FLIGHT SAFETY FOUNDATION
Airport Operations
Vol. 25 No. 3 *For Everyone Concerned with the Safety of Flight* May–June 1999

Factors in Near Midair Collisions Show Controller-Pilot Interdependence

Recorded ATC radar data showed the proximity of aircraft during two incidents that occurred in 1997. The closest proximity of a Boeing 747 and a Gulfstream IV was 0.83 nautical mile horizontally and 100 feet vertically. The closest proximity of a Boeing 737-200 and a Boeing 757 was 0.16 nautical mile horizontally and 200 feet vertically.

FSF Editorial Staff

Human factors that included deviations from procedures, incorrect assumptions and failure to communicate relevant information have been cited by the U.K. Air Accidents Investigation Branch (AAIB) in reports[1,2] on AIRPROX (C) incidents: one involving a Boeing 747 (B-747-300) and a Gulfstream IV (G-IV) in July 1997, and one involving a Boeing 737-200 (B-737) and a Boeing 757 (B-757) in August 1997.

The International Civil Aviation Organization in 1994 defined AIRPROX as "a situation in which, in the opinion of a pilot or controller, the distance between aircraft as well as their relative positions and speed have been such that the safety of the aircraft involved was or may have been compromised." The term "AIRPROX (C)" is used to designate a controller-initiated report. Such reports initially are investigated, and related actions are taken, by the Safety Data Department of the U.K. Civil Aviation Authority. The AAIB investigates certain AIRPROX (C) incidents based on safety criteria. The independent U.K. Joint AIRPROX Assessment Panel (JAAP) determines causal factors and assesses risk to improve flight safety, but does not necessarily indicate the JAAP's view of the seriousness of the incident. JAAP risk classification "A" indicates that actual risk of collision has existed and the JAAP classified both of these 1997 incidents this way; "B" indicates that safety of the aircraft has been compromised; "C" indicates that no risk of collision has existed; and "D" indicates that the risk classification could not be determined.

In the report on the B-747/G-IV incident, the AAIB cited procedural errors by a flight crew and by controllers, combined with limited error tolerance of the air traffic control (ATC) system. Traffic-alert and collision avoidance system (TCAS) equipment on both aircraft generated timely alerts; nevertheless, the investigation produced recommendations for optimal operation of TCAS II, which can generate a traffic advisory (TA) and a resolution advisory (RA) in the vertical plane. In its report on the B-737/B-757 incident, the AAIB cited "a breakdown in coordination" involving aircraft that were not equipped with TCAS.[3] The AAIB said that in both incidents, the controllers and the pilots were properly licensed, comprehensively trained, medically qualified, adequately rested and familiar with procedures for conducting operations in the London (England) Terminal Control Area (TCA), previously designated the London Terminal Maneuvering Area (TMA).

"In relation to the total number of flights within the London TMA [928,661 in 1997] the number of AIRPROX (C) incidents is relatively small [16 in 1997]," said the report on the B-747/G-IV incident. "Investigation of those reported

reveals few with such close proximities as [the July] incident. … As a general rule, any loss of separation detected by the [ATC radar's separation-monitoring function] will give rise to a report, and this equipment was set to function when aircraft were within two nautical miles [3.7 kilometers] and 600 feet [182 meters] of each other. Any loss of separation is more significant than the actual proximity of the encounter since it reveals a breakdown in the safety system … reports of AIRPROX are the current indicator of system safety."

The London TCA's Class A airspace extends from varying base levels to Flight Level (FL) 245, and encompasses five London airports and instrument holding areas. Surrounding airspace is divided into several ATC sectors. Aircraft in Class A airspace must operate under instrument flight rules (IFR) with ATC separation services that provide a minimum of 1,000 feet [305 meters] of vertical separation or a minimum radar separation of three nautical miles (5.6 kilometers) except on final approach, where separation of 2.5 nautical miles (4.6 kilometers) is approved under certain circumstances. (These minimums can be reduced in the vicinity of the airport under specified conditions of traffic visibility to the pilots and controllers, and when pilots can maintain visual separation with traffic.)

