ACCIDENTS INVESTIGATION BRANCH
Department of Trade and Industry

EL AL Boeing 720 4X-ABB and BOAC Vickers Super VC10 G-ASGD

Report on the circumstances of the airmiss over Epsom, Surrey on 11 November 1969

LONDON: HER MAJESTY'S STATIONERY OFFICE
1971

List of Civil Aircraft Accident Reports issued by AIB in 1971

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SBN 11 510633 2

Department of Trade and Industry
Accidents Investigation Branch
Shell Mex House
Strand
London WC2
March 1971

The Rt. Hon John Davies MP
Secretary of State for Trade and Industry

Sir,

I have the honour to submit a report by Mr N S Head, an Inspector of Accidents, on the circumstances of the air miss between Boeing 720 4X–ABB and Vickers Super VC10 G–ASGD, which occurred over Epsom, Surrey on 11 November 1969.

I have the honour to be
Sir,
Your obedient Servant,

V A M HUNT
Chief Inspector of Accidents

Accident Investigation Branch

Civil Accident Report No EW/C/330

Aircraft:	1	Boeing 720–058B 4X–ABB
Engines:		Four Pratt and Whitney type JT3D–3B
Owner and Operator:		El Al Israel Airlines
Crew:		Commander - Captain L D Easterman - Uninjured Captain - Captain R Narunsky - ,, Co-pilot - First Officer Y Maor - ,, Flight Engineer - Flight Engineer U Barzilay ,, Cabin Crew - Four stewards, three stewardesses - Slightly injured
Passengers:		27 – Two slightly injured
Aircraft:	2	Vickers Super VC10 type 1151 – G–ASGD
Engines:		Four Rolls Royce Conway 550
Owner and Operator:		British Overseas Airways Corporation
Crew:		Commander – Captain R H Ewens – Uninjured Co-pilot – Second Officer A G Smith – ,, Third Pilot – Senior First Officer W D Brinsden – ,, Flight Engineer – Engineer Officer T R Finlayson – ,, Supernumerary – First Officer C E McMahon – ,, Cabin Crew – Three stewards, three stewardesses – ,,
Passengers:		29
Place of Incident:		Over Epsom, Surrey
Date and Time:		11 November 1969 at 1415 hrs.
		All times in this report are GMT.

Summary

Both aircraft were operating scheduled passenger services. G–ASGD was inbound to Heathrow Airport, London, and had been cleared to leave the Epsom holding stack for radar positioning for landing, to maintain flight level (FL) 70 (ie 7,000 feet on an altimeter datum of 1013.2 mbs). 4X–ABB was outbound from Heathrow and had been cleared via the Epsom non-directional beacon (NDB) at FL 60. G–ASGD had just left the Epsom holding stack when 4X–ABB appeared slightly below and crossing from left to right. Both aircraft considered they were on collision courses and took avoiding action.

The investigation has shown that the airmiss incident was caused by 4X–ABB passing through its assigned flight level because the captain did not reset his altimeter to the standard setting of 1013.2 mbs when passing the transition altitude of 4,000 feet.

1. Investigation

1.1 History of the flights

The BOAC aircraft, Super VC10 G–ASGD, was operating a scheduled service, inbound to London. It arrived in the London control zone at FL 80 at 1401 hrs and joined the standard left-hand holding pattern over the Epsom NDB. Shortly after its arrival over Epsom it was recleared to FL 70 and during this time both the captain's and co-pilot's altimeters remained on the standard setting of 1013.2 mbs, whilst the standby altimeter fitted in the aircraft was set to London's QNH of 990. At 1414 hrs when the aircraft was almost overhead the Epsom NDB it was instructed to leave the facility on a heading of 050°M for radar positioning for a landing on Runway 23L at London Heathrow Airport and to maintain FL 70. The commander disconnected the automatic pilot and commenced a turn to the right from the inbound track of the holding pattern of 275°M; it was during this turn that the airmiss occurred.

