**ACCIDENT**

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| **Aircraft Type and Registration:** | Cessna 172M Skyhawk II, N9085H |
| **No & Type of Engines:** | 1 Technify Motors TAE 125-02-114 turbocharged diesel piston engine |
| **Year of Manufacture:** | 1975 (Serial no: 17265932) |
| **Date & Time (UTC):** | 30 April 2018 at 2045 hrs |
| **Location:** | Bermuda Airport, Bermuda |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - Minor Passengers - N/A |
| **Nature of Damage:** | Aircraft damaged beyond economic repair |
| **Commander's Licence:** | FAA Commercial Pilot's Certificate |
| **Commander's Age:** | 36 years |
| **Commander's Flying Experience:** | 878.6 hours (of which 748.6 were on type)<br>Last 90 days - 0 hours<br>Last 28 days - 0 hours |
| **Information Source:** | AAIB Field Investigation |

## Synopsis

Shortly after takeoff the aircraft exhibited a tendency to pitch nose down despite the application of NOSE UP trim. During the subsequent approach to land, the forces required to maintain the approach path increased to the point where the pilot could no longer control the glidepath and the aircraft struck the ground short of the runway. The investigation found that the drive chain for the elevator trim actuator had been fitted incorrectly, which resulted in the elevator trim tab moving in the opposite sense to the movement of the trim wheel.

The maintenance organisation has introduced procedures to ensure that duplicate inspections of all flight critical systems are carried out following maintenance.

## History of the flight

The flight was planned to consist of a number of circuits and landings to refamiliarise the pilot with the aircraft. The pilot had not flown for several months while the aircraft had undergone a prolonged maintenance input. As this was the aircraft's first flight after maintenance, the pilot fully checked the flying controls and their range of movement during the pre-flight checks. On completion of the in-cockpit pre-flight checks, the pilot confirmed that the elevator trim was set to the correct position for takeoff by checking that the trim indicator was in the TAKEOFF position.

The initial stage of the takeoff appeared normal but as the aircraft passed through 200 ft the pilot noted that the rate of climb appeared lower than expected. After reaching 1,000 ft, the pilot levelled the aircraft and reduced the engine power to maintain circuit height but found that the aircraft tended to pitch nose down even after the application of NOSE UP trim. The pilot increased engine power on the downwind leg of the circuit, which alleviated the tendency to pitch down and reduced the control forces.

The pilot decided to terminate the flight and informed ATC of her intentions. After turning onto the base leg and reducing airspeed, the pilot found that the nose-down pitch forces increased despite applying more NOSE UP trim. In an attempt to stabilise the aircraft, the pilot applied more engine power which reduced the forces but increased the aircraft's ground speed. During the final approach, the pitch-down tendency increased to the point where the pilot was unable to maintain the glidepath. The aircraft struck the ground approximately 15 metres from the runway threshold and continued along the ground before coming to a halt on the paved surface. The aircraft suffered significant damage (Figure 1) and the pilot, who had suffered minor injuries, was assisted from the aircraft by the AFRS.


**Figure 1**

Image of the aircraft taken shortly after the accident

### Cessna 172 elevator trim system

The Cessna 172 is fitted with a moveable trim tab on the right elevator. The trim tab is used to 'trim' the aircraft and allow it to be flown at various attitudes with minimal pilot control force. The elevator trim system consists of a cockpit-mounted wheel and position indicator connected to a pair of cables which extend, through a series of pulleys, to the elevator trim tab actuator (Figure 2). The two cables are connected at the elevator by a length of chain which is looped around a sprocket on the trim tab actuator. A chain guard ensures that the chain remains engaged with the sprocket.

Rotation of the trim wheel moves the drive chain on the actuator sprocket, extending or retracting the actuator which in turn moves the trim tab. When the cockpit control wheel is turned, the position indicator moves to indicate the direction of trim wheel movement, either NOSE UP or NOSE DOWN. Movement of the trim wheel in a NOSE UP direction results in the elevator trim tab moving downwards in relation to the elevator and movement of the trim wheel in a NOSE DOWN direction results in the elevator trim tab moving up. Prior to takeoff, to ensure that adequate pitch control is available, the elevator trim tab is set to the neutral position, identified by the TAKEOFF position marked on the trim position indicator.