The visual control room at London Heathrow Airport is staffed by a supervisor, five air traffic controllers and support staff, said the report on the B-737/B-757 incident. Three controllers control ground operations; the air-arrivals controller and the air-departures controller control aircraft operations on their respective runways.

"[London Heathrow Airport] uses 'segregated parallel operations' as a normal mode of operation but, for 'noise reduction' reasons, the westerly runway roles [arrivals and departures on Runway 27L and Runway 27R] are reversed each morning and afternoon," said the report. "With this operation — provided that aircraft on approach complete their landings — there is no risk of conflict. However, when a landing aircraft commences a missed approach, there will be a potential breach of minimum separation with any aircraft taking off." [FSF editorial note: In segregated parallel operations, simultaneous operations are conducted during which one of the parallel runways or near-parallel runways is used exclusively for approaches while the other runway is used exclusively for departures.]

The AAIB said that two other AIRPROX incidents — involving factors similar to the 1997 incidents — occurred near London Heathrow Airport in 1992 and 1996. The 1992 incident prompted a review of missed-approach procedures and led to improved controller training. The 1996 incident was attributed to "ineffective coordination between air departures and air arrivals." A subsequent survey of operations at the airport recorded approximately 43 missed approaches per 18,000 landings monthly, with most missed approaches conducted because an aircraft occupied the runway. The AAIB report for the B-737/B-757 incident said that improved training had not prevented the 1997 incidents. The report recommended further efforts to minimize the coordination among controllers during missed approaches.

"Ideally, both the missed-approach aircraft and the departing aircraft should be on predetermined flight paths where the probability of conflict is minimal," said the report. "On those occasions where conflict occurs, the responsibility for providing a satisfactory resolution should then rest with the controller with the lowest workload. Considering the various departure tracks and the relative workloads between the [air-arrivals controller and the air-departures controller], it would be most effective if the aircraft executing a missed approach established an initial track away from the departing runway. Air departures would then have the responsibility to maneuver departing aircraft away from the predetermined and anticipated track of the aircraft making the missed approach."

Loss of Separation Occurs During Descent for Approach

In the July loss-of-separation incident, which occurred 14 nautical miles (26 kilometers) east of Lambourne very-high-frequency omnidirectional radio (VOR), the B-747 was en route to London Heathrow Airport and the G-IV was en route to London Luton Airport. Both aircraft were equipped with TCAS II, and the report said, "TCAS alerts the crew to traffic that may present a collision threat and provides the crew with a vertical avoidance maneuver. … The TCAS equipment uses the [aircraft's] transponder to interrogate the transponders of other aircraft in the vicinity to determine their range, bearing and altitude. TCAS generates a [TA] when another aircraft becomes a potential threat; no maneuvers are required for a TA. If the [traffic conflict] continues and becomes an imminent threat, [an RA] is generated. The RA provides a vertical restriction or [vertical] maneuver to maintain or increase separation from the traffic."

The following chronology summarizes the loss of separation:

- The area controller for Clacton Westbound Sector cleared the B-747 crew directly to the Lambourne VOR with descents to FL 290 and FL 150, and instructions to reduce airspeed from 320 knots to 290 knots. The aircraft then was handed off to Lambourne Sector and the crew was told to report this assigned airspeed to the terminal controller;

- The area controller for Lydd Sector cleared the G-IV crew for a Lorel 3E standard instrument arrival (STAR), which begins at the Detling VOR, and then told the crew to descend to FL 210, to descend to FL 190 and to expedite the descent to be level at FL 130 crossing Detling VOR. The G-IV crew said that they were maintaining a descent rate of 4,000 feet per minute, and

reported a descent rate of 4,800 feet per minute during one radio transmission;

- The terminal controller for Lambourne Sector told the B-747 crew to descend to FL 110 and to fly directly to Lambourne VOR. At approximately the same time, the G-IV crew established contact with the terminal controller for Lambourne Sector and was told "you can keep up high speed" and to maintain FL 130. This terminal controller then handed off the B-747 to the Heathrow Intermediate North Director (terminal controller), briefed the North East Departures Sector controller, and arranged for the North East Departures Sector and the Lambourne Sector to be combined (bandboxed) temporarily, enabling the terminal controller for Lambourne Sector to take a short break from duty during a period of light traffic. The report said, "[Air traffic control] positions may be 'bandboxed' at times of light workload. [When bandboxed, aircraft operating in] two adjacent sectors are controlled by [one] controller who also has the option of cross-coupling the respective radio frequencies [that is, communicating on multiple frequencies as if they were one frequency]. Pilots receiving a service from a bandboxed position will be unaware of any change other than perhaps noticing additional traffic using the cross-coupled frequencies";

