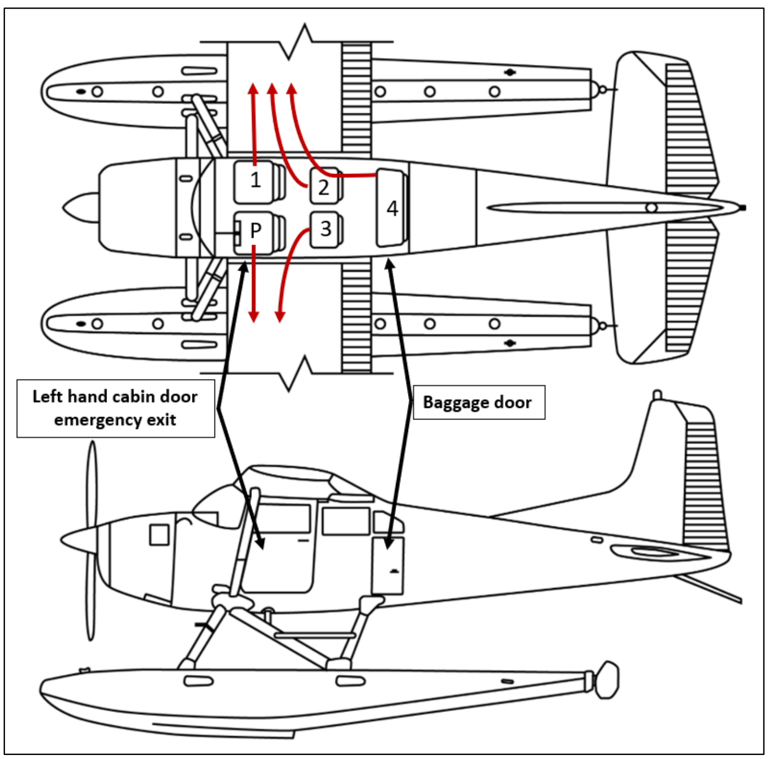
24 Transportation Safety Board of Canada, Air transportation safety information A19Q0109-D1-A1: Failure of the Kannad 406 AF-compact emergency locator transmitter switch locking system (11 February 2020), at https://www.tsb.gc.ca/eng/securite-safety/aviation/2019/a19q0109/a19q0109-d1-a1.html (last accessed 20 September 2022).

The pilot and the 3 passengers in the aft seats were able to release their safety belts and egress the aircraft without assistance. The passenger sitting in the front right seat was partially submerged in water and, due to disorientation, could not locate the safety belt latch. The other 3 passengers assisted and, after some difficulty locating and releasing the safety belt latch, they freed the right front passenger who then exited the aircraft through the right cabin door.

1.15.2 Emergency exits

The 2 designated emergency exits for the aircraft are the right and left cabin doors as outlined in the passenger briefing card. The aircraft also has a small baggage door (approximately 22 inches high by 15 inches wide) located to the left of the aft seat. The baggage door is not designed or designated as an emergency exit, and the aft passenger is expected to move through the middle seats (Figure 3) and pass any occupants on those seats to exit the aircraft.

Figure 3. Occurrence aircraft seating configuration and direction of egress for the aircraft occupants (Source: TSB Aviation Investigation Report A11Q0136)



The TSB has found that the risk of drowning for occupants in seaplane accidents is high and, in some instances, drowning can be attributed to able-bodied persons being trapped in a sinking aircraft.[25] Following an occurrence [26] on 29 November 2009 in which a commercially operated de Havilland DHC-2 Mk. 1 collided with water and resulted in 6 people drowning, the Board recommended that

> the Department of Transport require that all new and existing commercial seaplanes be fitted with regular and emergency exits that allow rapid egress following a survivable collision with water.
>
> **TSB Recommendation A11-05**

In its final response to this recommendation in January 2017, TC states "that there was no readily identifiable design solution that would have a major impact on the existing level of floatplane safety."[27] In its March 2017 assessment of TC's response, the TSB stated that, despite improvements made on emergency exits for certain types of aircraft,

> if the regulator does not mandate or promote voluntary modifications to normal exits, seaplanes will continue to operate with exits that could become unusable following an impact, diminishing the chance of occupants to exit the aircraft following a survivable accident.[28]

The TSB assessed the response to Recommendation A11-05 as "Satisfactory in Part" and, with no further planned activities by TC, the recommendation is "Dormant".[29]

1.16 Tests and research

Not applicable.

