Airbus A320-232, G-TTOA

AAIB Bulletin No: 12/2004	Ref: EW/G2004/04/14	Category: 1.1
INCIDENT		
Aircraft Type and Registration:	Airbus A320-232, G-TTOA	
No & Type of Engines:	2 International Aero Engine V2527-A5 turbofan engines	
Year of Manufacture:	2000	
Date & Time (UTC):	15 April 2004 at 0750 hrs	
Location:	Near Malaga, Spain	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 6	Passengers - 115
Injuries:	Crew - 4	Passengers - 2
Nature of Damage:	Nil	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	48 years	
Commander's Flying Experience:	13,750 hours (of which 2,150 were on type)	
	Last 90 days - 143 hours	
	Last 28 days - 70 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

A320 autopilot controls

The controls for the A320 autopilot are mounted on the Flight Control Unit (FCU) above the instrument panel. Fundamentally, the autopilot and autothrottle attempt to acquire or maintain target parameters determined either by manual inputs made by the handling pilot or by computations from the Flight Management Guidance System (FMGS). When the target parameter is set by the FMGS, the term 'managed' is used for the target parameter. When the target parameter is set by the flight crew, the term 'selected' is used.

The altitude and speed selection controls can either be pushed or pulled. When turned, the altitude selector knob adjusts the target altitude (or flight level) and when pushed, the same knob allows the FMGS to 'manage' any intermediate altitude constraints entered into a route. When pulled, the altitude selector knob triggers an 'open' climb or descent. The term 'open' means that any intermediate altitude constraints within the active route computed by the FMGS are ignored. When in descent, it also means that idle thrust is selected and airspeed is controlled by the elevators.

The speed selection control has comparable functions. When pushed, the target 'managed' speed is determined by the FMGS computation and the speed selection window is blanked. When pulled, it enters the current speed into the FCU SPD/MACH window and allows the pilot to adjust the target speed by rotating the knob. The speed selection options also include a change over push button whereby the target speed may be defined as a Mach number or as a calibrated airspeed. (In this context, calibrated airspeed or CAS is very similar to indicated airspeed or IAS).

Speed control

Mach number is a function of true airspeed and air temperature whereas IAS is largely a function of true airspeed and air density. Consequently, when an aircraft descends at a constant IAS, the Mach number reduces but when an aircraft descends at a constant Mach number, the IAS increases.

The suffix 'MO' may be added to a speed to indicate that it is the maximum permitted operating speed. If the aircraft's speed exceeds V_{MO} +6 kt or M_{MO} +0.006 Mach, or is likely rapidly to accelerate above these speed limits, the A320 flight control system adds a pitch-up load factor demand with a maximum authority of 0.75g to any pilot input. If an autopilot is engaged when this high speed protection is activated, the autopilot disconnects.

History of Flight

Both pilots were feeling tired at the start of their duty. They had just completed a pattern of three late finishes followed by a time assigned day (which became a day off) and a subsequent very early start on the day of the incident.

The co-pilot was acting as handling pilot and the aircraft was level at FL310 with the autopilot engaged in selected SPD (speed) control mode. The aircraft had been descended to FL310 unusually early by Madrid ATC and on commencing the approach for Malaga Airport, the co-pilot initiated a descent in the 'managed' lateral and vertical navigation modes. He also changed the speed target from SPD to MACH control mode. He did this because he thought he must have accidentally selected SPD mode with the SPD/MACH changeover button at some earlier time whilst adjusting the selected Mach number target. At the time he thought that automatic changeover from Mach 0.78 to the equivalent CAS speed of 300 kt should not take place until passing through FL285. After levelling at FL250, further descent to FL130 was initiated in the open descent mode.

On passing FL220 the aircraft was descending at 4,800 ft/min and maintaining a speed of between M 0.78 and M 0.79. The CAS had increased to 349 kt and the Mach number was approaching V_{MO} with the speed trend arrow indicating a continued acceleration to a speed well above V_{MO}.

The commander called "speed" to the co-pilot and a lower Mach number, equivalent to 320 kt CAS, was selected on the FCU although the autopilot and autothrottle were kept in the MACH mode. One second later the autopilot was disconnected and a further second later both pilots simultaneously applied aft stick demands of approximately 10° each in an attempt to prevent an overspeed. This resulted in the aircraft experiencing a sudden increase in normal acceleration, peaking at 2g, before returning to about 1g. For a further eight seconds both pilots continued to make inputs on their respective side stick controllers, with neither pilot pressing their sidestick take-over button. The autothrust remained engaged throughout and no speedbrake was used.

At the time of the incident the passenger seat belt signs were ON and the cabin crew were preparing the cabin for landing. The sudden increase in normal acceleration caused three of the four cabin crew to be thrown to the floor. Two of them suffered minor injuries and a third, who was in the aft galley, suffered a broken ankle. The fourth cabin crew member, who was occupying a passenger seat at the front of the cabin, was thrown onto an armrest. Two passengers also later complained of stiff necks.

After the incident the aircraft continued to make a normal landing at Malaga where medical assistance was provided.

Discussion

Selection of the MACH speed mode by the co-pilot was made after the aircraft had automatically selected the SPD mode during its descent to FL310. This had the effect of leaving the aircraft in MACH mode for the remainder of the descent unless the pilots had again made a manual selection, reverting back to the SPD mode.

With the autopilot in the MACH mode the aircraft attempted to maintain the selected Mach number, resulting in an ever-increasing CAS as the aircraft descended. Eventually this increase in airspeed lead to a point where the CAS required to maintain the selected Mach number exceeded V_{MO}.

The pilots had not recognised that, late in the descent, the aircraft was still being flown in the MACH mode and had not therefore appreciated, in relation to V_{MO}, the relevance of the Mach number previously selected as the aircraft descended.

With the aircraft close to V_{MO} and the speed trend significantly exceeding the V_{MO} red band, but before high speed protection activates, the Flight Crew Operating Manual (FCOM) gives the following procedures:

- *Select a lower target speed on the FCU and, if the aircraft continues to accelerate, onsider disconnecting the AP. (Autopilot)*
- *Before re-engaging the autopilot, smoothly establish a shallower pitch attitude.*

In this instance having selected a lower Mach number, both pilots almost immediately disengaged the autopilot in order to reduce the descent rate and so try and avoid exceeding V_{MO}. Either pilot's control input individually would probably have had the desired effect on both pitch and speed but, with neither pilot using their sidestick take-over button the inputs were summated, leading to the aircraft rapidly changing pitch and experiencing an increase in pitch-up and 'g' above that intended.

Of note is that whilst both pilots immediate reaction might be considered instinctive, they both continued to make inputs for a further eight seconds without realising that the other was also making sidestick inputs.

This situation of dual side stick inputs has arisen in several previous incidents and accidents and it is highlighted in the report on C-GTDK appearing in this bulletin. A modification exists which warns when dual inputs are being made. Had it have been fitted in this instance, it is unlikely to have prevented the cabin crew being injured, as this was the result of the pilots' initial actions before any warning might have been received or acted upon. It would, however, have prevented the potentially hazardous situation arising whereby both pilots were making control inputs after the initial event, each thinking he was in control.

Irrespective of the technology available, the importance of simply stating "I have control" cannot be underestimated.