Airbus A340, A40-LB and Boeing 757-236, G-BIKG, 23 November 1995

AAIB Bulletin No: 7/96 Ref: EW/C95/11/4Category: 1.1

Aircraft Type and Registration:i) Airbus A340, A40-LB

ii) Boeing 757-236, G-BIKG

No & Type of Engines: i) 4 CFM56-5C turbofan engines

ii) 2 Rolls-Royce RB211-535C turbofan engines

Year of Manufacture: i) Unknown

ii) 1983

Date & Time (UTC): 23 November 1995 at 1031 hrs

Location: Heathrow Aiport

Type of Flight: i) Scheduled Public Transport

ii) Scheduled Public Transport

Persons on Board:i) Crew - 17 Passengers - 241

ii) Crew - 7 Passengers - 113

Injuries:i) Crew - None Passengers - None

ii) Crew - 2 minor Passengers - None

Nature of Damage:i) Left winglet

ii) Rudder and fin

Commander's Licence:i) Airline Transport Pilot's Licence

ii) Airline Transport Pilot's Licence

Commander's Age:i) 43 years

ii) 53 years

Commander's Flying Experience: i) Approx 8,000 (of which600 were on type)

Last 90 days - 140 hours

Last 28 days - 55 hours

ii) Total 11,700 (of which 320 were on type)

Last 90 days - 175 hours

Last 28 days - 44 hours

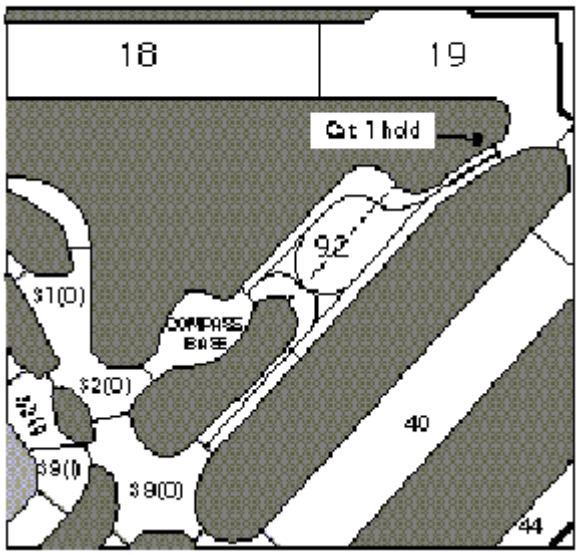
Information Source: AAIB Field Investigation

Background

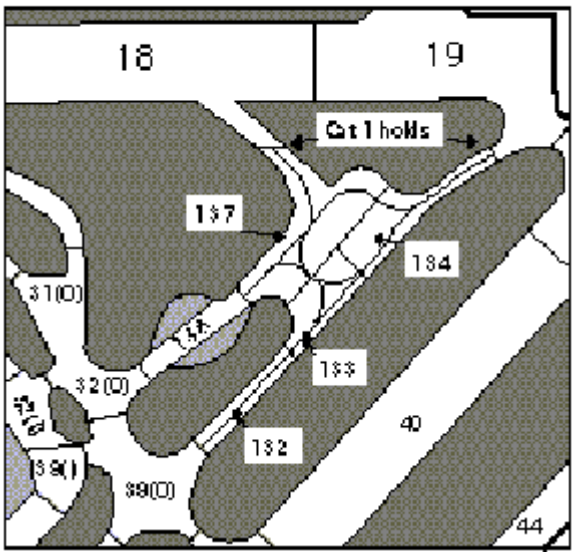
The runways and taxiways at Heathrow Airportare divided into 'blocks' with each block having an identificationnumber. Surrounding the central area are two orbital taxiwayswhich are essentially parallel; blocks on these taxiways alsohave the suffix 'I' for the inner taxiway and 'O' for the outertaxiway. Holding areas for each runway are located close to therunway thresholds. These contain a wide expanse of paved surfacewithin which aircraft can hold awaiting departure instructions. The width of these areas is such that aircraft cleared to enterthe runway can taxy past other aircraft awaiting departure instructions.

The accident occurred in the holding areafor Runway 27 Right. During the autumn of 1995, a new accessto Block 18 of Runway 27R was constructed as shown below. Withthe introduction of this taxiway the old holding area (Block 92)was subdivided into three new blocks and the compass base wasmoved to another part of the airport. Each block has a taxiwaycentreline marked on the ground by a yellow painted line and greenlights. (For clarity only the centrelines within the holdingarea are shown in the diagram below). At the end of each blockthere are stop lines and red lights across the centrelines markingthe extremity of the block.

