Aviation Safety Investigation Report 199501346

Boeing Co
B747
Boeing Co
B737-400

04 May 1995

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Aviation Safety Investigation Report

199501346

The Bureau did not conduct an on scene investigation of this occurrence. The information presented below was obtained from information supplied to the Bureau.

Occurrence Number:	199501346	**Occurrence Type:**	Incident
Location:	160 NM N Broken Hill		
State:	NSW	**Inv Category:**	3
Date:	Thursday 04 May 1995		
Time:	1652 hours	**Time Zone**	EST
Highest Injury Level:	None		

Aircraft Manufacturer:	Boeing Co		
Aircraft Model:	747-400		
Aircraft Registration:	G-BNLR	**Serial Number:**	
Type of Operation:	Air Transport High Capacity International Passenger Scheduled		
Damage to Aircraft:	Nil		
Departure Point:	Sydney NSW		
Departure Time:	1534 EST		
Destination:	Bangkok THAILAND		

Aircraft Manufacturer:	Boeing Co		
Aircraft Model:	737-476		
Aircraft Registration:	VH-TJK	**Serial Number:**	24436
Type of Operation:	Air Transport Domestic High Capacity Passenger Scheduled		
Damage to Aircraft:	Nil		
Departure Point:	Alice Springs NT		
Departure Time:	1550 EST		
Destination:	Sydney NSW		

Approved for Release: Thursday, January 16, 1997

FACTUAL INFORMATION

Sequence of events

The B747 had departed Sydney and was maintaining flight level (FL) 310 on air route A576. The crew had reported passing the position reporting point MASDA at 1642 EST, with an estimate for reporting point KALUG of 1735.

The B737 had departed Alice Springs and was proceeding on A576 in the opposite direction. The crew had reported passing KALUG at 1616 with an estimate for MASDA of 1702. The aircraft was maintaining FL290.

When the B737 crew made their KALUG position report, the crew of the B747 was monitoring a different control frequency and was unaware of the presence of the B737. However, when the B747 crew made their MASDA position report, the crew of the B737 was on the same frequency, but did not hear the report and was unaware of the presence of the B747 on the reciprocal track.

At 1648, the crew of the B737 requested climb to FL330 and was instructed to "stand by" by Air Traffic Control sector 5 (Sec 5). Sec 5 then co-ordinated the request with the Sec 6 controller who concurred with the change of level for Sec 6 airspace. The Sec 5 controller proceeded to calculate a time of passing so that he could assess when a change of level for the B737 could be initiated.

The Sec 5 controller elected to use the ground speed method to calculate the time of passing. He asked each crew, in turn, to report the ground speed of their aircraft. It was at this time that both crews first became aware of the presence of the other aircraft, and that there was a possible confliction.

The controller made the initial calculation mentally and followed this with a written calculation on a note pad. As both calculations produced a result of 1724, he wrote this time of passing on the flight progress strip.

At 1652, Air Traffic Control approved the B737 to climb to FL330, with a requirement to reach FL330 by time 1714. The crew commenced the climb immediately.

The crew of the B747 received an information symbol indicating "Other Traffic" on their traffic alert and collision avoidance system (TCAS) when the B737 was approximately 40 NM ahead. The target information changed to a proximity alert followed by a traffic advisory warning. At this point the crew decided that if the TCAS proceeded to a resolution advisory the pilot in command would manually fly the aircraft as directed by the advisory. The co-pilot would simultaneously make a radio broadcast indicating the action being taken.

At approximately 1653.20, the TCAS issued a resolution advisory advising "climb, climb". The pilot in command immediately commenced a climb in accordance with this advice. Aware that the other aircraft was also climbing, the pilot in command continued the climb at the best rate to approximately FL321, before returning the aircraft to the approved cruising level, FL310. The co-pilot made a radio broadcast indicating that they were carrying out a TCAS climb at the same time as the pilot in command initiated the climb manoeuvre.

Analysis of the B747's quick access recorder showed that the aircraft gained approximately 500 ft during the time that the resolution advisory was active and then gained a further 550 ft before descending.