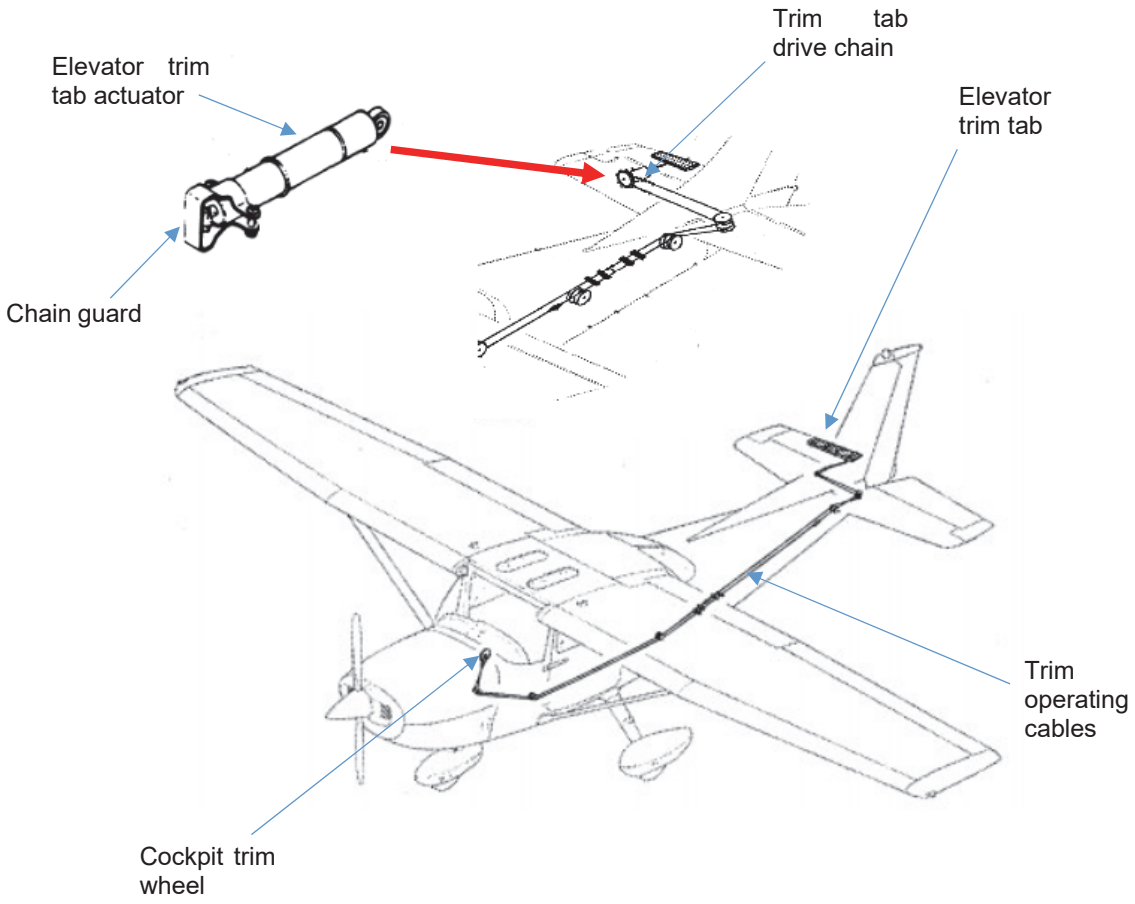


**Figure 2**

Cessna 172 pitch trim system

## Aircraft examination

Examination of the aircraft was conducted by members of the Bermuda Civil Aviation Authority (BCAA) under the guidance of the AAIB and by representatives of the aircraft operator and maintenance organisation.

To identify engine-related issues, the engine's control unit (ECU) was removed from the aircraft and shipped to the AAIB where it was downloaded. The data showed several power and rpm exceedances associated with the pilot's use of engine power to assist with pitch control on the downwind leg of the circuit and during the approach to land. No other exceedances, cautions or fault messages were recorded during the flight.