RUNWAY 27R HOLDING AREA BEFORE OCT 95



RUNWAY 27R HOLDING AREA ON 23 NOV95



The boundary line at the top of Block 137 in the right hand diagramis also the Cat I Hold line. The line was painted parallel tothe runway and 105 metres from its centreline. This is also theedge of the runway strip. (The runway strip is defined in CAP168; essentially it is an area enclosing the runway which mustbe kept clear of obstacles). There was also a Cat II/III Holdparallel to and 137 metres from the runway centreline.

Within the holding area (the old Block 92), the parallel portionsof the taxiway centrelines were 86 metres apart. The longestwingspan routinely encountered at Heathrow is 64.44 metres whichbelongs to the Boeing 747-400. Consequently, when on paralleltaxiways, any aircraft can safely pass another if each remainsover its respective centreline. At Heathrow the centrelines haveto be sited so that when the cockpit of the most critical aeroplanefor which the taxiway is intended is over the centreline, thedistance between the outer edge of the main wheels and the edgeof the pavement is at least 4.5 metres.

Air Traffic Departure Sequencing

During busy times at Heathrow there can be a sizeable queue ofaircraft waiting to depart. To improve the departure rate, ATCsequence departures so that aircraft depart in quick successionbut on different routes. There are also the added complicationsof meeting approved departure times (known colloquially as ATCslot times) and wake turbulence separation. There is no requirementfor wake turbulence separation between departing aircraft of thesame wake turbulence category or when a heavier category aircraftdeparts behind a lighter category aircraft. However, when anaircraft departs behind another of heavier category, it must waitfor two minutes if they depart from the same position on the runwayor for three minutes if it departs from an intersection.

To enhance the departure movement rate, Heathrow ATC issues line-upclearances to aircraft based on the departure of the aircraftahead of them in the sequence. (A typical instruction might be"SPEEDBIRD EIGHT, AFTER THE SYRIAN AIR SEVEN TWO SEVEN DEPARTS,LINE UP ON TWO SEVEN RIGHT"). However, the aircraft aheadin the sequence may not be the aircraft directly in front of theaircraft receiving its line-up clearance; the preceding aircraftin the sequence may be to one side or behind or in another block. In practice aircraft crews may be given line-up clearance whenthey are third or more in the departure sequence. This has theadvantage of minimising runway occupancy time by 'pre-clearing'aircraft to taxy onto the runway as soon as the preceding aircrafthas vacated the appropriate runway block. By cutting down therunway occupancy time, the departure flow rate is improved.

Because the departure sequence cannot be determined before aircraftare cleared to taxy, they invariably arrive at the holding areain a less than optimum departure order and ATC expect aircraftto pass beside one another in the holding area. The reason forbuilding the new taxiway between the holding area and runway 27Rwas to improve ATC's ability to vary the departure sequence byextracting aircraft from the holding area through an additionalrunway access point.

The accident

The accident occurred in daylight, fine weather and good visibility. The Boeing 757 callsign Shuttle 6N pushed back from stand A3at 1013 hrs with no ATC slot time required. After starting engines,the aircraft was cleared by the ground movement controller totaxy via the outer taxiway for runway 27R. The A340 pushed backfrom stand L3 at 1010 hrs to make good its approved departuretime of 1020 hrs and received the same clearance from theground movement controller but, having a greater distance to taxi,was behind the Boeing 757 on its way to the holding area.