1.16.1 TSB laboratory reports

The TSB completed the following laboratory reports in support of this investigation:

- LP094/2021 – NVM Data Recovery

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25 TSB Air transportation safety recommendation A11-05: Emergency egress for seaplanes (issued 17 March 2011), accessible at https://www.bst-tsb.gc.ca/eng/recommandations-recommendations/aviation/2011/rec-a1105.html (last accessed 21 September 2022).

26 TSB Aviation Investigation Report A09P0397.

27 TSB Air transportation safety recommendation A11-05: Emergency egress for seaplanes (issued 17 March 2011), accessible at https://www.bst-tsb.gc.ca/eng/recommandations-recommendations/aviation/2011/rec-a1105.html (last accessed 21 September 2022).

28 Ibid.

29 Ibid.

1.17 Organizational and management information

1.17.1 Transport Canada Civil Aviation – Aircraft weight control

Passenger weight in a small aircraft[30] constitutes a large portion of the total aircraft weight. For example, on the occurrence flight, the 4 passengers contributed to 26% of the total aircraft weight prior to takeoff.[31] This emphasizes the importance of accurate data in determining the aircraft weight and balance.

In June 2012, the *Commercial Air Service Standards*[32] were revised to provide the greatest accuracy for weight-and-balance calculations by mandating that *Canadian Aviation Regulations* (CARs) Subpart 703 air operators use either actual weights or segmented weights when determining the weights of both passengers and carry-on baggage. To supplement Standard 723, TC Advisory Circular (AC) 703-004 provides guidance for computing passenger weights for airplanes operating under CARs Subpart 703 and defines segmented weights as a modification to male and female average weights to better represent the current surveyed population (Table 4).

Table 4. Weight-and-balance control methods for Canadian Aviation Regulations Subpart 703 operators (Source: TSB, derived from Transport Canada Advisory Circular 703-004, Issue 04)

Approved weight control methods	Types	Weight collection	Addition to the collected weight
Actual weight*	Actual weighing	Weighing scale	+ personal clothing** + carry-on baggage**
	Volunteered	Provided by passenger	+ 10 lbs + personal clothing + carry-on baggage
	Estimated	Operator estimation	+ personal clothing + carry-on baggage
Segmented weight	N/A	Data published in the *Transport Canada Aeronautical Information Manual*, Table 3.2	N/A

* As outlined in the *Transport Canada Aeronautical Information Manual* (TC AIM), "[t]he only circumstance under which the weight of carry-on baggage may not be added to the weight of each passenger is when no carry-on baggage is permitted on the flight." (Source: Transport Canada, TP14371E, *Transport Canada Aeronautical Information Manual* [TC AIM], RAC – Rules of the Air and Air Traffic Services [07 October 2021], section 3.4.7: Computation of Passenger and Baggage Weights, Note 2, p. 209, at

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30 The *Canadian Aviation Regulations* (CARS) define a small aircraft as "an aeroplane having a maximum permissible take-off weight of 5700 kg (12,566 pounds) or less". (Source: Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, section 101.01).

31 The percentage is derived from the weight calculated by the TSB using the company's operational flight plan and the volunteered weights from passengers.

32 Transport Canada, *Commercial Air Service Standards,* Standard 723: Air Taxi - Aeroplanes, Division III: Flight Operations, subsection 723.37(3) (effective 09 December 2020).

https://tc.canada.ca/sites/default/files/2022-03/aim-2022-1_rac-e.pdf [last accessed on 21 September 2022]).