The pilot in command of the B747 did not see the B737. However, immediately before the TCAS resolution advisory warning activated, the co-pilot sighted the B737 straight ahead and at a slightly lower level. He lost sight of it as his aircraft entered the climb. At that point the B737 was passing directly below the B747.

The B737 was climbing at approximately 1,000 - 1,200 ft/min when the crew heard the TCAS climb radio call from the crew of the B747. They realised that their aircraft must have been the conflicting traffic and initiated an immediate descent. The crew looked up to see the underside of the B747 pass over and slightly to the right of their aircraft. The pilot in command levelled the B737 at FL305 and believed that his aircraft may have reached FL308 prior to the descent.

At 1653.30 (approximately ten seconds after the TCAS resolution advisory) the pilot in command of the B747 requested from air traffic control the position of the other aircraft. The Sec 5 controller responded by instructing the B737 to expedite climb to FL330. This instruction was carried out by the B737 crew.

The aircraft had passed with approximately 500 ft vertical separation and little or no horizontal separation. The required separation standard for two aircraft passing in the opposite direction on the same air route above FL 290 is a minimum of 2,000 ft vertical difference.

Air traffic control

During the investigation several people involved in the training and performance appraisal of the sector 5 controller indicated their concern with certain aspects of his abilities. These concerns were notably in the area of procedural separation standards. Examination of check reports and interviews with supervisors, training staff, and workface controllers revealed that the official air traffic controller performance and check reports related only to some of the perceived deficiencies.

Many supervisors and training officers (including the former "Check" controllers) prepared formal reports for official filing, but also retained other opinions in "private" files which were not readily available to management. However, the records that were available showed that his supervisors considered that the controller's performance was deficient in the area of procedural separation standards. When the controller was selected for training on another sector (Sector 6), the use of radar standards, which he had not used in previous ratings, was required. He subsequently failed this rating due to difficulty with procedural separation standards, rather than the radar standards. At the time of his final check for the Sector 6 rating the controller was experiencing personal problems which were not known to management.

There was no system in place to ensure that the responsible manager was specifically informed of a perceived weakness other than some review of the various reports prior to filing. This applied to ongoing performance appraisal as well as initial training and rating reports. As individual managers were often responsible for numerous controllers, the opportunity for them to adequately review all performance and check reports was not always available.

After the controller had failed to gain a rating on Sector 6, management elected to place him back on Sectors 1 and 5, those sectors on which he was rated prior to the Sector 6 training. The decision was made to retrain rather than refamiliarise the controller. Such a decision indicated a greater than normal concern for his ability to obtain the ratings which he had only recently held.

Having made this decision, management then elected not to provide the controller with simulator training to assist in this re-rating program, even though specific programs were available. The training officer was instructed to concentrate on separation standards during normal on-the-job training, especially time of passing and lateral separation problems.

Airborne collision-avoidance systems (ACAS)

ACAS are intended to improve air safety by acting as a last-resort method of preventing collisions or near collisions. The equipment utilises secondary surveillance radar technology to operate independently of ground-based aids and air traffic control. It monitors other aircraft in the vicinity and assesses the risk of collision by interrogating airborne transponders. Non-transponding aircraft cannot be detected. TCAS II, as fitted to the B747, is a version of ACAS which provides resolution advisories (for vertical manoeuvres only) as well as traffic information. The B737 was not equipped with any form of ACAS.

Time of passing calculation

Several attempts were made to replicate the calculation made by the controller for the time of passing. Neither the investigation team, air traffic services specialists, nor the controller concerned could determine how the time of 1724 was derived.

There was a 3 minute 20 second delay between the time the crew of the B737 requested the climb and the time the controller approved the climb. In this period the controller made two independent time of passing calculations, one mentally and one on a notepad. Whilst performing these tasks he was required to respond to nine separate air-ground and co-ordination communications involving 25 interchanges.

Two-way air routes

On 14 September 1995, a new upper air route network was introduced in the Australian Flight Information Region. The change resulted in numerous one-way air routes replacing many two-way routes and was intended, amongst other things, to reduce the potential for incidents such as this. The route being flown by the aircraft involved in this occurrence was not changed to a one-way route.

