Close Call in Khartoum

BY MARK LACAGNINA

Confusion reigned when an A321 was flown below minimums in a sandstorm.

A navigation fix that was not where the flight crew thought it was, omission of standard callouts and a mix-up in communication about sighting the approach lights were among the factors involved in an unstabilized approach that was continued below the minimum descent altitude (MDA) in nighttime instrument meteorological conditions (IMC) at Khartoum, Sudan, on March 11, 2005.

The Airbus A321 "came hazardously close to the ground" before the crew realized their mistake and initiated a go-around, said the U.K. Air Accidents Investigation Branch (AAIB) in its final report on the serious incident. A few seconds later, when the aircraft was 125 ft above ground level (AGL), the terrain awareness and warning system (TAWS) generated a "TERRAIN, PULL UP" warning.

The report said that if the go-around had been initiated six seconds later, the aircraft likely would have struck the ground 1.5 nm (2.8 km) from the runway threshold. The TAWS warning occurred between 3.4 and 5.1 seconds after the go-around was initiated.

"Given that procedural triggers to go around had not been effective, it is of concern that the warning system may not have provided sufficient alert time to prevent an impact with the ground," the report said.

The TAWS was found to have functioned according to applicable design and installation standards. The system received position information from the A321's flight management and guidance system (FMGS) based on multi-sensor area navigation calculations.[1] The report said that position information received directly from

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an on-board global positioning system (GPS) receiver is more accurate and results in more timely warnings.

Without a direct GPS feed, TAWS sensitivity is reduced when the aircraft is near the runway to prevent nuisance warnings that might be caused by less accurate position information. If the system in the incident aircraft had received position information directly from the on-board GPS and incorporated the latest software changes, a "TOO LOW, TERRAIN" warning likely would have been generated when the aircraft was at 240 ft AGL.

"The current TAWS standards undoubtedly were appropriate at the time of implementation, and statistics show that they have significantly reduced the CFIT [controlled flight into terrain] risks, most likely saving many lives," the report said. "However, operational experience of indirect GPS installations that do not directly feed GPS quality data to the TAWS … has highlighted problems that have been addressed by the TAWS manufacturers but that are not required to be implemented.

Airbus A321-200

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The A321 is a stretched version of the A320. The A321-200 has more fuel capacity, a higher takeoff weight and greater range than the -100. The incident airplane is an A321-231 that was built in 2002; it has International Aero Engines V2533-A5s rated at 146.8 kN (33,000 lb thrust), a maximum takeoff weight of 89,000 kg (196,209 lb) and a maximum landing weight of 79,000 kg (174,163 lb).

Source: *Jane's All the World's Aircraft*

"In essence, the CFIT protection technology has improved, but the required minimum TAWS standards have not. Thus, significant improvements in aviation safety in this area are available but not mandated."

Among recommendations based on the incident investigation, AAIB urged the European Aviation Safety Agency to work with industry on a review of TAWS design and installation standards "with particular emphasis on the timeliness of alerting when close to the runway." AAIB said, "Revisions to these standards arising from this review should apply [retroactively] to all aircraft currently covered by the TAWS mandate."

Sandstorm

The British Mediterranean Airways flight had originated in Amman, Jordan, at 2130 coordinated universal time (UTC; 2330 local time) with 19 passengers and eight crewmembers.[2] The commander, 46, had 7,400 flight hours, including 3,700 flight hours in type. The copilot, 39, had 4,700 flight hours, including 3,200 flight hours in type.

"The weather forecast for Khartoum, obtained before departure, had reported gusting northerly winds and reduced visibility in blowing sand," the report said. "During the cruise, and once they were in Sudanese airspace, the copilot asked ATC [air traffic control] for the latest weather report for Khartoum." The controller said that the surface winds were from the north at 20 kt and visibility was 1,000 m (5/8 mi) in blowing sand.

Runway 36 was in use. A notice to airmen advised that the instrument landing system (ILS) was not in service. The commander decided to conduct the VHF omnidirectional radio/distance measuring equipment (VOR/DME) approach. The Khartoum VOR/DME (KTM) is 0.6 nm (1.1 km) south of the Runway 36 approach threshold.