** Added only if the passenger is weighed without every item they are taking onto the aircraft (Source: Transport Canada, TP14371E, *Transport Canada Aeronautical Information Manual* [TC AIM], RAC – Rules of the Air and Air Traffic Services [07 October 2021], section 3.4.7[a]: Computation of Passenger and Baggage Weights, p. 208, at https://tc.canada.ca/sites/default/files/2022-03/aim-2022-1_rac-e.pdf [last accessed on 21 September 2022]).

AC 703-004 approves **estimated weight as an actual weight** with the following caveat:

> where actual weight is not available and volunteered weight is either not provided or is deemed to be understated; the operator may make a reasonable estimate of the passenger's weight, then add the allowances of personal clothing and carry-on baggage and use the resultant values as the passenger's weight.[33]

After the occurrence, TSB investigators calculated the total weight of the passengers using their volunteered weights. This total exceeded the flight follower's estimated weight by 27%.

The AC goes further in stating that actual weight will provide the greatest accuracy for the computation of weight and balance, and, if this is not possible, the alternative use of segmented weights will

> guarantee a 95 percent confidence level that the actual total weight of the passengers will not exceed the total weight of the passengers obtained by using segmented weights by more than one percent.[34]

TSB investigators also calculated the total weight of the passengers using segmented weights. This total exceeded the flight follower's estimated weight by 28%.

1.17.2 Operator

Atleo River Air Service Ltd. holds an air operator certificate and is based in Tofino, BC. The company provides commercial VFR air taxi and aerial work services for the local region in accordance with CARs subparts 702 and 703.

The company fleet at the time of the occurrence consisted of 3 Cessna A185F aircraft, a de Havilland DHC-2 Mk. I aircraft, a Bell 206B helicopter, and a Bell 206L-1 helicopter.

The company uses a Type D operational control system.[35] The occurrence flight had an OFP that had been filed with a company flight follower.

The company is also a TC-approved maintenance organization for all non-specialized work on the aircraft types operated.

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[33] Transport Canada, Advisory Circular (AC) 703-004: Use of Segmented Passenger Weights by Commercial Air Operators under Subpart 703 of the *Canadian Aviation Regulations* (Issue 04: 01 August 2019), at https://tc.canada.ca/en/aviation/reference-centre/advisory-circulars/advisory-circular-ac-no-703-004 (last accessed 21 September 2022).

[34] Ibid.

[35] A Type D operational control system delegates operational control from the operations manager to the pilot-in-command. Flights operated under this system are self-dispatched and released by the pilot-in-command.

1.17.2.1 Harbour procedures

Informally, the company encourages aircraft to take off from CAB4 in a northwest direction for the purpose of noise abatement, a recommendation subject to pilot discretion for aircraft performance, environmental conditions, and harbour traffic.

The Atleo River Air Service Ltd. operations manual contains no written procedures or training for taking off or landing at CAB4. Company personnel verbally communicate harbour hazards and safety concerns during pilot training exercises and periodic staff meetings.

In October and November 2021, 3 meetings were held regarding safety in Tofino harbour. These meetings were attended by various air and vessel operators, including Atleo River Air Service Ltd. Topics discussed included communication between operational personnel, best safe-practices, and possible ways to improve harbour safety. However, no written procedures or agreements were in place at the time of publishing this report.

In November 2021, local First Nations communities held a Water Ceremony on the Tofino First Street dock and in the Tofino harbour intended to cleanse the water, pilots, vessel operator, passengers, aircraft, and boats that were affected by 2 aircraft accidents that occurred in Tofino harbour in 2021[36] and to bring the community together to heal and move forward.