The El Al aircraft, Boeing 720 4X–ABB, was operating a scheduled service, outbound from London. It took off from Runway 28L at Heathrow at 1412 hrs, cleared for a 'Dover One' standard instrument departure. This required the pilot to turn left as soon as practicable after passing the end of the runway to intercept a QDM of 145° to the Epsom NDB and to cross Epsom NDB at 3,000 feet and Biggin VOR at 4,000 feet. Shortly after becoming airborne, the aircraft was instructed to change frequency to London radar who amended its clearance to climb to and maintain FL 60. During the climb cloud and heavy rain was encountered and the crew switched on the nacelle anti-icing system. The aircraft reported reaching FL 60 at 1414 hrs. About one minute later whilst carrying out the "climb out, and 5,000 feet" checks, the first officer, who had reset his altimeter from the QNH to the standard setting of 1013.2 mbs just after passing through 4,000 feet, noticed that the instrument was now reading FL 65. Before he had time to notify the captain, the airmiss occurred.

At the time of the incident the VC10 was in a right bank turning through approximately 035°M, flying in and out of cloud, when the Boeing 720 was seen approaching from the left, slightly lower, on what was considered a collision course. The commander of the VC10 stopped the turn and the Boeing 720 passed under it, disappearing from sight under the starboard wing.

The Boeing 720 was approaching the Epsom NDB, when its crew saw the VC10 at about 30°–45° off their starboard bow and slightly higher; they also judged they were on a collision course. The captain took immediate avoiding action and pushed the control column forward; the VC10 passed above them. During the avoiding action the Boeing 720 was subjected to considerable negative 'g' and some of the cabin crew, who were demonstrating

emergency procedures to the passengers, were thrown off their feet and suffered minor injuries; two of the passengers were also slightly injured. At this time the 'fasten seat belt' sign was still on. Both captains reported the airmiss immediately to their respective Air Traffic Control Services; G–ASGD to London approach control and 4X–ABB to London outbound radar. After landing at Munich the injured crew and passengers from the Boeing 720 were medically examined but, as their injuries were only very minor they rejoined the aircraft and the flight continued to Tel Aviv.

1.2 Injuries to persons

Injuries	*Crew*		*Passengers*		*Others*
	BOAC	*El Al*	*BOAC*	*El Al*	
Fatal	–	–	–	–	–
Non-Fatal	–	5 minor	–	2 minor	–
None	11	6	29	25	

1.3 Damage to aircraft

There was no damage to either aircraft.

1.4 Other damage

There was no other damage.

1.5 Crew information

1.5.1 *4X–ABB*

Captain L D Easterman, aged 49, was properly licensed and appropriately experienced to command Boeing 720 aircraft. He was flying as check captain and occupied the observer's seat.

Captain R Narunsky, aged 42, was properly licensed and appropriately experienced to command Boeing 720 aircraft. He occupied the left hand pilot's seat.

First Officer Y Maor, aged 34, was properly licensed and suitably experienced to act as co-pilot in Boeing 720 aircraft. He occupied the right hand pilot's seat.

Flight Engineer U Barzilay, aged 34, was properly licensed and suitably experienced to act as a flight engineer in Boeing 720 aircraft. He occupied the flight engineer's seat.

1.5.2 *G–ASGD*

Captain R H Ewens, aged 47, was properly licensed and appropriately experienced to command VC10 aircraft. He occupied the left hand pilot's seat.

Second Officer A G Smith, aged 20, was properly licensed and experienced to act as co-pilot under supervision in VC10 aircraft. He occupied the right hand pilot's seat.

Senior First Officer W D Brinsden, aged 53, was properly licensed and suitably experienced to act as co-pilot in VC10 aircraft and supervise others

acting as co-pilot. He occupied the jump seat between the captain and co-pilot.

Engineer Officer T R Finlayson, aged 37, was properly licensed and suitably experienced to act as a flight engineer in VC10 aircraft. He occupied the flight engineer's seat.