"Neither pilot had previously operated in blowing sand, and both were concerned about the possible implications," the report said. The pilots found no information about blowing sand in the airline's operations manual and used information about volcanic ash for guidance.

"As a result, the pilots discussed various possible actions, and the commander chose to select continuous ignition on both engines for the approach," the report said.

Although reported as blowing sand, the meteorological condition at Khartoum had the characteristics of a sandstorm. "Blowing sand is associated with strong winds which raise the particles above ground level but no higher than 2 m [7 ft]," the report said. "Sandstorms are usually associated with strong or turbulent winds that raise particles much higher." The operations manual recommended that pilots avoid flying in a sandstorm whenever possible.

Managed Approach

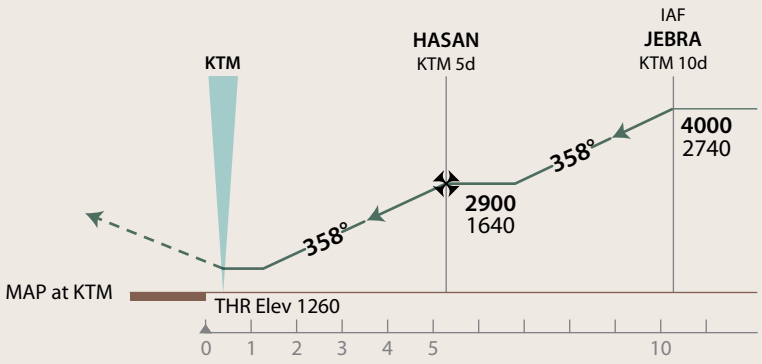
Another check with ATC on weather conditions at the airport indicated that visibility had improved to 3,000 m (2 mi). The commander decided to conduct a managed nonprecision approach (MNPA) to Runway 36. "This type of approach requires the autopilot to follow an approach path defined by parameters stored in the aircraft's commercially supplied [FMGS] navigation database," the report said.

At the time, however, the airline was in the process of developing MNPA procedures and had received authorization from a U.K. Civil Aviation Authority (CAA) flight operations inspector to conduct managed approaches only in visual meteorological conditions.

The commander had conducted managed approaches while flying for another airline. "Therefore, [he] did not consider it would be a problem, despite the fact that the reported visibility was below VFR [visual flight rules] limits," the report said. "The copilot's acceptance of this decision illustrates that neither pilot [realized] that not all the necessary safeguards were in place to conduct such approaches safely in IMC."

While setting up for the approach, the crew revised the MDA programmed in the FMGS database to 1,650 ft because the airline's standard operating procedures for a nonprecision approach required 50 ft to be added to the published MDA.

Charted Approach Profile



KTM = Khartoum VOR/DME (VHF omnidirectional radio/distance measuring equipment); d = DME distance (nm) from KTM; IAF = initial approach fix; THR Elev = Runway 36 approach threshold elevation; MAP = missed approach point

Source: U.K. Air Accidents Investigation Branch

Figure 1

The pilots were not aware that a discrepancy existed between the location of the final approach fix (FAF) depicted on their approach chart and the location programmed in the FMGS database. Approach charts and FMGS database updates were provided by different commercial vendors. The chart depicted the FAF, called HASAN, at "KTM 5d" — that is, 5.0 nm DME from KTM (Figure 1). The report said that this location resulted from the 2002 Sudanese *Aeronautical Information Publication* (*AIP*), which placed the FAF 5.0 nm from both the runway threshold and KTM. "By interpolating the depicted final approach gradient, the [chart vendor] determined that HASAN was actually 5.6 nm from the runway threshold," the report said. "This coincided with the KTM 5 DME position."

The FMGS database included a 2004 amendment to the *AIP* that placed the FAF 5.0 nm from the runway threshold and 4.4 nm DME from KTM.

"The pilots were unaware of [the] significant discrepancy between the approach parameters on the approach chart and those within the navigation database because they had not compared the two data sets before commencing the approach," the report said, noting that this omission was partly the result of the absence

The pilots were not aware that a discrepancy existed between their approach chart and the FMGS database.

of a formal U.K. CAA policy and clear guidance by the airline on how to conduct managed approaches.