1.17.2.2 Weight-and-balance control

CARs 703.37 mandates an air operator to

> specify in its company operations manual its weight and balance system and instructions to employees regarding the preparation and accuracy of weight and balance forms.[37]

The Atleo River Air Service Ltd. company operations manual (COM)[38] permits 2 methods for determining a passenger's weight as part of the weight-and-balance control system: actual weight using a weighing scale or, when a weighing scale is unavailable, adding 10 pounds to the weight volunteered by the passenger. The COM does not include the weight allowances for personal clothing and carry-on baggage for the calculation of volunteered weight, as outlined in the guidance material provided in AC 703-004.[39]

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[36] On 18 October 2021, a float-equipped de Havilland DHC-2 Mk. I Beaver aircraft and a water taxi collided in Tofino harbour. At the time of writing this report, a joint air and marine investigation is ongoing under TSB Air Transportation Safety Investigation A21P0111. The data on the marine transportation safety aspects of this occurrence are collected under occurrence M21P0290.

[37] Transport Canada, SOR/96-433, *Canadian Aviation Regulations,* subsection 703.37(3).

[38] Atleo River Air Service Ltd., *Operations Manual*, Amendment no. 11 (24 October 2019), section 4.4.2: Actual Weights, p. 4-2.

[39] Transport Canada, Advisory Circular (AC) 703-004: Use of Segmented Passenger Weights by Commercial Air Operators under Subpart 703 of the *Canadian Aviation Regulations* (Issue 04: 01 August 2019), at https://tc.canada.ca/en/aviation/reference-centre/advisory-circulars/advisory-circular-ac-no-703-004 (last accessed 22 September 2022).

The common practice at the company is for the flight follower to assist the pilot in performing the take-off weight calculation for the aircraft, which includes the weights of the passengers and cargo. The flight follower records the weights on the OFP and adds the relevant profile letter—which represents a specific pre-calculated weight-and-balance configuration found in the COM—to the balance column. The pilot then reviews the information and accepts the OFP with a signature.

During the flight-booking process, passengers typically volunteer their weight, which is recorded on the electronic booking spreadsheet. In this occurrence, the flight booking was made by a third party and passenger weights were not provided at the time of booking. Given the absence of information for passenger weights on the spreadsheet, the flight follower estimated the total passenger weight and recorded it as 730 pounds on the OFP. This resulted in a total aircraft weight of 3374 pounds at takeoff. Even though the regulations permit the use of estimated passenger weights, the procedure is not part of the weight-and-balance control system identified in the COM.

Using the weights volunteered by the passengers and guidance from AC 703-004, the investigation determined that the total passenger weight was 194 pounds heavier than that estimated by the flight follower, resulting in a total aircraft weight of 3568 pounds at takeoff.

The company does have a weighing scale on site.

1.18 Additional information

1.18.1 Aerodynamic stall

An aerodynamic stall occurs when the wing's angle of attack exceeds the critical angle at which the airflow begins to separate. When a wing stalls, the airflow breaks away from the upper surface and the amount of lift will be reduced to below that needed to keep the wing flying.

Airspeed is often used to predict stall conditions. The faster an airplane flies, the less angle of attack it needs to produce lift equal to weight. As the airplane slows down, the angle of attack needs to be increased to create the lift equal to weight. Stall speed is the speed below which the airplane cannot create enough lift to sustain its weight in flight.

In a climbing turn, the outer wing of the aircraft meets the relative airflow at a steeper angle of attack than the inner wing and, in the case of an aerodynamic stall, the outer wing will reach the critical stall angle first, causing the outer wing to drop and the aircraft to roll in the opposite direction of the controlled turn.

An increase in aircraft weight results in an increased stalling speed because the wing is required to produce more lift to maintain level flight, bringing its angle of attack closer to the critical angle. Furthermore, the location of the centre of gravity, even while remaining within aircraft limitations noted in the flight manual, will have an effect on the stalling speed and manoeuvrability of an aircraft.

Modifications of the wings’ cross-sectional shape (airfoil) through the addition of a STOL kit or combination of kits will result in changes to the aircraft's original stall speeds and handling characteristics. Typically, the addition of a STOL kit will decrease stall speeds and improve aircraft handling at slower speeds allowing aircraft to take off and land in more confined areas.