Given the pilot's report, the investigation focussed on the aircraft's flying controls. No defects were found within the aileron, rudder or elevator control circuits or the range and freedom of control surface movement. Photographs of the aircraft, taken immediately after the accident (Figure1) showed the elevator trim tab in a position which corresponded to a NOSE DOWN trim position. Operation of the elevator trim system showed that the elevator trim tab moved in the opposite sense to the movement of the elevator trim wheel in the cockpit, with movement of the trim wheel to increase NOSE UP trim resulting in movement of the trim tab to increase the aircraft's tendency to pitch NOSE DOWN. Detailed examination of the aircraft, carried out by the BCAA and the operator, confirmed that the trim tab drive chain was engaged on the actuator drive sprocket and that the chain guard was correctly fitted. Further examination showed that the elevator trim system cables were correctly routed through the fuselage but the section of the cables and chain in the horizontal stabiliser had been rotated through 180°, crossing the cables and drive chain. This resulted in the trim tab moving in the opposite sense to that commanded by the trim wheel input.

**Aircraft maintenance oversight**

N9085H was operated and maintained by a Bermuda-based organisation, holding BCAA approvals for the continued airworthiness and maintenance of several aircraft. Prior to the leasing of N9085H, the BCAA had requested changes to the aircraft's maintenance program, which were implemented, but responsibility for airworthiness regulatory oversight remained with the FAA and the maintenance of the aircraft was carried out by two FAA-licensed engineers.

The maintenance organisation's procedures for Bermuda-registered aircraft included a requirement to carry out duplicate inspections of all flight-critical components, including flying controls and trim systems, after any maintenance action. There was no equivalent FAA requirement for the maintenance of N9085H.

**Maintenance history**

Examination of the aircraft's maintenance records showed that the aircraft had undergone a prolonged maintenance input prior to the accident flight during which the elevators, rudder and horizontal and vertical stabilisers had been removed to allow replacement of the horizontal stabiliser's forward spar.

The procedure for the removal and reinstallation of the elevators, elevator trim system and rudder are detailed respectively in sections 8, 9 and 10 of the Cessna 172 Aircraft Maintenance Manual (AMM). Section 9, states in paragraph 9-2 " *A "nose-up" setting results in a tab-down position".* The instructions also provide a warning at the end of the procedure which states:

*WARNING*

*Be sure trim tab moves in correct direction when operated by trim wheel.*
*Nose down trim corresponds to tab up*

Interviews with the mechanics involved in the maintenance of N9085H, conducted by the operator, confirmed that reference had been made to the AMM, including the warning relating to the trim tab movement, when reinstalling the flying controls. No abnormalities were identified during any of the post-installation function checks. Because there was no requirement to do so, a duplicate inspection of the elevator trim system was not carried out.

## Analysis

The investigation confirmed that the elevator trim system had been rigged incorrectly, resulting in movement of the elevator trim tab in the opposite sense to the pilot's control inputs. The cables and drive chain which operated the trim tab actuator were rotated by 180° from their normal position within the horizontal stabiliser, reversing the movement of the trim tab. The presence of the elevator trim tab actuator chain guard, and the fact that the drive chain was still engaged on the actuator drive sprocket, confirmed that the actuator drive system had been assembled incorrectly during the maintenance input prior to the accident flight.

The movement of the elevator trim tab in the opposite sense to the movement of the control wheel, highlighted in the warning at the end of the AMM trim system reinstallation procedure, provided an opportunity for an incorrectly-connected trim system to be identified and corrected. The use of a duplicate inspection of flight critical systems, such as the elevator trim system, would have provided an additional opportunity to identify the mis-assembly of the pitch trim system. As the aircraft was being maintained in accordance with FAA regulations, there was no requirement to carry out a duplicate inspection.

The behaviour of the aircraft shortly after takeoff did not match the behaviour anticipated by the pilot. It has been demonstrated that such situations[1] induce a significant increase in the pilot's mental workload which greatly increases the time taken to assess the unexpected situation and carry out corrective actions. The pilot's lack of recent flying experience in the aircraft, and the increase in physical workload, required to control the aircraft, would have compounded this effect.

## Safety actions taken

The Bermuda-based maintenance organisation has introduced procedures to ensure that duplicate inspections of all flight critical systems are carried out, in line with its BCAA-approved maintenance procedures, on any aircraft that they operate or maintain, regardless of its State of Registration.

**Footnote**

[1] Annemarie Landman, Eric L. Groen, M. M. (René) van Paassen, Adelbert W. Bronkhorst & Max Mulder (2017) The Influence of Surprise on Upset Recovery Performance in Airline Pilots, The International Journal of Aerospace Psychology, 27:1-2, 2-14, DOI: 10.1080/10508414.2017.1365610