



Reassessment of the response to TSB Recommendation A17-01

Stall warning systems – DHC-2

Background

The float-equipped de Havilland DHC-2 Mk. 1 Beaver (registration C-FKRJ, serial number 1210), operated by Air Saguenay (1980) inc., was on a visual flight rules sightseeing flight in the region of Tadoussac, Quebec. At 1104 Eastern Daylight Time, the aircraft took off from its base on Lac Long, Quebec, for a 20-minute flight, with 1 pilot and 5 passengers on board. At 1127, on the return trip, approximately 2.5 nautical miles north northwest of its destination (7 nautical miles north of Tadoussac), the aircraft stalled in a steep turn. The aircraft descended vertically and struck a rocky outcrop. The aircraft was substantially damaged in the collision with the terrain and was destroyed by the post-impact fire. The 6 occupants received fatal injuries. No emergency locator transmitter signal was captured.

The Board concluded its investigation and released report A15Q0120 on 7 September 2017.

TSB Recommendation A17-01 (August 2017)

The pilot in this occurrence regularly conducted stall exercises under controlled conditions as an instructor. He was also aware of the DHC-2's more abrupt stall characteristics during steep turns. However, despite his experience, he was not able to detect the impending stall before control of the aircraft was lost.

A stall warning system was not required when the DHC-2 was certified in 1948, because the aerodynamic buffeting that occurs immediately before a stall was considered to constitute a clear, distinctive stall warning. As a result, the Canadian Aviation Regulations do not require stall warning systems to be installed on DHC-2s. Certification standards have since evolved, and a stall warning system is now required for the certification of new aircraft.

In the controlled conditions of certification, the stalling of the DHC-2 was described as gentle. However, as is the case for many other aircraft, a stall in a steep turn under power, triggers an incipient spin with few or no signs of an impending stall, and the flight path changes from horizontal to vertical. In low-altitude flight, stalling followed by incipient spin, no matter how brief, prevents the pilot from regaining control of the aircraft before impact with the ground.

In the conclusion of Aviation Investigation Report A1200071 in October 2013, the TSB included a safety concern that the DHC-2's aerodynamic buffeting does not provide pilots with adequate

warning of an impending stall. The TSB also noted the high frequency of accidents caused by an aerodynamic stall, as well as the catastrophic consequences of these accidents when they occur at low altitude and during critical phases of flight.

Since that time, 2 more accidents related to a DHC-2 stall have occurred: 1 in 2014, and this accident, in 2015. In total, 13 accidents following the aerodynamic stalling of a DHC-2 have occurred in Canada since 1998.

To reduce the risk of losing control of the aircraft, the pilot must have an immediate, clear indication of an impending stall: immediate because it is urgent, and clear in order to prevent any possibility of mistaking the impending stall for another type of event. The aural and sometimes visual signal of an impending aerodynamic stall emitted by these warning systems means they are one of the last lines of defence against accidental stalls.

In 2014, Transport Canada and the manufacturer, Viking Air Limited, recommended that stall warning systems be installed on DHC-2s, but only 4 have been installed on Canadian-registered DHC-2s. There are currently 382 DHC-2s registered in Canada, 223 of which are used in commercial operations.

Level of risk is determined by the probability and severity of adverse consequences. Given the number of DHC-2s without a stall warning system in commercial operations, combined with the fact that low-altitude manoeuvres are an integral part of bush flying, it is reasonable to conclude that a stall at low altitude is likely to occur again. Because stalls at low altitude lead to catastrophic consequences, this type of accident carries a high level of risk.

Until, at a minimum, commercially operated DHC-2s registered in Canada are required to be equipped with a stall warning system, pilots and passengers who travel on these aircraft will remain exposed to an elevated risk of injury or death as a result of a stall at low altitude.

Therefore, the Board recommended that

the Department of Transport require all commercially operated DHC-2 aircraft in Canada to be equipped with a stall warning system.

TSB Recommendation A17-01

Transport Canada's response to Recommendation A17-01 (December 2017)

Transport Canada (TC) agrees in principle with the recommendation.

TC agrees that stalls encountered during critical phases of flight often lead to disastrous consequences. Although the historical accident rate does not indicate that there is any particular stall-related problem with the DHC-2 Beaver when it is flown within its certified envelope, the installation of an Artificial Stall Warning System can enhance operational safety. TC acknowledged this fact with the publication of Civil Aviation Safety Alert (CASA) 2014-02 recommending installation of Viking Air's artificial stall warning system.

Mandating the installation of a stall warning system on all commercially operated DHC-2 aircraft in Canada will require further study, evaluation, and justification by TC. In 2018, the department will initiate an in-depth examination of the issue, particularly to determine how many accidents would have been prevented by a functioning artificial stall warning system. Following this evaluation the department will determine the most effective means of addressing the risks underpinning this recommendation and then outline its plan and consult industry stakeholders.

