SYSTEM KNOWLEDGE STALL

MISHAP
A Cessna 525A CitationJet CJ2+ had a loss of control accident during a flight from Leeds/Bradford Airport to Palma de Mallorca.

Late in the morning of the 31st of December 2013, N380CR a Cessna 525A (Citation CJ2+) was pulled out of the heated hangar where it was kept at UK Leeds Bradford Airport. The single pilot completed the flight preparation for a flight to Palma de Mallorca in Spain. Once all set, the only passenger boarded the aircraft together with three small dogs. While the pilot and the passenger wore the seat belts, the three small dogs remained unrestrained and rested near the passenger.

Since the day was cold and some layers of clouds were expected during the climb, the pilot selected the pitot and static heat on before departure. Takeoff and initial climb were uneventful.

The freezing temperatures above 4300ft posed no significant danger. Regardless the pilot had selected both engine anti-ice and wind and tail de-ice on as a precaution.

Regarding the autopilot, the pilot had noticed in previous flights that the aircraft tended to "hunt" in pitch in Flight Level Change mode. Therefore he opted to operate in vertical speed (VS) mode during climb.

Experience might be an expensive teacher when the subject is travelling in the air. Capt. Carl C. Norgren and Michael R. Grüninger exemplify the importance of monitoring airspeed

Initially he set the VS to 2,000 feet per minute (ft/min) in Maximum Continuous Thrust. While climbing, the pilot decreased the VS in 500 ft/min decrements.

When passing FL 410 the aircraft was climbing with 1000 ft/min and the Indicated Airspeed (IAS) slowed to 150 kts.

The pilot noted that the indicated airspeed was lower than he had expected. The green "donut" marker on the speed tape showing a Vref, slightly faster than the actual airspeed at 128 kts. Based on his experience the pilot believed that the aircraft would have sufficient energy in reserve, to reach FL 430 and he further reduced the VS to 5000 ft/min.

Between FL420 and 430 the pilot discontinued monitoring the energy status and focussed on checking the forecast winds on his tablet. Suddenly, while he was head-down, he heard a "click" and the aircraft pitched severely nose-down and rolled to the right.

The aircraft had almost reached FL 430, but the airspeed had decreased to stall speed. In stall, the aircraft executed four 360s to the right losing altitude with a rate of 20,000 ft/min. It's only when the pilot reached VMC below high stratus clouds, that he was able to regain control of the aircraft.

The aircraft had not given any warning. No pre-stall buffet, no stick-shaker, no stall warning. In fact, the angle of attack vane of the aircraft was frozen.

Climbing with VS

Although the AFM does not prohibit the use of the VS mode during climb, a pilot selecting this mode risks that the kinetic energy decreases below stall speed.

SAFETY
A second pilot provides a monitoring function that might prevent loss of control.

The decision to select VS mode during climb the distraction in the last phase of the climb, combined with the failure of the stall warning system, put the pilot in a difficult situation and made the aircraft stall.

In VS mode the autopilot prioritises vertical speed over airspeed. Pilot vigilance and intervention are required to avoid a low-speed condition.

Recognizing Decluttered PFD

When the AOA exceeds a certain amount, the PFD displays a decluttered image which reduces complexity and focuses on the information required to exit the upset condition. The main features are big chevrons indicating the direction to which to pitch to recover from the stall. Large red chevrons point towards the horizon line when the pitch attitude approaches 30° up or down.

Recovering from a Full Stall

The pilot had previously attended a "jet upset" course on an L-39 aircraft in Albuquerque, New Mexico. So prepared, the pilot managed to stabilise the Cessna 525A as soon as he was in VMC again. The passengers and the three small dogs remained unharmed.

Know Your Aircraft

The AAIB report highlighted the relationship between systems knowledge and decision-making. The pilot did underestimate the necessity to monitor airspeed while climbing. To focus on wind forecasts in a situation of low-energy was a wrong decision.

Structural Damage

The high overload exerted during the stall recovery caused five ribs in the outboard wingbox of the left and right wings to buckle. The bonded joints between the ribs and the upper and lower wing skins failed. The upper and lower outboard wing skins of both wings were permanently deformed with a significant loss of aerofoil shape.

Despite such deformation, the integral fuel tank did not leak. The damage was consistent with symmetrical pullout manoeuvre loads between +3.6*g* ("limit load") and +5.4*g* ("ultimate load"). The limit load is the load level that the aircraft's structure must be capable of sustaining without permanent deformation or damage occurring.

The prescribed minimum factor of safety in FAR/CS-23 aircraft, such as the Cessna 525A, for limit loads is 1.5, meaning that the ultimate positive load factor on the aircraft is at least +5.4*g*.

When the structure is subjected to load levels above the limit load but lower than the ultimate load, the structure must withstand the additional load but may permanently deform whilst doing so.

Human Factors

The pilot was operating a modern aircraft approaching FL 430 as a single flight crew member at the age of 69 and within the privileges of a private pilot's licence. At a critical moment in the flight he took his attention away from the primary flight instruments to review weather charts stored on a PED. Head-down, with airspeed decaying and the aircraft suddenly stalling and the autopilot disconnecting, the pilot was startled.

To overcome this startle effect the pilot must regain situational awareness and be able to effectively judge the situation. Effective mitigating actions were delayed by the confusion of unfamiliar information on the PFDs. The unfamiliarity with the sights and sounds during an in-flight upset delays corrective action as the brain races to understand the situation.

The aircraft performed ever faster spins and the rate of descent increases to 20,000 ft/min. The discomfort of high *g* forces and unfamiliar indications on the PFDs compounded an already difficult situation for the single pilot. Despite the aircraft being out-of-trim the pilot regained control of the aircraft around flight level 240.

The fact that the stall occurred at FL 430 allowed sufficient altitude for a recovery. Daylight VMC conditions also facilitated spatial orientation.

Had the weather conditions not been VMC and the stall occurred at lower altitudes the aircraft may well have been lost.

Know When You Need a "Safety" Pilot

The decision to fly without a second pilot, although in line with regulations, has to be questioned considering the low recent flight experience (16 hours in 90 days) as well as the fact that the pilot was 69 years old. A Cessna Citation jet is a fast-moving complex machine.

A second pair of eyes reduces the workload and provides a monitoring function which might prevent such a loss of control at altitude.

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