1.18.2 Pilot decision making

Pilot decision making (PDM) is a cognitive process consisting of gathering information, evaluating it, then selecting an option between alternatives. Once a course of action is being performed, the decision-making process starts again in order to validate whether the decision made corresponds to the best possible option. Decision making is therefore a dynamic process. According to an educational package published by TC, pilot decision making is a function of time, so that before the flight there is “ample-time decision making,” and while in flight, in a dynamic environment, there can be time-critical decision making.[40]

Several factors, contextual circumstances, and biases can affect PDM, including the flight objective or goal(s), and the pilot’s knowledge, experience, and training.[41] Mental models are an intrinsic component of decision making. Mental models are internal representations that allow an individual to describe, explain, and predict events or situations in their environment.[42] When a mental model is adopted, it generates expectations and is resistant to change. Compelling new information must be absorbed to modify a mental model.

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[40] Transport Canada, TP 13897, *Pilot Decision Making – PDM* (20 May 2010), Module 5: Risk Management, at https://tc.canada.ca/en/aviation/publications/pilot-decision-making-pdm-tp-13897/module-5-risk-management.

[41] M.R. Endsley, “Toward a Theory of Situation Awareness in Dynamic Systems,” in Human Factors, Vol. 37, No. 1 (1995), pp. 32–64.

[42] E. Salas, F. Jentsch and D. Maurino, *Human Factors in Aviation*, 2nd edition (Academic Press, 2010), p. 66.

2.0 ANALYSIS

2.1 General

There was no indication that the weather conditions were a factor in this occurrence. The pilot held the appropriate licence for the flight in accordance with existing regulations, and there was no indication that the pilot's performance was degraded by physiological factors such as fatigue.

There was no indication of a mechanical malfunction in the airframe or engine during the occurrence flight. However, an analysis of the aircraft records raised concerns with regard to multiple modifications made to the aircraft since it was first manufactured.

The information obtained during the investigation, such as the video recordings, indicates that an aerodynamic stall had occurred on the left wing while the aircraft was in a right turn shortly after takeoff.

This analysis will focus on the weight-and-balance control procedures and available guidance, the aircraft modifications, and both pilot and aircraft performance during the takeoff.

2.2 Weight-and-balance control

Accurately calculating passenger weights is critical in aircraft operated under *Canadian Aviation Regulations* Subpart 703 where the passengers account for a significant portion of the take-off weight.

The Atleo River Air Service Ltd. company operations manual[43] includes 2 methods for determining a passenger's weight: actually weighing the passenger using a weighing scale or adding 10 pounds to the weight volunteered by the passenger. The volunteered weight calculation in the company operations manual[44] is missing the added values for clothing and carry-on baggage that are required by regulation for a more realistic passenger weight. As a result, company operations personnel were adding only 10 pounds to the weights volunteered by passengers when completing the operational flight plans.

By regulation and guidance material, Transport Canada (TC) considers estimated passenger weights to represent actual passenger weights and, if available, TC recommends using estimated passenger weights instead of using the statistically researched and calculated segmented passenger weights. TC expects operators to make "reasonable estimate[s]" [45] for

[43] Atleo River Air Service Ltd., *Operations Manual*, Amendment no. 11 (24 October 2019), section 4.4.2: Actual Weights, p. 4-2.

[44] Ibid.

[45] Transport Canada, Advisory Circular (AC) 703-004: Use of Segmented Passenger Weights by Commercial Air Operators under Subpart 703 of the *Canadian Aviation Regulations* (Issue 04: 01 August 2019), at https://tc.canada.ca/en/aviation/reference-centre/advisory-circulars/advisory-circular-ac-no-703-004 (last accessed 23 September 2022).

passenger weights, but there is no guidance on what qualifies as a reasonable estimate or how to achieve one. As a result, estimated passenger weights can be highly variable and, therefore, may not represent actual passenger weights or provide accurate expectations for aircraft performance.

Finding as to risks

If using estimated passenger weights is permitted without adequate guidance on how to perform a reasonable weight estimate, passenger weights may be underestimated, and lead to the risk of an overweight condition adversely affecting the safety of the flight.