- The terminal controller for the Heathrow Intermediate North Sector told the B-747 crew to descend to FL 90, to depart Lambourne VOR on a heading of 270 degrees and to "reduce your speed now to 210 knots";

- The terminal controller for the combined North East Departures Sector and Lambourne Sector told the G-IV to turn left to a heading of 340 degrees, and to descend from FL 130 to FL 120. This heading assignment was not part of the Lorel 3E STAR, but customarily was used to provide a shorter, direct routing to London Luton Airport. Nevertheless, this direct routing at high speed — deviating from the STAR — created a horizontal-track conflict between the G-IV and the B-747, said the report. Both aircraft were operating in instrument meteorological conditions;

- On reaching FL 120, the G-IV pilot told the terminal controller that the aircraft's TCAS showed traffic in his one o'clock position. The TCAS showed this traffic at an approximate range of three nautical miles, said the report. The terminal controller initially told the G-IV pilot that the traffic was 1,000 feet (305 meters) below the G-IV. "[This controller later said] that it was possible that he misread the [secondary-surveillance radar (SSR)] label as '107' (i.e., 10,700 feet) instead of '117' (i.e., 11,700 feet), thus explaining his impression of at least 1,000 feet vertical separation, which he initially reported to the G-IV [crew]," said the report. The G-IV pilot then told ATC that TCAS showed traffic 300 feet [91 meters] below his aircraft. The terminal controller immediately told the G-IV pilot to turn left to avoid another aircraft. During this turn, the G-IV crew briefly saw the B-747 before the B-747 was obscured again by cloud. The TCAS on the G-IV did not generate an RA; and,

- During this communication, the B-747 crew complied with a TCAS "climb" RA — climbing to FL 122 — and a subsequent TCAS "descend" RA. The crew did not communicate with ATC about the TCAS RAs. Their TCAS showed the G-IV 300 feet (91 meters) above the B-747 at an approximate range of three nautical miles. While descending, the B-747 crew briefly saw the G-IV in a left turn and at a higher altitude than the B-747. The Heathrow North Intermediate Director was alerted by the short-term conflict alert (STCA)[4] and told the B-747 crew to turn right immediately to avoid another aircraft. "The aircraft were converging at right angles to each other, the B-747 on a westerly track towards [Lambourne] VOR and the [G-IV] on an assigned radar heading of 340 degrees … ," said the report. The closest proximity of the two aircraft was 0.83 nautical mile [1.5 kilometers] horizontally with vertical separation of 100 feet (30 meters), according to recorded radar data.[5] "Four seconds later, the vertical separation increased to 200 feet (61 meters), with a corresponding horizontal separation of 0.66 nautical mile [1.22 kilometers]," said the report.

Compliance with Procedures Would Prevent Conflict

The report said, "The ingredients of this AIRPROX include procedural errors by a flight crew and [by] controllers (human error) combined with limited error tolerance of the system (STCA and TCAS). The [formal safety analysis] should allow lessons to be learned leading to preventative measures."

The report included the following findings:

- The B-747 crew began a descent from FL 120 to the assigned altitude of FL 90 as cleared, but interrupted the descent at approximately FL 117 for about 50 seconds while reducing speed from 290 knots to 210 knots. Thus, for energy-management reasons, the B-747 crew did not maintain the minimum 500-feet-per-minute (152-meters-per-minute) rate of descent required during IFR operations in the United Kingdom, and did not inform ATC that they could not comply with the standard rate. A terminal controller then cleared the G-IV crew to descend to FL 120; that is, before the required vertical separation of at least 400 feet (122 meters) was established, and before verifying that the B-747 was "continuing in the anticipated direction" using SSR Mode C altitude information;

- A terminal controller simultaneously told the B-747 crew to reduce speed to 210 knots and to descend to