'Late' Descent

The commander's input caused the autopilot to command a descent rate of 300 fpm, rather than a 3.0-degree flight path angle.

The report said, "The pilots commenced the approach with the autopilot engaged in managed modes — that is, the approach profile being determined by the FMGS instead of pilot selections."

At 0025 UTC (0325 local time), the aircraft crossed the initial approach fix, JEBRA, at 4,000 ft, and then completed the procedure turn to the final approach course. During this time, the crew asked ATC for the current visibility and were told that it was between 1,000 m and 1,200 m (3/4 mi).

The crew said that the A321 was fully configured for landing and stabilized at the appropriate airspeed when it crossed the 5.0 DME location for HASAN depicted on the approach chart at 2,900 ft, the published minimum altitude for crossing the FAF.

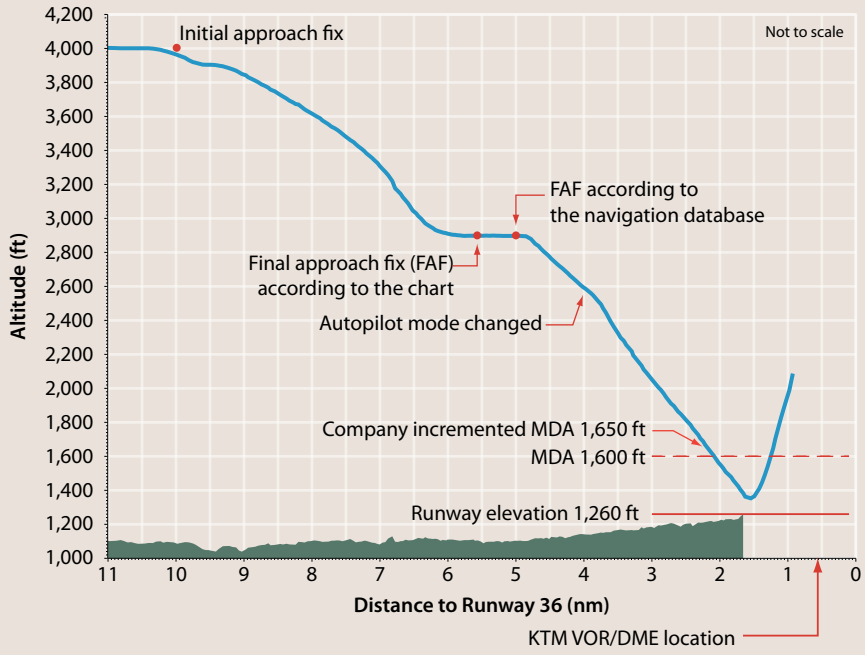
The managed approach was being conducted correctly by the autopilot based on the FMGS data. Thus, the aircraft did not begin the final descent at 5.0 DME, as the pilots expected (Figure 2). "The aircraft began its final descent 0.6 nm later than the pilots were expecting," the report said. "Believing the aircraft was high on the approach, the handling pilot [the commander] changed the autopilot mode in order to select an increased rate of descent."

The commander intended to establish the A321 on a 3.0-degree vertical flight path angle, which was equivalent to a descent rate of about 800 fpm at the selected airspeed. He mistakenly believed that the autopilot was in the track/flight path angle mode. The autopilot actually was in the heading/vertical speed mode, and the commander's input caused the autopilot to command a descent rate of 300 fpm, rather than a 3.0-degree flight path angle.

As the aircraft descended on final approach, it entered the sandstorm, and the crew's forward visibility decreased rapidly. "The commander described the effect of the sand as like watching iron filings flying past the windscreen," the report said. He also noted that the visual effect of the landing light reflecting off the sand was disorienting.