2.3 Aircraft modifications

2.3.1 Sierra Industries Ltd. Robertson/short take-off and landing high-lift system

The flight testing conducted by the Safety Investigation Authority, Finland indicates that the Robertson/short take-off and landing (STOL) modification can induce the initial aerodynamic stall at the wing tip whereas the original aircraft design targets the initial stall at the wing root for increased lateral stability.

The airplane flight manual supplement (AFMS) for the Robertson/STOL high-lift system provides updated aerodynamic performance for the modification on the Cessna 185, but there is no caution or warning to the pilot of the potential change in the aircraft stall characteristics. The AFMS is the primary source of information for the pilot and should warn the pilot of the potential wing tip stall and the recovery thereof.

Finding as to risk

If the wing tip stall characteristics of the Robertson/STOL high-lift system are not documented in the airplane flight manual supplement, there is a risk that pilots of aircraft with this system installed will be unaware of uncommon handling characteristics that may lead to a loss of control.

2.3.2 Compatibility and performance of multiple modifications

When a single aircraft undergoes multiple modifications under several supplemental type certificates (STC), testing is generally not carried out to verify the aerodynamic interactions among the modifications. Additionally, TC provides minimal guidance for owners, operators, and installers on how to assess compatibility of multiple STC and resolve potential conflicts.

The Board has previously issued a safety concern about the absence of guidance on how to evaluate and document the effects of multiple modifications.

In the case of the occurrence aircraft, the 6 modifications altered the aerodynamic and engine performance characteristics along with an increased take-off weight compared to the original type certified aircraft. The Robertson/STOL AFMS lists the stall speeds only for the original take-off weight without accounting for the other modifications that were incorporated on the occurrence aircraft, including the wing extensions, the leading edge cuffs of the Sportsman STOL kit, and the floats, all of which may affect the aircraft stall speed.

The aircraft's technical records provided no indication that the installer had conducted a compatibility assessment of the modifications to the aircraft, and no AFMS that incorporated the interaction of the modifications in flight was available. Consequently, it was not possible for the pilot to know how the aircraft would perform with these modifications.

Findings as to risk

If multiple supplemental type certificates are installed without adequate guidance on how to evaluate and document their cumulative effects on aircraft handling and performance, there is a risk that the aircraft will have unexpected flight characteristics, increasing the possibility for loss of control.

2.4 Factors affecting pilot performance

2.4.1 Pilot decision making

During the occurrence flight, the low tide exposed the sandbar that was located at the north-northwest end of the harbour and impassable by both aircraft and marine vessels. Despite the presence of the sandbar and the limitation it places on the take-off distance, the north-northwest departure was commonly used in the interest of noise abatement if operational and environmental conditions permitted. If additional take-off distance was required, the confined deepwater channel adjacent to the sandbar was considered a viable option. As a result, the choice to depart on the north-northwest take-off run for that flight was not an extraordinary event, and the pilot’s mental model was based on the following assumptions:

- increased aircraft power and his knowledge of STOL characteristics
- weight parameters within the aircraft weight and balance envelope
- calm winds, favourable water conditions, and good visibility
- minimal conflicting harbour traffic
- a successful takeoff in the same relative direction earlier that day

For the second take-off run, the pilot opted for a trajectory that was less aligned with the deepwater channel than the first. The pilot anticipated to be airborne prior to the red buoy on the near side of the deepwater channel. However, the aircraft encountered an unexpected boat wake during the take-off run that, coupled with the aircraft being heavy, hampered the aircraft rate of acceleration. As a result, the pilot needed to perform a step-turn to the right to access the deepwater channel and gain additional distance for the takeoff.

Success in utilizing the channel is dependent on navigating between the staggered red and green buoys that mark obstacles on either side of the channel opening. Based on the take-off heading, the aircraft first passed the red buoy on the right hand side (passenger side) and, approximately 178 m later, the green buoy on the same side, which was the last marker before the sandbar. The pilot was unable to manoeuvre into the deepwater channel between the red and green buoys.

