MID-AIR

It's 10 years since the world's deadliest mid-air collision. Macarthur Job reviews major mid-air accidents over the past decade, and looks at how technology has been used to prevent further collisions.

On November 12, 1996, a Boeing 747 and an Ilyushin 76 collided in mid-air to the west of Delhi, India. Both aircraft plummeted in flames, killing all 349 occupants, the deadliest in-flight collision in history.

The accident occurred near Delhi in visual conditions at dusk. The Boeing 747, HZ-AIH, operated by Saudi Arabian Airlines, had left Delhi's Indira Gandhi International Airport at 6.30pm west-bound, and was climbing to cruising level. With a crew of 23 and 289 passengers, it was on a scheduled flight to Dhahran on the Persian Gulf. The Ilyushin 76, UN-76435, a Russian manufactured, four-engined cargo aircraft, operated by Air Kazakhastan, was nearing Delhi east-bound, towards the end of a charter flight from Chimkent, Kazakhastan, with a crew of 10 and 27 passengers.

When the Boeing reported approaching FL100 (10,000ft) on climb, the Delhi controller instructed it to "maintain level 140 – standby for higher". The reason was that the Ilyushin 76, now on descent 70nm from Delhi Airport, had reported "passing through FL230 for FL180", and the controller had cleared the Ilyushin to continue descent to FL150.

When the Ilyushin reported 46nm from the airport at FL150 not long afterwards, the controller responded: "Roger, maintain FL150, identified traffic 12 o'clock, reciprocal Saudi Boeing 747, 14 miles. Report in sight". When the Ilyushin crew queried the distance, the controller replied, "14nm now". When there was no acknowledgement, the controller again warned: "Traffic in 13nm, level 140".

This time the Ilyushin crew acknowledged the transmission, but about a minute later at 6.40pm, the controller saw the radar blips of the two aircraft merge and disappear from the screen as the aircraft collided.

In an arid, flat farming area, thinly populated with small villages, 100km west of Delhi Airport, witnesses saw "a fireball" and "thick black smoke" falling to the ground. The main wreckage of both aircraft fell into open cotton and mustard fields several kilometres apart, that of the 747 narrowly missing a tiny village. Scattered between the two impact sites lay debris from both aircraft. No-one on the ground was injured.

The only access to the area was by rough farm tracks, rendering rescue work and examination of the wreckage difficult. While emergency services struggled to reach the crash sites, local villagers began the recovery work by the light of oil lamps. Four badly injured occupants of the 747 were still alive when found, but died soon afterwards.

Police cordoned off the area for the investigation to proceed, and the recorders from both aircraft were soon recovered. Both aircraft were fully serviceable at the time of the accident and their crews were experienced, each having logged well over 9,000 hours.

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The investigation by Indian civil aviation authorities, followed by a judicial inquiry, found that the Ilyushin, instead of maintaining FL150 as ATC instructed, had descended below this level. Shortly before the collision, its flight data recorder showed it to be flying at FL145, and a few seconds later it had descended another 310ft. Because Delhi Airport was not equipped with secondary surveillance radar at the time, air traffic controllers were unable to monitor the altitudes of the aircraft they were directing.

The Indian investigation determined that "the root and approximate cause of the collision was the unauthorised descending by the Kazakhastan aircraft to FL140 and failure to maintain the assigned FL150".

Why the TCAS equipment fitted to the Saudi Arabian Boeing 747 did not enable its crew to avert the collision, or why the respective aircraft crews did not sight each other's aircraft, despite the controller's warning, is unknown. Similarly, it is not known if the descending Kazakhastan Ilyushin was fitted with TCAS.

Disaster debris: A fireman sprays water over the smouldering debris of the Saudi B747 which collided mid-air with an Air Kazakhastan cargo plane killing 349 people on November 12, 1996, near the town of Charkhi Dadri, about 100km west of New Delhi. The Saudi

TCAS: TCAS, also known as ACAS (airborne collision avoidance system) by ICAO, was developed in the USA over a number of years, provides pilots with a "last line of defence", electronically detecting and tracking other aircraft in the vicinity of their own to enable them to avoid a potential mid-air collision. The value of TCAS has been demonstrated by the fact that, despite the sheer volume of transport aircraft plying the air routes of North America around the clock, no airline mid-air collisions have occurred

DISASTERS

there since U.S. airlines began equipping their aircraft with TCAS in 1990.

TCAS detects proximate or intruder aircraft in two ways. Firstly TCAS uses a Mode C Only All Call to interrogate nearby Mode A/C transponder and then tracks range, altitude and bearing using this information to generate Traffic and Resolution Advisories (TA and RA). It is worth noting that TCAS will not detect a Mode A only transponder.

TCAS can also detect spontaneous transmissions or squitters from Mode S transponders and then interrogates the individual transponders using the aircraft's unique 24-bit address. TCAS uses the replies to these interrogations to determine range, bearing and altitude of the proximate aircraft. TCAS tracks range and altitude of the aircraft and this information is provided to the collision avoidance logic to determine whether a TA or RA is issued. Relative bearing of the intruder is provided so that the target's position can be shown on the traffic display. Bearing information is not used for threat detection and advisory selection.

airliner was climbing after takeoff from New Delhi airport when it collided with the Kazakhastan aircraft coming in for landing. The wreckage was strewn across 10km of wheat and mustard fields.

If the TCAS determines there is a potential collision risk, it provides visual and audio advisories to the crew for vertical manoeuvres that will avoid the altitude of the so-called "intruder". For this purpose, TCAS employs two types of cockpit displays.