The copilot conducted a distance/altitude check at 4.0 DME and found that the aircraft was about 200 ft above the descent profile shown on the approach chart. "The commander stated that as the aircraft approached 3.0 DME, it became apparent that it was

A321 Flight Path



KTM = Khartoum VOR/DME (VHF omnidirectional radio/distance measuring equipment); MDA = minimum descent altitude

Source: U.K. Air Accidents Investigation Branch

Figure 2

not closing with the vertical profile, and so he increased the rate of descent to about 2,000 fpm," the report said. A few seconds later, he reduced the selected rate of descent to 1,200 fpm. "The pilot's selections resulted in a varying flight path angle that averaged about 4.5 degrees," the report said.

Lights in Sight?

The cockpit voice recorder (CVR) recording of the verbal communication between the pilots during the approach subsequently was overwritten. "It has not been possible to establish exactly what was said between the pilots at this time," the report said. "However, it is apparent that at some stage late in the approach, the commander asked the copilot if he could see the approach lights. The copilot mistook this question to be the commander stating that he could see the lights. As a result, the copilot informed ATC that they could see the approach lights and requested confirmation that they were cleared to land. The commander, hearing the copilot's transmission, took this to mean that the copilot had got the approach lights in sight."

Standard callouts were omitted, and neither pilot had the required visual references in sight as the A321 descended below 1,650 ft — about 390 ft AGL. "Had appropriate calls been made at the critical moments, they would have almost certainly prevented the confusion that allowed the aircraft to continue below MDA without the required visual references," the report said.

The commander looked up and saw lights at the one o'clock position but realized that they were not the approach lights. A note on the approach chart cautions pilots against "confusing local street and bridge lighting with approach and runway lights."

The misidentified lights and the disorienting effect of the blowing sand prompted the commander to initiate the go-around at about 180 ft AGL — 210 ft below the MDA. He advanced the throttles to the takeoff/go-around power setting, which automatically engaged the autopilot go-around mode. During this process, the aircraft sank to 125 ft AGL, where the TAWS "TERRAIN, PULL UP" warning was generated. "The commander reported that he noted the aircraft's attitude was 5 degrees nose-up, so he pulled back on his sidestick with sufficient force to disengage the autopilot and increase the pitch attitude to between 17 degrees and 20 degrees nose-up," the report said.

The commander pulled the sidestick about halfway back, instead of all the way back, as required by the emergency procedure for responding to the TAWS warning. He told investigators that he believed he already was "overpitching the aircraft." Nevertheless, the report said, "By nature, any [TAWS] terrain warning requires prompt and decisive action, and the protections built into the aircraft's flight control system allow for the application and maintenance of full back sidestick until the warning ceases."

Two More Tries

During the missed approach, the commander briefed the copilot for another approach. He decided not to conduct another managed approach but to use raw data and selected autopilot modes. "The pilots also decided to leave the landing lights off for this second approach to prevent the disorienting effect of light scattering off the sand," the report said.

During the second approach, the pilots did not have the approach lights in sight at the missed approach point, KTM, and another missed approach was conducted at 0049 UTC. "While carrying out the go-around, the commander could make out the running strobe lights below and stated that the aircraft passed slightly to the right of them," the report said.

The pilots told investigators they became aware that the crew of another aircraft had conducted the ILS approach and landed on Runway 36. However, when they tuned the ILS frequency, they found that a test code was being transmitted, indicating that the ILS must not be used for an approach. The crew decided to conduct another VOR/DME approach.

"While maneuvering, they heard the pilots of another inbound aircraft ask Khartoum Tower to confirm that the visibility was now 200 m [1/8 mi]," the report said. "When this reported visibility was confirmed, the copilot immediately questioned the tower controller about the current visibility at Khartoum. The initial reply from the controller was that the visibility was 900 m [between 1/2 and 5/8 mi], followed quickly by a correction to 800 m [1/2 mi] and then a further correction by the controller to 200 m."

The commander broke off the approach at 4,000 ft and diverted to Port Sudan, where the aircraft was landed without further incident at 0214 UTC (0514 local time). ●

This article is based on U.K. AAIB Aircraft Incident Report No. 5/2007 (EW/C2005/03/02).

Notes

1. FMGS is an Airbus term. Flight management system (FMS) is another term used to describe the equipment.
2. British Mediterranean Airways was founded in 1994 and operated as a British Airways franchise until 2007, when it was acquired by the U.K. airline bmi.