Flight crew response

TCAS resolution advisory

The pilot in command of the B747 was aware of the separation standard of 2,000 ft which was applicable at FL310. He chose to continue climb beyond that normally expected for a TCAS event, because of the known position and climbing attitude of the other aircraft. He wanted to ensure that his aircraft would outclimb the B737 and took into consideration the fact that any third aircraft in the area should be at least 2,000 ft above his aircraft.

ANALYSIS

This occurrence involved the provision of an airways clearance to permit an aircraft to climb through the level of another aircraft travelling in the opposite direction on the same air route.

Calculation of the closest point of approach indicates that, had the crews of both aircraft not responded following the TCAS activation, the aircraft would have passed with no horizontal separation and approximately 200 ft vertical separation.

Flight crew response - TCAS resolution advisory

The resolution advisory is an indication given by TCAS II to a flight crew that a vertical manoeuvre should or should not be performed to maintain safe separation from other aircraft. If required, such a manoeuvre should average between 300 ft and 400 ft. To prevent possible secondary separation problems, the manoeuvre should not normally exceed 700 ft. In this occurrence, the pilot in command decided to climb his aircraft in excess of this expected range because of the relative positions of the two aircraft.

The crew of the B737 did not see the B747 until after the TCAS broadcast by the crew of the B747, and the only visual acquisition was by the co-pilot of the B747 some seconds before the TCAS resolution advisory after he had received traffic advice from the TCAS. It is therefore reasonable to say that, had the B747 not been equipped with TCAS, neither crew would have seen the other aircraft in time to commence effective avoiding action.

Time of passing calculation

The separation standard based on the time of passing calculation was correct. It was the calculation itself that was in error.

The controller was confident that his calculations were correct because the time written on his notepad agreed with his mental assessment. However, he had been distracted by the amount of air-ground and co-ordination exchanges required in such a short period of time. This level of distraction would have resulted in a high mental workload and may have contributed to the erroneous time of passing calculation.

Management strategies

Having decided to re-rate the controller on Sectors 1 and 5 instead of refamiliarising his previous ratings, management indicated a greater than normal degree of concern for his performance. Information stored in "private files" would have given management a better insight into these perceived procedural deficiencies.

A re-rating program was devised to assist the controller, but this plan did not require simulator training for procedural separation standards. Such training may have provided a more comprehensive preparation for his rerating. Although adequate simulator exercises were available, finding appropriate training staff for the simulator proved difficult.

SIGNIFICANT FACTORS

1. The aircraft were travelling on a two-way air route in opposite directions.

2. Management strategies for the early detection and remedy of perceived deficiencies in controllers' competencies were ineffective.

3. The controller miscalculated the time of passing of the aircraft.

4. The TCAS on the B747 provided the only catalyst for avoiding action by the aircrew.

SAFETY ACTION

During the course of the investigation the Bureau of Air Safety Investigation issued the following interim recommendation to the then Civil Aviation Authority on 6 June 1995:

"IR 950117

"The Bureau of Air Safety Investigation recommends that the Civil Aviation Authority:

"(i) mandate the fitment and use of an Airborne Collision Avoidance System (ACAS) in all aircraft engaged in Regular Public Transport (RPT) operations;

"(ii) consider the requirement for the fitment and use of a suitable ACAS in other aircraft engaged in the carriage of passengers for hire or reward;

"(iii) mandate the activation of any SSR transponder in aircraft so equipped at all times when airborne, irrespective of the class of airspace in which the aircraft may be flying;

"(iv) mandate the standard of ACAS equipment to be carried in each aircraft classification;

"(v) set a timetable for the introduction of ACAS equipment; and

"(vi) ensure that air traffic services officers are given adequate and timely education and continuation training in the capabilities and operational impact of ACAS equipment."

The following response was received from the Civil Aviation Safety Authority on 21 August 1995:

"I refer to Air Safety Interim Recommendation IR950117 regarding Airborne Collision Avoidance Systems (ACAS).

"In response to the reported airmiss occurrences referred to as justification, in part, for this recommendation, the Civil Aviation Safety Authority has commenced an examination and analysis of both BASI and AA incident data in order to identify and better understand the nature of these deficiencies within the Australian aviation system. Significant differences between BASI and AA data, in both number and classification of reported incidents, has complicated and restricted this process to date.

