Altitude excursion, Boeing 737-300, 9H-ABT

Micro-summary: This Boeing 737-300 diverted from its clearance by 1400' and 600' under MSA on approach.

Event Date: 1997-08-01 at 0943 UTC

Investigative Body: Aircraft Accident Investigation Board (AAIB), United Kingdom

Investigative Body's Web Site: http://www.aaib.dft.gov/uk/

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Boeing 737-300, 9H-ABT

AAIB Bulletin No: 5/98 Ref: EW/C97/8/3Category: 1.1

Aircraft Type and Registration:	Boeing 737-300, 9H-ABT
No & Type of Engines:	2 CFM56 turbofan engines
Year of Manufacture:	1993
Date & Time (UTC):	1 August 1997 at 0943 hrs
Location:	On approach to Manchester Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 7 - Passengers - 93
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Nil
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	11,765 hours (of which 7,500 hours were on type)
	Last 90 days - 255 hours
	Last 28 days - 96 hours
Information Source:	AAIB Field Investigation

History of flight

The crew were operating a scheduled flight, as AMC 202, from Malta to Manchester. For the first part of the flight, the first officer was the handling pilot. However, the forecast weather at Manchester indicated that Low Visibility Procedures (LVP) would be required and, in accordance with company procedures, this would require the commander in the left seat to be the handling pilot. Therefore, towards the end of the cruise, the commander took over the handling duties and the first officer assumed the normal non-handling duties including the radio monitoring and response. Prior to flight, the commander had confirmed the serviceability of the aircraft and noted that there were no 'Carried Forward Defects' in the Technical Log; additionally, he had also confirmed that both the first officer and himself were qualified to carry out the expected LVP approach. Throughout the flight, the aircraft was fully serviceable.

Before descent, the crew obtained the airport weather information and the commander briefed for the expected approach to Runway 24 at Manchester. Information 'X', timed at 0850 hrs,

confirmed the landing runway as 24 and described the weather as follows: "Surface wind 220°/06 kt, visibility 2,500 metres in drizzle, cloud broken at 100 feet and overcast at 300 feet, temperature and dew point 16°C, QNH 1011 mb and a wet runway." During the descent, the crew were instructed to enter the 'Hold' at 'Dayne' and, while in the 'Hold', were transferred to Manchester Director on frequency 121.350 MHz at 0936 hrs. On initial contact,the crew confirmed their cleared level as FL 70 and this was acknowledged by the controller together with the message that they would shortly be leaving the 'Hold'.

Then, at 0937 hrs, the controller passed three separate messages to AMC 202: the first was to fly at a speed of 180 kt, the second was to descend to FL 50 and the third was to cancel the 'Hold' and to turn right onto 010°. All these messages were passed clearly and acknowledged correctly by the crew. At 0940 hrs, the crew reported level at FL 50. Shortly afterwards, the controller passed two further messages to AMC 202. The first was: "AMC202 reduce to 160 kt and maintain until at four DME"; this was acknowledged as: "160 kt till four DME AMC 202". Then, the controller transmitted: "202 correct descend to altitude four thousand feet QNH 1011"; the crew replied: "Four thousand feet on QNH 1011 AMC 202". Within the cockpit, the clearance to an altitude was the prompt for the crew to action their 'Approach checks'. At 0942 hrs, the controller turned the aircraft left onto a heading of 335°M and this was acknowledged correctly. Then, at 0943, the controller noted from his radar display that AMC 202 was indicating at a altitude lower than cleared and immediately asked the crew to confirm their altitude. When AMC 202 stated that they were: "Passing two thousand four hundred feet", the controller promptly replied: "AMC 202 climb to three thousand feet immediately your cleared level was four thousand feet". The crew responded immediately with an application of power coincident with their radio acknowledgement. Thereafter, the controller advised them that the minimum safe altitude in their immediate area was three thousand feet and gave them radar vectors to intercept the ILS. The aircraft landed uneventfully shortly afterwards.

Radar information

Radar information was available from the Plessey Watchman Radar at Manchester and this indicated that the aircraft reached a minimum altitude of 2,300 feet; the radar information is based on the airfield QNH of 1011 mb. Calculations show that the aircraft descended continuously from FL 50 at a rate of 1,000 to 1,400 feet per minute to an altitude of 2,300 feet and then climbed at 1,700 feet per minute to 3,000 feet. The radar information was superimposed onto a map to determine the aircraft's proximity to the ground and whether any of the aircraft warning systems should have activated. Taking account of possible errors, the aircraft track related to altitude would have given an approximate lowest terrain clearance of 500 feet. However, if the aircraft had descended to 2,000 feet, the terrain clearance would have been less than 500 feet. Within approximately one mile of the point at which AMC 202 reached 2,300 feet, there was high ground rising to 2,037 feet.

Altitude restrictions

The highest minimum sector altitude (MSA) for Manchester is 3,500 feet; this is based on a minimum clearance of 1,000 feet above the highest obstacle within 25 nm of Manchester. The crew of 9H-ABT were using 'Jeppeson Airway Manual' information. The Manchester chart 10-4 contained a comment that: "Due to high ground east of the airport, descent below 3,000 feet will be in accordance with chart Manchester 18-1". Chart, 18-1, included a comment that: "Aircraft entering airspace between TMA boundary and boundary of Radar Vectoring Area between the extended centre-line Runway 24 and Manchester VOR/DME R-170 will be cleared initially not less than

4,000 feet. ATC will not clear aircraft for descent below 4,000 feet until within the Radar Vectoring Area." This later chart displayed a MSA for the south east area of 3,100 feet as did the approach charts for Runway 24. The MSA for the north east area is 3,500 feet.