FL 90. The B-747 was beyond the selected range of the controller's radar display, however, and the controller assumed that the crew previously had reduced speed to 250 knots. The B-747 crew had not reported the assigned airspeed (called "the speed control" in the report) of 290 knots to the terminal controller during their initial radio call, as directed by an area controller. The B-747 crew did not report that only a minimal rate of descent was possible while making the 80-knot speed reduction. The terminal controller's words — "reduce your speed now" — also were interpreted by the B-747 crew as prioritizing rapid speed reduction. Nevertheless, the controller later said that these words were not meant to communicate urgency; and,

- The TCAS aboard the G-IV probably was not operating in the mode that enabled the two aircraft to automatically coordinate collision-avoidance maneuvers, said the report. Thus, the B-747's initial TCAS "climb" RA reduced the separation distance.

Loss of Separation Occurs During Missed Approach

In the August 1997 loss-of-separation incident, the B-737 crew was conducting a missed approach following an instrument landing system approach to Runway 27L at London Heathrow Airport in heavy rain showers. The B-757 crew was conducting the Brookmans Park 6F standard instrument departure (SID) from Runway 27R at London Heathrow Airport. The following chronology summarizes the loss of separation:

- When the B-737 flight crew reported the missed approach to the air-arrivals controller, the air-arrivals controller activated the missed-approach alarm, advised the air-departures controller about the missed approach and requested information about departing aircraft. (The two controllers work in adjacent positions and have direct contact in the visual control room.) The published procedure for this missed approach requires the aircraft to climb straight ahead to 3,000 feet, then as directed by ATC.

- The air-departures controller told the air-arrivals controller that an aircraft (type unspecified) had departed on the Midhurst 3F SID from Runway 27R, in which the aircraft turns left onto the 244-degree radial of the London VOR, then crosses the extended centerline of Runway 27L. An instructor supervising the air-departures controller told the air-arrivals controller that the departing aircraft later would be turned right onto a northwesterly track. The air-arrivals controller saw this aircraft on the screen of an air traffic monitor (ATM), said the report.

- Based on the observed positions of the two aircraft, the air-arrivals controller told the B-737 flight crew to turn right to a heading of 310 degrees. This turn was intended to provide maximum separation between the B-737 and the aircraft on the Midhurst 3F SID, and to avoid interference with the flight path of that aircraft. When the instructor heard the air-arrivals controller announce that he had turned the B-737 to the heading of 310 degrees, the instructor supervising air departures immediately told the air-arrivals controller that a B-757 also was airborne from Runway 27R on a Brookmans Park 6F SID, which requires initiation of a northerly turn approximately three miles from the airport, said the report.

- The air-arrivals controller immediately told the B-737 to turn left and the air-departures controller immediately told the B-757 to turn right. Both aircraft were in instrument meteorological conditions and neither flight crew saw the other. The report said, "Almost immediately, all three controllers saw the aircraft symbols for [the B-757] and [B-737] appear very close together on the ATM with the two aircraft tracks beginning to diverge." The closest proximity of the two aircraft was 200 feet vertically and 0.16 nautical mile horizontally, according to recorded radar data. At that time, the aircraft with the highest altitude was 2,400 feet above ground level (the aircraft was not identified in the report). The flight crews were not told by ATC about the AIRPROX; the AAIB later notified the aircraft operators about the loss of separation.

Misjudgment of Aircraft Relevance Causes Omission of Information

The report on the B-737/B-757 incident said, "A missed approach is not an unusual occurrence at [London Heathrow Airport] although [the maneuver] is acknowledged by the [airport's] Technical Committee as a potential emergency situation. However, strict adherence to the published instructions would have prevented this incident. This leads to the conclusion that a human failing, i.e., a breakdown in communications, was the only cause of this incident." The report included the following findings:

- Ineffective coordination and communication between the air-arrivals controller and the air-departures controller occurred; that is, the air-arrivals controller was not told that the B-757 was airborne at the time of the B-737 crew's missed approach, and that the air-arrivals controller told the B-737 crew to turn right prior to obtaining concurrence on that action by the air-departures controller; and,

- ATC procedures for maintaining separation of aircraft conducting a missed approach at London Heathrow Airport relied too heavily on interpersonal communication, which could be subject to human error. These procedures also were considered insufficiently clear and comprehensive

in defining "conflicting aircraft." Revised procedures emphasized the critical importance of coordination among controllers, and that all departing aircraft should be considered risk factors for loss of minimum separation from aircraft conducting missed approaches.