"Apart from analysis of risks in a non ACAS environment, CASA also recognises the need to assess the impact of ACAS on future major projects such as TAAATS and implementation of AACS. The Authority also intends to review any potential disbenefits that may arise from ACAS, including spurious activations and effects of resolution advisories (RAs) in complex air traffic situations.

"Industry and Public consultation will precede any adoption of requirements for aircraft to carry ACAS. The Authority continues to monitor world trends and is currently reviewing recent UK safety studies on ACAS."

The Bureau has classified the response as OPEN and has initiated further correspondence on the matter.

Additionally, Interim Recommendation IR950218 was issued to the Civil Aviation Safety Authority and Interim Recommendation IR950219 was issued to Airservices Australia, after the 1995 reorganisation. These were issued on 11 January 1996:

"IR950218

"That the Civil Aviation Safety Authority in conjunction with other operators of TCAS-equipped aircraft, evaluate the initial and recurrent training requirements for aircrew of TCAS-equipped aircraft.

"The evaluation should ensure that the risks associated with excessive vertical deviations in response to TCAS RAs are identified."

The Civil Aviation Safety Authority responded on the 12 February 1996 as follows:

"I refer to your interim recommendation number IR950218 regarding the incident involving Boeing 747, G-BNLR and Boeing 737-476, VH-TJK, on 4 May 1995.

"Summary

"The authority accepts the Interim Recommendation.

"Background to response

"Details of the exact nature and extent of training currently undertaken by TCAS equipped operators will be determined to establish whether or not such training adequately addresses the risks associated with excessive and inappropriate pilot responses to RAs."

The Bureau has classified this response as CLOSED/ACCEPTED.

"IR 950219

"That Airservices Australia evaluate the TCAS initial and recurrent training requirements for ATS personnel. This evaluation should ensure:

"(i) thorough and consistent practical knowledge is achieved throughout ATS; and

"(ii) TCAS RA encounters are practised in simulator sessions."

Airservices Australia responded on the 22 February 1996 as follows:

"I am writing in response to your Interim Recommendation IR950219 which recommends that Airservices Australia:

"evaluate the TCAS initial and recurrent training requirements for ATS personnel.

"Preliminary evaluation of the level and extent of TCAS training provided to Air Traffic Services personnel indicates that training on TCAS was generally consistent across Air Traffic Services centres.

"The training provided consisted of local team development supported by a video presentation with accompanying booklet detailing TCAS procedures.

"The ATS Operational Training Unit is currently developing a comprehensive package for the purpose of evaluating TCAS training and awareness. The purpose of this evaluation is to assess both the level of initial training and the current appreciation of TCAS.

"Future TCAS training will be dependent upon the results of this evaluation. The focus of any proposal will be on improving and enhancing training delivery to ensure that both initial and recurrent training needs are clearly identified and addressed.

"A variety of instructional methodologies and strategies will be considered during the evaluation process. Any proposal for simulation of TCAS RA encounters will also be dependent on the results of the evaluation and the feasibility of successfully simulating such encounters."

The Bureau classified this response as CLOSED/ACCEPTED.

Note: In December 1996 CASA issued a Legislative Instrument Proposal which proposed the mandatory carriage of TCAS equipment in some classes of aircraft, and addressed further the recommendations IR950218 and IR950219.

Final recommendations

The Bureau of Air Safety Investigation made the following recommendations on 1 November 1996:

"R950227

"That Airservices Australia further review the upper air route structure to create, wherever practicable, one-way air routes within the Australian Flight Information Region."

"R950228

"That Airservices Australia review the training given to ATC and Flight Service staff in coping with distractions in the workplace, and consider improvements in the techniques to reduce the impact of distractions on staff performance."

"R950229

"That Airservices Australia:

"(i) develop strategies that encourage all officers who carry out performance appraisals to notate all concerns in an adequate and timely manner on the approved proforma;

"(ii) develop strategies for improved management oversight of appraisal reports, especially in the area of "below expected performance" assessments; and

"(iii) ensure that specific training programs, including simulator and desk-top exercises, are developed to address perceived deficiencies in each of the skill and knowledge items contained in any appraisal report."