Ground Proximity Warning System

The GPWS of 9H-ABT was subsequently checked and confirmed as serviceable for all modes. The relevant mode for this incident is 4B; this gives a warning for: 'Unsafe Terrain Clearance With Landing Gear Not Down'. The mode has two boundaries depending on aircraft speed. With 9H-ABT at 160 kt, the standard upper boundary is 500 feet radar altitude; since no warning activated, the terrain clearance was greater than 500 feet.

ATC procedures

The R/T exchanges between ATC and the crew of 9H-ABT were standard and clear. All other ATC procedures were in accordance with the Manual of Air Traffic Services. There was no requirement for the controller to monitor Mode 'C' for altitude confirmation but his normal mode of operation is to use a 'scan' procedure whereby he checks each aircraft on his screen in turn. In this incident,the controller had instructed AMC 202 to descend to 4,000 feet and had heard a clear acknowledgement. Thereafter, with other aircraft under his control, his next instruction to AMC 202 was an instruction to turn left; as he passed this instruction, he noted the aircraft's Mode 'C' readout as about 4,000 feet. When he next reviewed AMC 202, he noted the discrepancy between the Mode 'C' information and the assigned altitude. His response to this discrepancy was immediate and clear.

Company and crew procedures

The requirement to check the MSA and monitor altitude during the descent is comprehensively covered in the company manuals. Both crew members remember briefing 3,100 feet as the MSA and remember being cleared to 4,000 feet. Then, the commander set 4,000 feet on the Mode Control Panel (MCP) and cross-checked the selection with the first officer. Thereafter, the commander called for the 'Approach' checks; these checks comprised: 'Altimeters and Instruments - Set and Crosschecked' and 'N1/IAS bugs - Checked and Set'. Following the completion of the 'Approach' checks, both crew members stated that they were then cleared to 2,000 feet; the commander remembers setting this new altitude on the MCP and the first officer stated that he acknowledged this instruction from ATC. From that time, until they were instructed to climb, neither crew member was aware of looking at the radar altimeter display but both were certain that the Ground Proximity Warning System (GPWS) did not activate.

Radio recording

A clear recording was available of frequency 121.350 MHz. With the crew's recollection that they were passed and acknowledged a clearance to descend to 2,000 feet, the recording was examined to determine if any such message or anything similar was evident. The initial clearance and acknowledgement to 4,000 feet, which was recalled by the controller and both pilots, was clear. There was no evidence of any clearance to 2,000 feet from the controller. Furthermore, there were no other aircraft on frequency with similar callsigns and 3,000 feet was the lowest altitude to which an aircraft on frequency was cleared. Finally, the recording was evaluated to determine if any transmissions from other sources were evident; none were detected and no replies from AMC 202, to acknowledge a clearance to 2,000 feet, were heard.

Discussion of incident

The flight was uneventful until AMC 202 was cleared to 4,000 feet. This clearance was correctly acknowledged and was the expected minimum for the location of the aircraft. Subsequently, the crew were sure that they had been further cleared to 2,000 feet; there was no evidence of this clearance on the R/T recording. Furthermore,any such clearance would have been below MSA and should not have been accepted by the crew without confirmation as the commander has the ultimate responsibility for terrain clearance.

Since there was no evidence that AMC 202 was cleared to 2,000 feet, the crew must initially have set the wrong altitude on the MCP or there must have been an uncommanded change on the MCP. An uncommanded change on the MCP is not unknown on the B737 but crews are aware of this possibility and should still be continuously monitoring aircraft altitude. With the crew's perception that they had been cleared to 2,000 feet at some point, the most likely scenario is that 2,000 feet was incorrectly set on the MCP when AMC 202 was initially cleared to 4,000 feet. This would have occurred at a time when the crew were cleared for the relatively short descent from FL50 to 4,000 feet on QNH 1011 mb. As well as acknowledging the clearance, the crew needed to reset their altimeters, set the MCP altitude, interrogate the Flight Management Computer (FMC) to confirm Vref speeds and then both confirm and set their 'Bug' speeds on their ASIs. Examination of the radar recording shows that AMC 202 then made a continuous descent from FL 50 to 2,300 feet indicating that the error probably occurred at FL 50. Awareness of the applicable MSA should have prompted a question in the crew's mind; it may be relevant that the commander stated that he had a high regard for UK controllers and was confident that, under radar control, he was in a suitable location for the cleared altitude.

Examination of the radar recording indicates that the aircraft would not have contacted the ground on its cleared track but was below the published safety altitude; 9H-ABT was never closer than 500 feet from the ground. The monitoring by the controller was commendable as was his rapid reaction to the perceived altitude discrepancy; the flight crew also reacted immediately to the ATC instruction to climb.

Following the incident, the operating company reviewed its procedures and have now reduced the actions required during the 'Approach' checks.

Minimum Safe Altitude Warning (MSAW)

During the investigation, it was discovered that the Federal Aviation Administration (FAA) has furnished some ATC facilities with a computer function to assist controllers in detecting aircraft that are within or are approaching unsafe proximity to terrain/obstacles. The function generates an alert when a participating aircraft is, or is predicted to be, below a predetermined minimum safe altitude. Federal Aviation Regulations are similar to the Air Navigation Order (ANO) in that pilots are responsible for safe altitude management. However, MSAW provides the controller with information of an altitude infringement which could be relayed to the pilot; the system would seem to be an appropriate facility for some UK ATC units.

National Air Traffic Services Limited (NATS), as UK national representatives, are aware of the system and are reviewing the operational requirements and concepts of MSAW as part of the European Air Traffic Control Harmonisation and Integration Programme (EATCHIP).