Missed approaches at London Heathrow Airport are considered high-workload events because the air-arrivals controller must perform the following tasks during a missed approach:

- Activate the alarm to warn the visual-control-room supervisor, terminal control, the Northolt Radar Maneuvering Area controller and the special visual flight rules controller;
- Coordinate vectors with the air-departures controller;
- Coordinate with the terminal controller on headings for the missed-approach aircraft;
- Vector the aircraft conducting the missed approach;
- Handle the continuous flow of aircraft approaching the airport; and,
- If necessary, dispatch aircraft rescue and fire-fighting personnel or other services to clear the runway or respond to an accident.

Procedures Enable Controllers To Make Assumptions

The report on the B-747/G-IV incident said that controllers relied upon procedures to make assumptions about flight-crew behavior in the absence of information to the contrary. Assumptions also are a factor when controllers vary from standard procedures for traffic-management and tactical-planning reasons, said the report. In those circumstances, timely exchange of complete information is critically important. The following procedural issues were involved:

- "The crew of the B-747 did not report the [290-knot] speed control, as requested, when handed over … and accordingly the controller could not pass it on … ;
- "Both controllers thought that … the B-747 would be at the correct speed, less than 250 knots, by the speed limit point, which is 12 [nautical miles (22 kilometers] east of [Lambourne] VOR … ;" and,
- " … [The terminal controller for the combined North East Departures Sector and Lambourne Sector] cleared the G-IV to descend to FL 120 although [the B-747] had not yet achieved the mandatory 400 feet descent from FL 120 that would allow him to clear another aircraft to that level."

Prior to the B-737/B-757 incident, the following ATC procedures were used:

- "Normally [aircraft conducting] missed approaches from Runways 27R/09L will be turned, after coordination, towards the north and [aircraft conducting missed approaches] from runways 27L/09R [will be turned] towards the south;
- "The aerodrome controller may issue a tactical heading to an aircraft executing a missed approach to solve an immediate [conflict];
- "Other relevant instructions are that [the] air-arrivals [controller] and [the] air-departures [controller] are to coordinate with each other to establish separation between the 'go-around' [aircraft] and any conflicting departing traffic;" and,
- "Aircraft carrying out a missed approach shall not be instructed to make any turns below 1,500 feet QNH [corrected mean sea level pressure] unless there are over-riding safety reasons."

Based on these procedures, the controllers had interpreted the terms "coordinate" and "conflicting departing traffic" subjectively, said the report. That is, the air-departures controller took action based on two assumptions: that the air-arrivals controller would turn the B-737 to the left, and that the aircraft on the Brookmans Park 6F SID was not a factor, thus it was not necessary to tell the air-arrivals controller about that aircraft. (The instructor also said that he had never seen a missed-approach aircraft from Runway 27L being turned right, said the report.) Following the B-737/B-757 incident, London Heathrow Airport revised the missed-approach procedures used by controllers. The changes clarified the actions required of air-arrivals controllers and air-departures controllers when aircraft are conducting missed approaches. The following language was added: "If a decision is made to turn a missed-approach aircraft towards the departure runway, the air-arrivals controller must ensure that specific authority is obtained from the departure controller and acknowledged. The arrival controller may issue a tactical heading to an aircraft executing a missed approach to solve [conflicts] with departing traffic."

The report said that expectations can lead to communication failure, but expectations also have a positive effect on safety when procedures are followed.

"Even [the use of robust, unambiguous procedures] is not fail-safe and relies on any deviation from the set procedure to be communicated to those who need to know," said the report. "Nevertheless, the safety and integrity of a system cannot, and ideally should not, be predicated on something as potentially fallible as human communication. … Placing emphasis on following procedures does not preclude the possibility of taking tactical action which may run counter to the procedure."