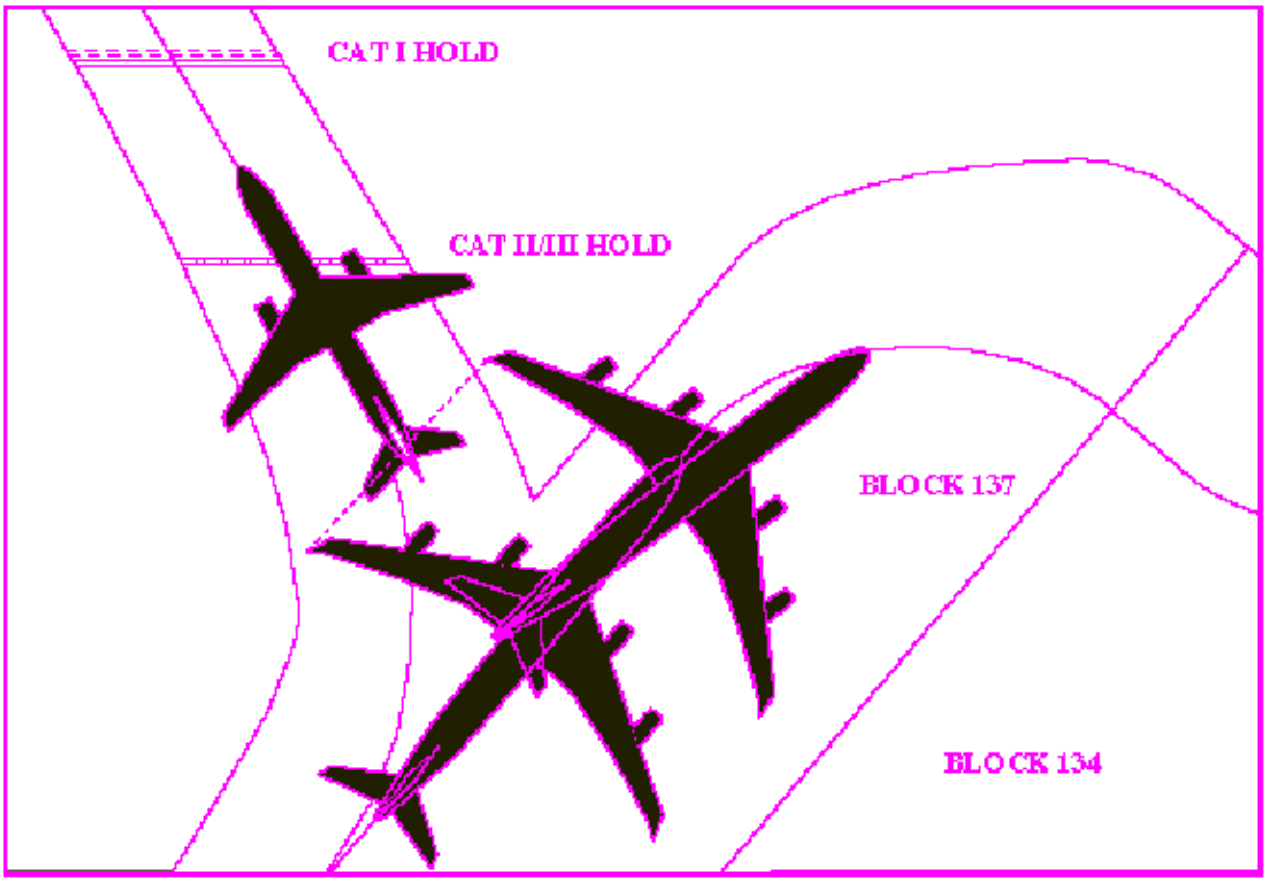
Both aircraft entered the holding area via Block 32(O) where therewas a queue of aircraft waiting to depart. At 1020 hrs the crewof Shuttle 6N were instructed to "HOLD FOR BLOCK 18". The aircraft was taxied by the co-pilot from the holding areainto the taxiway of Block 137 where it remained, stationary, untilthe accident. The A340 was behind several aircraft includingan Aer Lingus Boeing 737 and an MD11. Between 1023and 1031 hrs, ATC made several requests to pilots to taxy intoa different position. These calls took the forms of "STARTPULLING FORWARD NOW"; "PULL FORWARD BEHIND THE ALITALIA";"PULL OVER TO THE LEFT" and "PULL FORWARD AS FARAS POSSIBLE PLEASE". At 1025 hrs the controller asked theMD11 crew to "PULL OVER TO THE RIGHT HAND SIDE BEHIND THESYRIAN AIR" to which its pilot replied "YOU HAD US PULLUP BEHIND THE AER LINGUS SO WE CAN'T NOW". Next the controllerasked the crew of a Boeing 757 behind the A340 whether they couldmanoeuvre for a Block 18 departure but the crew replied that theywere unable to do so. They were then instructed to "PULLOVER TO THE RIGHT HAND SIDE FOR A FULL LENGTH".