TC will continue to participate in and support international efforts to improve passenger safety, particularly through the International Civil Aviation Organization (ICAO) passenger Safety Working Group and follow-on activities with a view to harmonization with international partners.

TSB assessment of Transport Canada's response to Recommendation A17-01 (March 2018)

In its response, TC acknowledges that the installation of a stall warning system on all commercially operated DHC-2 aircraft in Canada can improve operational safety.

TC indicates that it has published a Civil Aviation Safety Alert (CASA) in 2014 (CASA 2014-02), recommending the installation of a stall warning system on all DHC-2 series aeroplanes, and advising of the enhancement to safety offered by the installation of such a system, where available. To date, records show that only 4 of the 223 commercially operated DHC-2 aircraft in Canada are equipped with a stall warning system.

TC advises that it will initiate an in-depth examination of the issue to determine the most effective means of addressing the risk associated with the safety deficiency identified in Recommendation A17-01. To do so, it plans on consulting industry stakeholders and to continue participating in and supporting international efforts to improve passenger safety, particularly through the International Civil Aviation Organization passenger safety working group and follow-on activities.

The Board is encouraged that TC acknowledges the safety benefits of stall warning systems. However, until TC reaches conclusions as to the most effective means of addressing the risks underpinning this recommendation and provides the TSB with its plan of action moving forward following those conclusions, it is unclear when or how the safety deficiency identified in Recommendation A17-01 will be addressed.

Therefore, the Board considers Transport Canada's response to Recommendation A17-01 to show **Satisfactory Intent**.

Transport Canada's response to Recommendation A17-01 (March 2019)

TC agrees in principle with the recommendation.

In 2018, TC initiated an in-depth examination of the effects of such equipment, particularly to determine how many accidents would have been prevented by a functioning artificial stall warning system.

The Aviation Safety Analysis' database search found 120 DHC-2 Beaver accidents recorded in the TSB's ASIS system between 2001 and 2016. Of these, 101 were domestic accidents and 19 were foreign. Thirteen of the accidents included a stall in the accident sequence. Investigation reports (Class 2 or 3) are available for 30 of the accidents, including 11 of the 13 stall accidents. None of the foreign occurrences were stall related.

In the short-term, an expert panel will be convened by June 2019 to complete the evaluation. The results of the in-depth analysis will provide us with a measure of the extent to which the adoption of Rec 17-01 will reduce risk to the flying public. This, in turn will enable a cost-benefit analysis of the TSB's recommended regulatory change.

TSB reassessment of Transport Canada's response to Recommendation A17-01 (May 2019)

To date, Transport Canada (TC) has taken and plans the following actions to address the safety deficiency identified in Recommendation A17-01, regarding the requirement for all commercially operated DHC-2 aircraft in Canada to be equipped with a stall warning system:

- In 2018, TC initiated an in-depth examination of the effects of a stall warning system; and
- In 2019, TC will convene with an expert panel to complete the evaluation of the in-depth examination.

The Board acknowledges TC's continuing efforts in addressing this recommendation. However, until TC provides the TSB with its plan of action moving forward following the conclusions of its examination of the effects of a stall warning system, it is unclear if the safety deficiency identified in Recommendation A17-01 will be addressed.

Therefore, the Board is **unable to assess** Transport Canada's response to Recommendation A17-01.

Transport Canada's response to Recommendation A17-01 (December 2019)

TC agrees in principle with the recommendation.

In its last update in March 2019, TC committed to undertake an in depth study to determine the most effective means of addressing the risk associated with stall related accidents in DHC-2 aircraft.

This work has been completed.¹ In August 2019, TC convened a panel of experts in flight operations and flight testing to examine DHC-2 accident reports. The panel examined 13 stall related accidents involving DHC-2 aircraft between 2001 to 2016. Of these 13 accidents, the panel identified only 4 accidents where an artificial stall warning device may have been helpful in preventing the accident.

The analysis of the accidents showed that an artificial stall warning system would not likely have helped prevent the accident in the other cases given that the aircraft was operated outside its certification envelope (e.g. weight and balance) or was operated in an environment where a stall was inevitable (e.g. box canyon scenario).

However, the study demonstrated that in specific configurations, the DHC-2 provides little natural warning of an impending stall. In these configurations, even with a stall warning system installed, a stall occurs and gives the pilot little to no time to react and recover.

The panel noted that, in several cases, inadequate planning placed the aircraft in a situation where the risk of encountering a stall was highly probable, compounded by insufficient altitude to recover when a stall occurred.

In the light of the findings, TC determined that there is insufficient justification to proceed with mandating the installation of a stall warning system on all commercially-operated DHC-2 aircraft in Canada.