The reports said that several omissions of information contributed to the losses of separation. The following consequences of the omissions were cited:

- "The Heathrow Intermediate North Director was unaware of the high energy state of the B-747, which was not yet showing on his radar display. … However, he was entitled to expect [the aircraft] to be at 250 knots in the absence of any speed-control report. If he had known the actual speed (290 knots), his instruction to 'slow down and go down' may have appeared to him to have been obviously inappropriate … ;
- "The [B-747] pilot entered the descent [altitude, 9,000 feet] and speed reduction [210 knots] into the aircraft's performance management system (PMS) which, by design, prioritized the speed reduction. [While] attempting to achieve this deceleration, the PMS commanded a reduction in descent rate such that the aircraft leveled at FL 117 for the 50-second period prior to the TCAS instructions. The crew of the B-747 did not inform the controller that they had ceased descending."

The report on the B-737/B-757 incident said that the loss of separation occurred under conditions that normally support safe operations. The controllers had used the relevant procedures at London Heathrow Airport many times, and the controllers had significant experience working together. Time on duty, physical arrangement of the ATC facility, the temporary combination of two ATC sectors and fatigue were not considered factors.

Collision-avoidance Technology Helped Compensate for Human Errors

In the B-747/G-IV incident, both aircraft were equipped with TCAS, and a TCAS alert enabled the G-IV crew to provide the first notice to ATC of the developing loss of separation. "Collision avoidance was as a combined result of the TCAS and the turn given to the G-IV by the controller, which the crew executed with commendable haste," said the report. The B-747 crew subsequently complied with two TCAS messages — a "climb" RA and a "descend" RA — as the B-747's TCAS equipment responded to a rapidly changing situation.

Nevertheless, investigators found that the modes of TCAS operation on each aircraft probably were mismatched, thus providing less-than-optimal alerts to the flight crews that momentarily led to a further reduction of separation. This finding could not be confirmed by the G-IV crew, but investigators deduced from recreation[6] of the incident on a TCAS simulator that the TCAS aboard the G-IV probably was in the TA-only mode rather than the normal TA/RA mode, which would have matched the operating mode of the B-747 TCAS and enabled a coordinated, vertical evasive maneuver or restriction.

"It is probable that the [B-747's] initial 'climb' RA was derived from the observed high descent rate of the G-IV, which the equipment would assume would continue, since [TCAS software] was unaware of the other aircraft's cleared altitude," said the report. "This descent rate would have been approximately 2,000 feet per minute because the G-IV flight-management system [FMS] would command a three-degree descent profile regardless of the aircraft's speed, which at this time was approximately 300 knots.

"When the B-747 TCAS equipment observed that the G-IV had leveled at FL 120 and, therefore, that by climbing it was liable to [collide with the G-IV, the TCAS] then issued a reversed RA to 'descend.' … The current TCAS software[7] does not allow for reversals in RAs during encounters with other TCAS-equipped aircraft operating in the RA mode. Avoiding maneuvers are coordinated between aircraft which both have selected TA/RA [mode] on their TCAS. If this situation had existed in this incident, the 'climb' RA given to the B-747 would not have occurred and the [closest point of approach] would have been greater. The maximum benefit of TCAS will depend on optimum usage of TA/RA [mode] selections."

The investigation of the B-747/G-IV incident also examined the effectiveness of ground-based systems in predicting loss of separation, warning controllers of conflicting flight paths and recording incident data.

" … [The Heathrow North Intermediate Director] had his attention drawn to the [traffic] conflict by the 'red' alert of the STCA," said the report. "Because of the range setting he had selected, the B-747 was not yet showing on his screen. However, he was able to confirm the identity of the conflicting aircraft from the alert listing on screen and promptly issued an avoidance turn to the B-747, which was under his control. Following the TCAS report by the G-IV, [the terminal controller for the combined Heathrow North East Departures Sector and the Lambourne Sector] … recognized the conflict and issued a prompt avoidance turn."

The report said, "The [ATC system] 'safety net,' designed to provide continued safety assurance following procedural lapses, was unable to prevent the loss of separation because the STCA could only provide a very late warning and the TCAS maneuver was not fully coordinated between the conflicting aircraft," said the report.