1.6 Aircraft information

1.6.1 *4X–ABB*

The aircraft had a valid certificate of airworthiness and a current maintenance release. Its weight and centre of gravity were within the prescribed limits; it had flown for a total of 22,327 hours since new.

1.6.2 *G–ASGD*

The aircraft had a valid certificate of airworthiness and a current certificate of maintenance. Its weight and centre of gravity were within the prescribed limits; it had flown for a total of 16,832 hours since new.

1.7 Meteorological information

A post-incident appreciation of the weather situation in the area shows that at the relevant time a deep depression was centred over the southern Irish sea; pressure at the centre of the depression was 980 millibars. Central and southeast England lay in the associated warm sector. Strong southwesterly winds prevailed over these areas and weather was generally cloudy with intermittent light rain.

A weather observation taken at London Heathrow Airport at 1415 hrs was as follows

Surface wind:	200°/24 knots
Weather:	Cloudy
Visibility:	25 kilometres
Cloud:	2/8 stratus at 1,200 feet 6/8 stratocumulus at 2,200 feet 8/8 altostratus at 9,000 feet
QNH:	989.7
QFE:	986.8

Reports from the crews indicate that both aircraft were flying in and out of cloud at the time of the incident.

1.8 Aids to navigation

Both aircraft were using the Epsom NDB: the VC10 had left this facility inbound to London Heathrow Airport, the Boeing 720 was outbound from Heathrow via the NDB.

1.9 Communications

The VHF radio communications between the two aircraft and London approach control (G–ASGD) and London outbound radar (4X–ABB) were normal.

1.10 Aerodrome and ground facilities

The relevant facilities at London Heathrow Airport were serviceable at the time of the accident.

1.11 Flight recorders

Both aircraft were fitted with flight data recorder systems; individual aircraft information is as follows:

1.11.1 *Boeing 720 4X–ABB*

4X–ABB was fitted with a Fairchild Industries type 5424–220 flight recorder. This system is of the oscillograph scriber type which provides, on steel foil, an engraved data record of pressure altitude, indicated airspeed, magnetic heading and normal acceleration.

Examination of the foil by the Israeli authorities showed that there was a complete record of the flight. The parameters covering the first 9 minutes were plotted. On the plot the zero datum for the pressure altitude data was the pressure at airport level on Runway 28L at Heathrow (QFE). Analysis of the pressure altitude data shows that approximately 2½ minutes after take-off the aircraft reached an indicated pressure altitude of 5,875 feet, during this time it had also turned left from the runway heading of 280°M. Approximately 40 seconds later, still at an indicated pressure altitude of 5,875 feet, an acceleration increment of -2.3g occurred. This acceleration is the first indication on the record of any flight path deviation associated with the incident and is related to a pitch-down manoeuvre when the captain pushed the control column forward. Following this, the altitude decreased to an indicated level of 5,425 feet and after increasing over the next 30 seconds to 6,075 feet it decreased over a period of 1 minute to 4,975 feet where it stabilised. The pressure altitude recorded immediately preceding the event was 5,875 feet, related to a datum pressure of 987 mbs, the Heathrow QFE. Corrections therefore have to be added to the recorded heights to allow for the difference in datum pressure between 987 mbs and the standard setting of 1013.2 mbs. This correction is 725 feet, consequently the pressure altitude recorded related to a datum pressure of 1013.2 mbs, would be 6,600 feet. Corrections must also be made for the system tolerances, which in this case amount to ±150 feet. Therefore, immediately prior to the manoeuvre associated with the airmiss, the flight recorder indicated that 4X–ABB was at a pressure altitude of 6,600 ±150 feet, related to a pressure scale datum of 1013.2 mbs.

1.11.2 *Super VC10 G–ASGD*

To meet the mandatory flight data recording requirements, G–ASGD was fitted with an EFDAS recorder which recorded mandatory parameters on stainless steel wire and on a non-protected tape recording cassette together with additional information which BOAC was recording for domestic reasons.