During the next five minutes an A320, a Boeing 727 and a Boeing757 departed from the full length and a Boeing 737 departed fromBlock 17. Another Boeing 737 began its take-off run from thefull length after the departure from Block 17. As it did so,the MD11 followed by the A340 began to move forward. At 1031hrs the left hand wingtip of the A340 struck the Boeing 757'srudder and fin.

The impact was felt in both aircraft. In the Boeing 757 two cabincrew standing by the aft galley received minor injuries when theylost their balance but no one on board the A340 was injured. After the collision the A340 commander taxied a few feet furtherforward to ensure that his wing tip was clear of the 757's APU. Both aircraft then remained parked whilst the emergency serviceswere summoned by ATC. The Airport Fire Service arrived shortlyafter the accident and supervised the deplaning of all the passengersvia mobile airstairs and into coaches.

Measurements

Measurements taken after the incident showed that the nose landinggear of G-BIKG was 23.6 metres (along the taxiway centreline)behind the CAT I stop bar and 8.6 metres ahead of the CAT II/IIIstop bar. Profiles of the two aircraft imposed on a plan viewof the taxiways and holding area are shown below. The diagramshows that, with G-BIKG in its measured position and A40-LB inits final position, the contact measured on the winglet and rudderwould have occurred with A40-LB on its taxiway centreline at thepoint of contact.



Damage

On the B757 most of the damage was sustained on the lower partof the rudder, with further damage to beams and composite fairingpanels aft of the fin's rear spar. The rudder itself was splitinto two parts and was replaced. A number of the rudder attachmentbearings were also replaced but there was no evidence of damageto the rear spar of the fin itself. On the A340 most of the damagewas limited to the left-hand winglet, with minor scratching anddenting damage to the No. 6 slat on the leading edge. The left-handwinglet was removed and the aircraft was despatched without itin accordance with the Minimum Equipment List.

Human factors

Ten minutes before the collision, the Boeing 757 had been instructedto "HOLD FOR BLOCK 18". The co-pilot parked the aircraftwith the flight deck beyond the Cat II/III hold line but shortof the Cat I hold line. The commander was content with this parkingposition. He stated (correctly) that the hold line representsa limit not a target and no part of the aircraft should protrudeover the line which was painted diagonally across the taxiway. He was also anxious not to get too close to the runway becauseaircraft departing from the full length would pass close to hisaircraft and, should they encounter any directional control problems,he would be unable to get out of their way. The AAIB were unableto find any UK documentation requiring or encouraging pilots topull forward to the limit of a holding position.

The A340 commander taxied his aircraft by reference to the yellowtaxiway lines. He believed that if he followed these lines, hisaircraft would remain clear of any obstacles beside the taxiway. He had to hold in Block 137 for a while and there he receivedclearance to line up after an MD11 in

front of him departed. He was aware of the 757 in the link taxiway leading to Block 18and also of another 757 on his right. He made no comment to theother two pilots on the flight deck about the proximity of theseaircraft and they did not perceive the collision risk. (Neithercould have seen the left wing tip from his own seat). The sizeof the aircraft relative to the holding area and the positionof the link taxiway meant that the commander had to start turningright to follow the taxiway centreline at about the time his wingtip approached the parked B757's tail. The commander stated thatpart way around the right turn he looked to his left at the offendingwingtip but it was too late to avoid a collision.

The ATC tower is several hundred metres from Block 137 and thecontroller was unable to assess the collision risk between taxyingaircraft. He was totally reliant upon the "duty of the commanderof an aircraft to take all possible measures to ensure that hisaircraft does not collide with any other aircraft or with anyvehicle" (The Rules of the Air Regulations 1991, Rule 37).

Neither Heathrow Airport Limited (HAL) nor Heathrow ATC had conductedany studies to determine the collision risks involved in usingthe new taxiway link which was available to any aircraft regardlessof its size. Moreover, no account had been taken of taxying collisionrisks when designing the shape and position of the new taxiwayand holding points.