The STCA had displayed immediately in red; that is, the high-severity alert was not preceded by less-urgent display colors. Investigators determined that the immediate red alert occurred because the relative positions of the aircraft had changed quickly from a safe condition to an unsafe condition. The aircraft were converging laterally, but the STCA first predicted that the G-IV would pass safely beneath the B-747.

The report said, "When the G-IV slowed its rate of descent and began to level at FL 120, STCA 'imminent' linear prediction conditions were met [that is, lateral separation fell below the linear prediction-alerting criteria of two nautical miles

(3.7 kilometers)] and an alert [was] immediately declared. The alert continued as the aircraft closed laterally with less than 500 feet vertical separation. The alert stopped as both aircraft had begun lateral avoidance maneuvers. Furthermore, STCA has no knowledge of cleared levels and therefore could not predict that the G-IV would level until the maneuver had begun. … [In] this instance, in which the aircraft proximity was extremely close, the STCA provided little useful warning of a potential conflict and the concept of a safety net for the controller was minimal. This was not an equipment or design shortcoming, but rather the inability of the current conflict-alert system to provide sufficient warning in this particular scenario."

Based on findings from the B-747/G-IV incident, the AAIB said, "[The U.K. National Air Traffic Services (NATS)] should re-evaluate the performance and operational use of the current STCA equipment in order to ensure that the maximum amount of warning, consistent with traffic density, is provided to controllers. … NATS should ensure that the development and introduction of an effective [medium-term conflict alert (MTCA)] system[8] is given a high priority." The report said that the STCA had performed as designed but that "if [an MTCA system] had been available and in service, with the ability to detect potential separation conflicts greater than two minutes ahead, the [conflict] which led to this AIRPROX may have been predicted at an earlier stage."

Based on findings from the B-737/B-757 incident, the AAIB recommended improvements to the ATM, a radar system that assists controllers at London Heathrow Airport in maximizing runway utilization, but is not used to provide approach radar services. The ATM uses a filter to reduce interference from aircraft operating on the ground, but the AAIB said that a reduction of artificial "blanking" of extraneous aircraft-transponder returns on these displays would enhance controller awareness of the relative positions of airborne traffic and aircraft identities during a missed approach.

Reports Suggest Measures for Improved Collision Avoidance

The report on the B-747/G-IV incident made the following recommendations to reduce the risk of midair collisions:

- Air traffic controllers should have a structured system of familiarization training to better understand aircraft characteristics, aircraft-energy management, and aircraft operational limitations. Such recurrent training would enhance controllers' ability to use procedures effectively and to anticipate problems that flight crews might encounter in complying with ATC instructions. "Equally, flight crews need to be familiar with the problems encountered by ATC staff controlling a busy segment of airspace," said the report; and,

- Flight crews using a PMS — or similar vertical-navigation equipment — should be aware of how such equipment prioritizes commands, and the possible effect on ability to comply with ATC instructions and clearances. "When in a descent mode, the PMS [used by investigators on a B-747 simulator] will prioritize speed: i.e., if a descent and a speed reduction [are] entered, the PMS will command the speed reduction [while] maintaining essentially level flight and then, once the [reduced] speed is achieved, it will command the descent," said the report. "The [B-747] simulator results indicate that in that flight regime [descending and reducing speed], a reduction from 290 knots to 210 knots cannot be achieved in less than 120 seconds in level flight. This is irrespective of whether the PMS prioritizes the speed, as it is programmed to do, or whether the pilot does so by responding to the instruction to reduce speed 'now.' … The use of speedbrake to [help reduce airspeed to] 250 knots, prior to the selection of flap position 1, made little difference to the rate of deceleration [in one simulator test recreating the incident]."

The report on the B-737/B-757 incident recommended:

- Analysis of ATC training found that individual controllers do not receive regular practice in controlling aircraft during missed approaches other than simulations. The report said that on average, each London Heathrow Airport controller should expect to experience eight missed approaches per year, but not necessarily a variety of missed-approach scenarios. Thus, increased emphasis should be placed on training controllers on the types of error that are possible and how such errors might occur, said the report;

- "The training situation in [the August] incident, though not unique, was somewhat unusual in that the trainee was an experienced controller … ," said the report. "At the time of the incident, [the air-departures controller] had been back at the unit as a trainee for approximately one month. The [instructor] was therefore faced with the task of monitoring a trainee with whom he had worked previously and who already possessed many years [of] ATC experience. This is not a situation conducive to maintaining adequate vigilance;" and,

- Investigators found that the workload of the controllers involved in this incident — as in the B-747/G-IV incident — was not excessive. Nevertheless, opportunities to balance controller workload and reduce the required degree of coordination among controllers during missed approaches should be studied further.