The traffic advisory (TA) display shows the intruding aircraft's relative position and altitude graphically, with a trend arrow to indicate if it is climbing or descending at greater than 500ft per minute. This TA display may be provided on the nav display (ND), weather radar screen, on a dedicated TCAS display, or a TA vertical speed indicator display, identifying the relative threat of each intruder with symbols and colours. Traffic advisories are intended only as a warning to the crew that another aircraft is in the vicinity and pilots should not take avoiding action on the basis of a TA alone.

When a resolution advisory is in conflict with an ATC instruction, crews should follow the more immediate RA, and inform ATC accordingly.

The TCAS resolution advisory (RA) display on the other hand, is intended to inform the crew of action immediately required to avoid a possible collision. It is incorporated into the aircraft's vertical speed indicator and, by illuminating red and green areas around the dial, shows the rate of climb or descent needed.

In addition to its graphic display notification, TCAS provides aural announcements to the crew with an electronically synthesised voice. Resolution advisories include a positive aural annunciation to "climb, climb" or "descend, descend". A prompt climb or descent manoeuvre is then expected, which should be accomplished with a smooth transition to a climb or descent rate of 1,500ft per minute.

The RA may subsequently be reinforced (for example,"increase climb, increase climb"), by a so-called iterated advisory. It may also be relaxed, or even reversed ("descend, descend NOW"), depending on the movement of the other aircraft.

Ever-increasing traffic densities on the world's designated international airways today emphasise the importance of TCAS as a protection against collisions. However, for the system to work as intended, it is vital that flight crews execute correct responses to the equipment's traffic advisories and resolution advisories.

Correct procedures: Failure to follow correct procedures can contribute to tragedy. This happened in July 2002, when a Russian Tupolev TU154M, west-bound from Moscow to Barcelona with a crew of nine and 60 passengers, collided in mid-air with a two-crew Boeing 757 freighter, northbound for Brussels from Bahrain. Many of the Tupolev's passengers were school children, going on a keenly anticipated holiday. Contributing factors to the accident, which occurred over southern Germany late at night, were staff and equipment difficulties at the Zurich area control centre, the ATC unit responsible for the airspace concerned. Yet if the directions of the aircrafts' respective TCAS equipment had been properly followed, the collision would not have occurred.

Both aircraft were cruising at FL360 on intersecting tracks when traffic advisories from their respective TCAS equipment alerted their crews to a possible conflict. Shortly afterwards Zurich control, recognising the developing traffic situation, instructed the Tupolev to descend and to expedite the descent. A moment later, the Tupolev's TCAS aural warning, "climb, climb" sounded. Unfortunately, as it turned out, the Tupolev's crew chose to follow the ATC instruction, rather than the more urgent and immediate TCAS resolution advisory.

Meanwhile, the Boeing 757's TCAS had given a resolution advisory to descend, to which its crew promptly responded. As a result, both aircraft were now descending. The situation was exacerbated when Zurich ATC repeated its instruction to the Tupolev to expedite its descent, and the two aircraft collided a little below 35,000ft. Had the Tupolev crew correctly responded to their TCAS resolution advisory to climb, rather than the less up-to-the-moment ATC instruction, the accident would have been avoided.

As a result of this and other experience with TCAS, aviation authorities advise that when a resolution advisory is in conflict with an ATC instruction, crews should follow the more immediate RA, and inform ATC accordingly.

Much more recently, on October 1 this year, another mid-air tragedy took place late in the afternoon over the Amazon jungle in northern Brazil, when an Embraer Legacy 600 corporate jet carrying a crew of two and seven passengers collided with a near-new Boeing 737-800 operated by Brazilian Gol Airlines. All 155 occupants of the 737 were killed when the aircraft plunged into a remote, inaccessible area of jungle in the State of Para in northern Brazil. Amazingly, the crew of the Legacy 600, despite the fact that their aircraft had lost a portion of one wing, managed to regain control and continue for long enough to reach the Brazilian Air Force's Cachimbo base, located deep in the jungle. The aircraft made a successful emergency landing. No one on board the Legacy 600 was injured.

Both aircraft were on reciprocal headings between the capital, Brazilia, and the Amazon centre of Manaus, and both aircraft are understood to have been equipped with TCAS. The accident is still under investigation. Other than the fact that the crew of the Legacy 600 did not sight the Boeing until the instant of the collision, and then only as a momentary "shadow", no further details were available at the time of writing. It is not known at this stage whether any TCAS warnings were triggered in either aircraft before the collision.

Pilots need to remember that TCAS cannot detect any aircraft, large or small, that is not equipped with an operating transponder.

Taking into account the enormous amount of passenger and air cargo traffic now flying congested international air routes, 24 hours a day, every day of the year, the wonder is that the world has been relatively free of major mid-air collisions.

In Australia since the beginning of 2000, TCAS has been mandatory on all turbine powered commercial transport aeroplanes of more than 15,000kg MTOW, or with more than 30 passenger seats.

ATC procedures, as well as the long established "see and avoid concept", continue to be the primary means of ensuring aircraft separation. However, TCAS provides an important backup in avoiding conflicting traffic, especially if communication is lost with ATC for any reason.

But pilots need to remember that TCAS cannot detect any aircraft, large or small, that is not equipped with an operating transponder. For this reason, it is important that all transponder-equipped general aviation aircraft, except those operating in GAAP airfield circuits, should fly with their transponders switched on, selected to the altitude mode, at all times.

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