Collision Hazard

Studies by the AAIB using scale drawings showed that if an aircraftwith a long fuselage was holding in the taxiway of Block 137,there was a very real collision risk whenever an aircraft witha large wingspan followed the taxiway centreline to pass behindit in the same block. For pilots of some large aircraft types,separation between their wing tip and the tail of a parked aircraftis difficult to assess because of the restricted view from theflight deck. For instance, in the A340 the wing tip is 51 metres(167 feet) from the pilot and 41 metres (134 feet) behind him;in Concorde the wing tip is almost abeam the fin. In many contemporaryswept-wing airliners a wing tip can only be seen by making a specialeffort and then only from one pilot's seat. Pilots cannot seethe right wing tip from the left seat and vice-versa. Moreover,wing tips can be hard to see through rain spattered side windows(although on this occasion it was not raining) and some aircrafttypes, notably the ubiquitous Boeings 737, 757 and 767, do nothave a white navigation light on the tail; they have one on thetrailing edge of each wingtip. They do have logo lights to illuminatethe fin but there is no requirement for these lights to be switchedon. Consequently, the risk of collision may be greatest in heavyrain or at night.

Airport Design Requirements

The taxiways at Heathrow generally met the design criteria ofCAP 168 Licensing Requirements which generally mirror the standardslaid down in ICAO Annex 14 - Aerodromes. Both documents specifyminimum distances between taxiway centrelines and permanent featuressuch as runways, other taxiways and apron taxiways. The requirementsalso stipulate that taxiway centrelines must provide a clearanceof not less than 20% wingspan between an aeroplane's wing tipand a temporary obstacle when the aeroplane is in the centre ofthe taxiway. Both documents contained recommended minima forthe distance between a taxiway holding position and a runway centrelinebut only Annex 14 made reference to the distance between a taxiwayholding position and an adjacent taxiway centreline. The referencewas a recommendation which applied to the clearance between aparked aircraft's nose and a passing aircraft at an intersectionof two taxiways; there was no mention of tail to wing tip separationminima.

Airworthiness requirements

Requirements for the view from the A340 flight deck were containedin JAR 25.773 which states: *'Each pilot compartment must bearranged to give the pilots a sufficiently extensive, clear, andundistorted view, to enable them to perform any manoeuvres withinthe operating limitations of the aeroplane, including taxying,take-off, approach and landing'.* The requirements also statedthat internally, the flight deck windows must have a demistingsystem which provides sufficient visibility to execute the manoeuvresdescribed above. However, only the windshields have to be externallycleared of precipitation. The requirement was to provide '*aclear portion of the windshield during precipitation conditions,sufficient for both pilots to have a sufficiently extensive viewalong the flight path in normal flight attitudes of the aeroplane'.* Consequently, aircraft generally do not have screen wipingsystems for side windows.

Safety actions

The new taxiway was withdrawn from use immediatelyafter the accident. The CAA then invited HAL and Heathrow ATCto devise procedures for the use of the new taxiway which wouldminimise collision risks.

HAL appreciated the need to explain to pilots that on the taxiways,following the centreline provided adequate clearance from obstaclesbut not from other aircraft in the holding areas. There the centrelines represent only the centre of the taxiway route and wingtip clearance from other aircraft is not assured. However, duringlow visibility operations the green centreline lighting wouldbe used to provide two separate routes to the runway. One routewould be via Blocks 136 and 137 to Block 18 and the other wouldbe via Blocks 132, 133 and 134 to Block 19. Under these conditionsseparation would be assured.

On 7 February 1996 HAL proposed new measures to the CAA for re-openingthe taxiway link. Briefly these measures were:

a. Provision of new information signs at the entrances to eachof the four departure holding areas.

b. Issuing a Class II NOTAM showing the four departure hold areas,explaining their significance in terms of permanent green centrelinelighting and reminding pilots that separation from other aircraftis their responsibility in these areas.

c. Provision on a trial basis of lighting to illuminate aircraftholding in the taxiway of Block 137.

d. Publication of notices in the UK AIP and NOTAMS encouragingpilots to pull forward to stop bars.

The CAA accepted HAL's proposals on conditionthat further safeguards affecting the tactical use of the holdingarea were implemented by the Airport Authority.

The CAA also ordered that the taxiway shouldnot be used until the installation of signs and lighting, agreementon the wording of procedures and notices, and the education ofairport users had been co-ordinated with the Authority.

Safety recommendation 96-43

Whilst noting the measures enforced by theCAA, the AAIB were wary of the trend to route all departing aircraftthrough a common area on different taxiways whilst relying uponpilots to avoid collisions when pilots cannot always see the extremitiesof their aircraft. Therefore, it was recommended that:

The CAA should, in liaison with the appropriateICAO committees, consider what action may be taken in the longerterm to ensure that flight crews of large public transport aircraftare better able to achieve a positive clearance between theiraircraft and others while manoeuvring on the ground.