TC will continue to work to reduce the incidence of stall related accidents in DHC-2 aircraft by recommending the voluntary installation of stall warning systems on DHC-2s as per Civil Aviation Safety Alert 2014-02.²

TSB reassessment of Transport Canada's response to Recommendation A17-01 (March 2020)

In its March 2019 response, Transport Canada (TC) had committed to undertake an in-depth study to determine the most effective means of addressing the risks associated with stall-related accidents in DHC-2 aircraft. The study has been completed and TC has concluded that it will not require all commercially operated DHC-2 aircraft in Canada to be equipped with a stall warning system.

The TSB does not agree with TC's statement that, "...even with a stall warning system installed, a stall occurs and gives the pilot little to no time to react and recover."

¹ Transport Canada (2019), An Evaluation of the Potential of a Synthetic Stall Warning Device to Improve Safety in Commercial DHC-2 Beaver Operations. RDIMS-#15821663-A17-01 - AN EVALUATION OF THE POTENTIAL OF A SYNTHETIC STALL WARNING DEVICE TO IMPROVE SAFETY IN COMMERCIAL DHC-2 BEAVER OPERATION – (AUGUST 2019) – 2019-20 TSB REASSESSMENT – PHASE 3.

² Transport Canada (2014), Installation in DHC-2 Aeroplanes Not Originally Equipped of an Artificial Stall Warning System. Available at: <https://www.tc.gc.ca/en/services/aviation/documents/casa-2014-02.pdf>.

Since no new measures will be taken by TC to address the risks associated with stall-related accidents in DHC-2 aircraft, the Board believes that the risks associated with the safety deficiency identified in Recommendation A17-01 remain.

Therefore, the response to Recommendation A17-01 is assessed as **Unsatisfactory**.

Transport Canada’s response to Recommendation A17-01 (December 2020)

TC agrees in principle with the recommendation.

As noted in the last update of December 2019, TC has determined, based on research that was provided to the TSB, that mandating stall warning systems on DHC-2 aircraft is not supported. Alternatively, TC continues to promote the voluntary installation of stall warning devices on Canadian registered DHC-2s as promulgated by Civil Aviation Safety Alert 2014-02.³

No further action is planned by TC in connection with this recommendation.

TSB reassessment of Transport Canada’s response to Recommendation A17-01 (March 2022)

In its response, Transport Canada (TC) reaffirmed that it agrees in principle with this recommendation.

Although TC stated that it would continue to promote the voluntary installation of stall warning devices on Canadian-registered DHC-2s as promulgated by Civil Aviation Safety Alert 2014-02, TC has determined that mandating stall warning systems on DHC-2 aircraft was not supported.

Even though a stall warning system would not likely have prevented an accident in *all* the cases examined by TC, a clear indication of an impending stall increases the pilot’s situational awareness and reduces the likelihood of a loss of control in flight. The TC study indicated that in specific configurations, the DHC-2 provides little natural warning of an impending stall, which in itself speaks to the need for a stall warning system that will alert the pilot. However, TC concluded that “in these configurations, even with a stall warning system installed, a stall occurs and gives the pilot little to no time to react and recover.” The TSB does not agree with this statement.

To reduce the risk of losing control of an aircraft, the pilot must have an immediate, clear indication of an impending stall: immediate because it is urgent, and clear to prevent any possibility of mistaking the impending stall for another type of event. The aural, and sometimes visual, signal of an impending stall emitted by these warning systems means it is one of the last lines of defense against an accidental stall.

³ Transport Canada (2014). Civil Aviation Safety Alert 2014-02. *Installation in DHC-2 aeroplanes not originally equipped of an artificial stall warning system*. Available at: <https://tc.canada.ca/en/aviation/reference-centre/civil-aviation-safety-alerts/installation-dhc-2-aeroplanes-not-originally-equipped-artificial-stall-warning-system-civil-aviation-safety-alerts-casa-no-2014-02>

Level of risk is determined by the probability and severity of adverse consequences. Given the number of DHC-2s without a stall warning system in commercial operations, combined with the fact that low-altitude manoeuvres are an integral part of bush flying, it is reasonable to conclude that a stall at low altitude is likely to occur again. Because stalls at low altitude lead to catastrophic consequences, this type of accident carries a high level of risk.

Certification standards have evolved since 1948, and a stall warning system is now required for the certification of new aircraft as a last line of defense against accidental stalls.

Consequently, until TC establishes new measures to address the risks associated with stall-related accidents in DHC-2 aircraft, the Board believes that the risks associated with the safety deficiency identified in Recommendation A17-01 remain.

Therefore, the response to Recommendation A17-01 is assessed as **Unsatisfactory**.

Next TSB action

The Board has determined that because the residual risks associated with the deficiency identified in Recommendation A17-01 remain, and because no further action is planned by TC, continued reassessments will likely not yield further results.

The deficiency file is **Dormant**.