"The design of the [ATC system] remains safe so long as the procedures are followed implicitly by pilots and controllers alike," said the report on the B-747/G-IV incident. " … This incident has shown potential weaknesses which can be safeguarded by more rigid adherence to procedures and enhancement of the existing technology-based alerting systems."

Thus, in both AIRPROX (C) incidents, the interdependence of controllers and pilots was demonstrated by the need for coordination of action within an error-tolerant ATC system.♦

References and Notes

1. U.K. Air Accidents Investigation Branch (AAIB). *AIRPROX (C): Boeing 747 and Gulfstream G-IV; Report on an Incident near Lambourne VOR on 3 July 1997.* Aircraft Incident Report 4/98. U.K. AAIB, London, England: Aug. 13, 1998.

2. U.K. AAIB. *AIRPROX (C): Boeing 737-200 and Boeing 757; Report on an Incident near London Heathrow Airport on 27 August 1997.* Aircraft Incident Report 5/98. U.K. AAIB, London, England: Sept. 10, 1998.

3. At the time of these incidents, aircraft operating in airspace of the United Kingdom were not required to have airborne collision-avoidance systems (ACAS). Section 1.668, Airborne Collision Avoidance System, of the Joint Aviation Requirements JAR-OPS 1, Commercial Air Transportation (Airplanes), says, "An operator shall not operate a turbine-powered airplane: (1) having a maximum certificated takeoff mass in excess of 1,500 kilograms [33,000 pounds] or a maximum approved passenger-seating configuration of more than 30 after 1 January 2000; or (2) having a maximum certificated takeoff mass in excess of 5,700 kilograms [12,500 pounds] but not more than 15,000 kilograms, or a maximum approved passenger-seating configuration of more than 19, but not more than 30, after 1 January 2005, unless it is equipped with an airborne collision-avoidance system with a minimum performance level of at least ACAS II.

4. The AAIB defined short-term conflict alert as "an automated system which alerts controllers to potential conflicts between aircraft [in the next two minutes] using the radar display."

5. The AAIB reports said that the closest proximities of aircraft cited were estimated from interpolations of the raw radar data, and may not accurately show the actual separation of the aircraft.

6. The AAIB's report on the B-747/G-IV incident said, "[While] there is a reasonable level of confidence in the fidelity of the simulation, it is sensitive to slight variations in the input data, which in this instance was recorded radar data. The TCAS algorithms evaluate the data once every second whereas the rate of acquisition of the radar data is dependent on the rate of rotation of the radar head, which is typically once every eight [seconds] or nine seconds. Missing data [are] therefore obtained by interpolation and consequently [their] accuracy cannot be assured."

7. The TCAS equipment on each aircraft met the same software standard, Version 6.04A (enhanced), said the report on the B-747/G-IV incident.

8. The AAIB said that medium-term conflict-alert systems are being developed in Europe "to detect potential separation conflicts … approximately two [minutes to] 20 minutes ahead of [the] closest point of approach."

AIRPORT OPERATIONS

Staff: Roger Rozelle, director of publications; Mark Lacagnina, senior editor; Wayne Rosenkrans, senior editor; John D. Green, copyeditor; Karen K. Ehrlich, production coordinator; Ann L. Mullikin, production designer; Susan D. Reed, production specialist; and David A. Grzelecki, librarian, Jerry Lederer Aviation Safety Library.

Subscriptions: US$60 (U.S.-Canada-Mexico), US$65 Air Mail (all other countries), six issues yearly. • Include old and new addresses when requesting address change. • Flight Safety Foundation, Suite 300, 601 Madison Street, Alexandria, VA 22314 U.S. • Telephone: +1(703) 739-6700 • Fax: +1(703) 739-6708