Examination of the mandatory flight data recorder cassette after the incident showed that no data had been recorded relating to the incident flight because the cassette had run out of wire before the flight began. It was subsequently established that maintenance personnel had made an error

in estimating the amount of unused wire which remained before the cassette was required to be changed. The domestic tape recorder had however worked correctly and the mandatory data was recovered from it. Analysis of the data shows that at 1414 hrs the aircraft was established at an altitude of 6,925 feet related to a datum pressure of 1013.2 mbs. Shortly after this time it made a steady turn to the right from a heading of 270°M. During this turn, at an indicated pressure altitude of 6,875 feet a pitch-up of about 10° occurred. This pitch-up is the first indication on the record of any flight path deviation associated with the incident. At, and following this time, some changes of indicated altitude are apparent. These changes include a decrease of altitude to an indicated level of 6,825 feet, followed by an increase to 7,225 feet and a further decrease to 6,850 feet. By about 1417 hrs the pressure altitude became relatively stable at an indicated value of about 7,025 feet. Although these variations are indicative of altitude gained or lost during the turn manoeuvre they also contain the related static system errors under the manoeuvre conditions.

The static vent which supplies static pressure data to the recorder system is not the same one used to supply the pilots' instruments. The particular position error corrections for this static vent are set out in the flight manual for the aircraft and amount to +90 feet for the associated conditions: IAS 215 knots, flaps 20°, altitude not exceeding 10,000 feet, weight 200,000 lb. With this correction applied, the pressure altitude becomes 6,875 + 90 = 6,965 feet. However, allowance must also be made for processing and other errors in the 'play back' system. Analysis of these errors and a cross reference of the recorded altitude on touchdown indicates that immediately prior to the manoeuvre associated with the airmiss the aircraft (G–ASGD) was at a pressure altitude between 6,870 feet and 7,060 feet related to a pressure scale datum of 1013.2 mbs and it was most probably with +30 feet of 6,965 feet.

1.12 Wreckage

Not applicable.

1.13 Fire

Not applicable

1.14 Survival aspects

Not applicable

1.15 Tests and research

The captains' and co-pilots' altimeters from both aircraft were checked for calibration; the readings from all four altimeters were found to be within the specification limits.

1.16 Other information

1.16.1 *Altimeter settings (procedures)*

Safe vertical separation of aircraft is achieved by requiring them to conform to prescribed altimeter setting procedures. The UK procedures are set out in detail in Chapter 8 of the RAC Section of the *United Kingdom Air Pilot*.

This incident is essentially concerned with the altimeter setting procedures during the climb phase in controlled airspace. For flights above a certain height (called the transition altitude) the altimeter sub scale datum to be used is the International Standard Atmosphere pressure of 1013.2 mbs or 29.92 inches of mercury. This is called the 'Standard Setting' (QNE). The vertical displacement of aircraft climbing through and flying above the transition altitude is expressed in hundreds of feet and are termed 'flight levels'.

In controlled airspace in the vicinity of an aerodrome, whilst flying at or below the transition altitude, or descending through it, the altimeter datum used is the latest aerodrome or regional barometric pressure reduced to sea level (QNH) and vertical displacement is expressed in feet and termed 'altitude'.

When departing from an aerodrome and when cleared to a flight level it is necessary for the pilots to change the altimeter datum from the QNH to the standard setting (QNE). Unless otherwise instructed, this is required to be done whilst climbing through the transition altitude. The vertical interval between the transition altitude and the lowest flight level, called the 'transition layer', provides time and space for the adjustment of altimeter settings.

Aircraft cleared to leave a flight level and descend through the transition layer to an altitude preparatory to making an approach to land may set the altimeter datum to the QNH on vacating the flight level unless ATC require reports passing specified flight levels.