2.5 Takeoff

The normal takeoff procedure in the Robertson STOL AFMS configures the aircraft with a 20° flap setting and a resulting 13° aileron deflection. Following calculations and test flights, the Safety Investigation Authority, Finland identified 3 performance characteristics for a Cessna 185 aircraft equipped with the Robertson STOL modification during takeoff:

- The stall speeds listed in the AFMS are slightly too slow.
- The aircraft speed should be increased near the water to over 65 knots before climbing.
- The aircraft should not turn during the initial climb.[46]

During the occurrence takeoff, the aircraft became airborne in a right turn and nose-up attitude at a low airspeed. The investigation was unable to determine whether the aircraft was launched into the air from a second boat wake or the pilot lifted the aircraft off the water due to the approaching sandbar. The pilot recognized the low airspeed and attempted to keep the aircraft airborne by pushing the control column forward and by adding 10° of flap. Despite the additional control inputs, the left wing experienced an aerodynamic stall that initiated the crash sequence.

Findings as to cause and contributing factors

The aircraft rate of acceleration was slowed by a boat wake during the take-off run, and the pilot attempted to gain additional distance with a right turn on the water's surface. The aircraft then lifted off of the water at a low airspeed as a result of either a second boat wake or a control input.

The aircraft became airborne at a low airspeed and in a right turn that increased the angle of attack on the left wing. As a result, the left wing stalled aerodynamically at too low an altitude for control to be regained before the wing contacted the water.

[46] Safety Investigation Authority, Finland, Investigation report B 2/2003 L, Aircraft Accident at Enontekiö, Finland, 25 June 2003, Section 2.10, p. 29, at https://turvallisuustutkinta.fi/material/attachments/otkes/tutkintaselostukset/en/ilmailuonnettomuuksientutkinta/2003/b22003l_tutkintaselostus/b22003l_tutkintaselostus.pdf (last accessed 23 September 2022).

3.0 FINDINGS

3.1 Findings as to causes and contributing factors

These are conditions, acts or safety deficiencies that were found to have caused or contributed to this occurrence.

1. The aircraft rate of acceleration was slowed by a boat wake during the take-off run, and the pilot attempted to gain additional distance with a right turn on the water's surface. The aircraft then lifted off of the water at a low airspeed as a result of either a second boat wake or a control input.

2. The aircraft became airborne at a low airspeed and in a right turn that increased the angle of attack on the left wing. As a result, the left wing stalled aerodynamically at too low an altitude for control to be regained before the wing contacted the water.

3.2 Findings as to risk

These are conditions, unsafe acts or safety deficiencies that were found not to be a factor in this occurrence but could have adverse consequences in future occurrences.

1. If using estimated passenger weights is permitted without adequate guidance on how to perform a reasonable weight estimate, passenger weights may be underestimated, and lead to the risk of an overweight condition adversely affecting the safety of the flight.

2. If the wing tip stall characteristics of the Robertson/short take-off and landing high-lift system are not documented in the airplane flight manual supplement, there is a risk that pilots of aircraft with this system installed will be unaware of uncommon handling characteristics that may lead to a loss of control.

3. If multiple supplemental type certificates are installed without adequate guidance on how to evaluate and document their cumulative effects on aircraft handling and performance, there is a risk that the aircraft will have unexpected flight characteristics, increasing the possibility for loss of control.

3.3 Other findings

These items could enhance safety, resolve an issue of controversy, or provide a data point for future safety studies.

1. The aircraft was overturned in shallow water on the sandbar, which likely contributed to the survival of the occupants by reducing the risk of drowning and providing time for the occupants to egress the aircraft.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 Atleo River Air Service Ltd.

The company, through its scheduling, has increased the time between flights by an additional 15 minutes to provide the pilots with more time to complete their pre-flight duties.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 28 September 2022. It was officially released on 06 October 2022.