Transition altitudes vary for different countries and different aerodromes. For the London control zone it is 4,000 feet. The lowest flight level normally used is 50 (ie 5,000 feet on the standard setting). However, on occasions when the actual barometric pressure is substantially lower than the standard setting, the use of flight level 50 would give insufficient vertical clearance above traffic at the transition altitude of 4,000 feet. On these occasions a higher minimum flight level is used. On the day of the incident the QNH was 989.7 therefore, for outbound traffic from Heathrow the lowest flight level was 60 and consequently the lowest flight level available to inbound aircraft, or aircraft holding preparatory to making an approach to land, was 70.

1.16.2 *Altimeter settings (crew drills)*

The El Al operations manual includes the following information with regard to altimeter setting and cross-checking procedures:

General Both pilots' altimeters shall be set to the same reference (QNH or QNE) at all times, in order that cross-checking can be done.

All landings and take-offs, and flight below the transition altitude shall be performed with the pilots' altimeters set on the latest available QNH.

Take-off and climb At the initial cockpit check, set both altimeters to the QNH given by the control tower or Automatic Terminal Information Services.

For take-off and climb to the published transition altitude, keep both altimeters on the QNH.

At the published transition altitude, change both altimeter settings to QNE (1013.2 mbs or 29.92 inches).

Altimeter cross-checking procedures: climb and descent During climb and descent the first officer shall call out 1,000 feet before reaching the cleared level, and upon reaching the cleared level.

As an 'aide memoire' to their pilots to help ensure correct altimeter setting and height reporting procedures, El Al have installed an indicator in their Boeing 720 aircraft.

This indicator is located on the instrument panel coaming between the two pilots and consists of a dial with figures 1 to 42, a movable pointer and a position index. In practice, the movable pointer is set against the figures representing an altitude or flight level to which the aircraft has been cleared whilst the position index is set to the required figure in cases where ATC requests reports on passing specified flight levels or altitudes.

2. Analysis and Conclusions

2.1 Analysis

It is apparent from the straightforward evidence supplied by the crew of 4X–ABB that at the time the airmiss occurred, their aircraft was being flown by reference to an altimeter set to 990 mbs instead of 1013.2 mbs. Consequently the aircraft was approximately 640 feet above the flight level to which it had been cleared.

Examination of the flight recorder data indicates that at the time of the incident this aircraft was flying at a height of not less than 6,450 feet and not greater than 6,750 feet related to a pressure datum of 1013 mbs.

The read-out of the flight recorder from the BOAC aircraft indicates that at the relevant time, and on the same pressure datum, this aircraft could have been at any height between 6,870 feet and 7,060 feet. It is appreciated that because of different static sources the pilot's instruments in both aircraft may have been giving slightly different indications but so far as the flight recorder evidence is concerned the two aircraft passed each other with a vertical separation not greater than 610 feet and not less than 120 feet. The evidence from the crews of both aircraft indicate that it was closer to the latter. Although they took avoiding action it is unlikely, having regard to their proximity when sighted, and therefore the very short time available, that this materially affected the margin of separation.

2.1.1. *El Al procedures*

The El Al operations manual clearly sets out the altimeter setting procedure to be followed by their pilots. During the climb both altimeters are to be changed to the standard setting when passing through the transition altitude, and the first officer should call out 1,000 feet before feaching any significant altitude (including the transition altitude) during climb or descent. Specific reference is made to the transition altitude in the "climb out, 5,000 feet check" and it was while this check was being completed that the failure to re-set the captain's altimeter to the standard setting was noticed, but by then the aircraft had climbed through the level to which it had been cleared. It is therefore relevant to examine how this error could have occurred.

Because of its low take-off weight the aircraft had the capacity for a high rate of climb and it is noted that it reported reaching FL 60 approximately 2 minutes after take-off. Therefore, the workload on the flight deck, which is necessarily high during take-off and initial climb, was further concentrated into a comparatively short period of time. In this particular case also, a noise abatement procedure had to be carried out which required changes in power settings and concentration on speed and timing. In addition, the handling limitations of the aircraft regarding angle of bank and flap retraction

had to be observed. The departure instructions were to turn to the left soon after take-off to intercept a predetermined track to the Epsom NDB and initially to climb to 3,000 feet over Epsom and 4,000 feet over Biggin Hill. Soon after take-off the flight was required to change to another R/T frequency for London radar who immediately amended the clearance to FL 60. It was about this time that the crew's attention was occupied by the necessity to select and check the nacelle anti-icing system as rain was encountered.

2.1.2. *Omission to re-set altimeter*

Whilst the over-all flight responsibility rests with the commander of 4X–ABB the error in altimeter setting was in fact made by a captain undergoing a route check. It can be appreciated that when the workload is high there is a greater tendency for any distraction to result in an omission. There is also a tendency for a pilot undergoing a check to over-concentrate on some aspects such as speed or heading to the detriment of other equally important factors.

It now appears from evidence supplied by other airline pilots that similar errors of altimeter setting have been made on other occasions, but pilots are naturally reluctant to report them and consequently it is likely that they have occurred on many more occasions than is generally appreciated.

On this occasion the possibility that separation might be seriously reduced as a result of the delay in resetting the altimeter was increased by the large difference between the actual and standard barometric pressures.

In the circumstances of the climb after take-off it is not feasible for the change of altimeter setting from QNH to QNE to be an executive command, acted upon in response to the item being called out from a check list. Therefore, in common with some other airlines, El Al use a memory procedure (known sometimes as a "set-up") during this phase of flight, in which individual crew members take appropriate actions including, inter alia, adjustments of the altimeter setting at the appropriate transition altitude. The various items on the "set-up" are then checked as having been carried out when the "climb out, 5,000 feet check" is read. Although this check revealed the error that had occurred it is worthy of note that when the transition altitude is lower than 5,000 feet all such a check can do is ensure flight at the wrong setting is not continued. Consequently, reliance must be placed on the setting being correctly made and cross checked at the transition altitude itself.

2.1.3 *Relevance of present ATC requirements*

The present transition altitude for the London control zone was established some years ago. At that time traffic was less dense and there was no requirement for noise abatement procedures and departure routings which have added considerably to the workload on pilots and on air traffic controllers. The majority of aircraft were piston engined types with a lower climb performance than the modern jet and it is estimated that at that period the normal elapsed time from take-off to FL 60 would have been in the order of 6 to 8 minutes as opposed to 2 minutes in this incident. Therefore, and in the light of information obtained in the course of the investigations, it is relevant to question whether the existing routings, the 4,000 feet transition altitude and the vertical separation standards represent the best

possible compromise under present day conditions. ATC have continually kept the London control zone traffic procedures under review, and following this incident, discussions took place to see if the transition altitude should be raised. It is appreciated that this would not only be against the existing recommendations of ICAO but would also create other problems. Nevertheless, the grave possibilities of this sort of human error are obvious. As it now appears that the error may have been made more frequently than was at first appreciated, and as the resultant risk will increase with a rise in traffic density, the problem should be given urgent consideration.

It is recommended that operators should review flight deck procedure which might in some instances be capable of improvement. In addition, operators and ATC should, once again, examine the London control zone traffic procedures in the light of present day conditions to see if alterations could be made which would reduce the concentration of flight deck workload immediately after take-off, and increase safety margins.

2.2 Conclusions

(a) *Findings*

(i) The crews were properly licensed and experienced.

(ii) The documentation of both aircraft was in order and they had been properly maintained.

(iii) The captain of 4X–ABB did not reset his altimeter to the standard setting of 1013.2 mbs at the transition altitude of 4,000 feet.

(iv) Because of the low atmospheric pressure obtaining, the missed resetting of the altimeter resulted in 4X–ABB climbing to a level very close to the flight level used by G–ASGD.

(b) *Cause*

The airmiss was caused by the failure of the captain of 4X–ABB to reset his altimeter at the transition altitude. This resulted in the aircraft passing through its assigned flight level and approaching the flight level in use for other traffic.

N S HEAD
Inspector of Accidents

Accidents Investigation Branch
Department of Trade and Industry
March 1971

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