
AIRPROX, Embraer EMB-145EU vs. Two McDonnell Douglas F-15Es

Micro-summary: An altitude bust by a flight of F-15Es puts an Embraer at risk.

Event Date: 2005-01-27 at 1135 UTC

Investigative Body: Aircraft Accident Investigation Board (AAIB), United Kingdom

Investigative Body's Web Site: <http://www.aaib.dft.gov/uk/>

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INCIDENT

Aircraft Type and Registration:	(i) Embraer EMB-145EU, G-EMBE (ii) Two Mc Donnell Douglas F15E Eagle aircraft
Date & Time (UTC):	27 January 2005 at 1135 hrs
Location:	Between reporting points EBOTO & SIVDA (near Bedford) at FL210
Type of Flight:	(i) Public Transport (Passenger) (ii) Military
Persons on Board:	(i) Crew - 4 Passengers - 35 (ii) Crew - 4 Passengers - None
Injuries:	None
Nature of Damage:	None
Information Source:	AAIB Field Investigation

Synopsis

The aircraft commander reported seeing a military fighter aircraft pass close in front of him whilst his aircraft was cruising on Airway P155 at FL210. The conflicting aircraft was later identified as one of a pair of United States Air Force F15E 'Eagle' aircraft diverting from RAF Lakenheath to RAF Valley. The military aircraft were both low on fuel and were diverting due to poor weather and air traffic delays at Lakenheath. They had climbed above their cleared level and one aircraft passed within 0.53 nm of the aircraft on the airway. It has not been possible to determine the vertical separation during the 'Airprox' encounter.

History of flight

Two F15E 'Eagle' aircraft departed in formation from RAF Lakenheath, Suffolk at 0948 hrs for a close air support training sortie at Otterburn Range which is about 20 nm north-west of Newcastle. Each aircraft was crewed by a pilot and a weapons system officer. The formation commander had the allocated callsign Tahoe 51 and his wingman callsign Tahoe 52. The formation was to operate under the leader's callsign.

The sortie had been planned early that morning and fuel calculations took into account the Allocated Sortie Duration (ASD) of 1.3 hours and the nominated diversion of RAF Valley in Anglesey, Wales. "BINGO" fuel, the lowest fuel load required to return to base from the range and if necessary divert, was 10,000 lb.

On reaching the range the aircraft flew at altitudes between 10,000 and 12,000 ft being guided onto ground targets by ground based forward air controllers. About twenty-five minutes into the exercise Tahoe 52 informed the formation commander that he was approaching "BINGO" fuel. The formation commander decided to reduce "BINGO" fuel to 9,000 lb as he considered that under the prevailing conditions, both aircraft still had sufficient fuel remaining to complete one more run at 20,000 ft during the climb to their cruising altitude for their transit back to Lakenheath. About 10 nm from the target Tahoe 52 informed the formation commander that he was now at the new lower "BINGO" fuel level, but the formation commander decided to complete the run

as he estimated that to do so would only burn an additional 200-300 lb in fuel.

Having completed this final run the two aircraft climbed to FL240 and flew in formation towards Lakenheath, at the normal transiting speed of 320 KCAS. Shortly after reaching FL240, Tahoe 52 requested they slow down in order to conserve fuel as his flight management system was indicating that his aircraft would arrive at Lakenheath with 5,800 lb of fuel; the calculated diversion fuel being 6,900 lb. The formation commander judged that fuel could be conserved by carrying out a minimum power descent from their cruising altitude which would result in the aircraft arriving at Lakenheath with sufficient fuel to divert.

Between 75 and 100 nm north of Lakenheath, at about 1105 hrs, the formation commander contacted the SOF¹ at Lakenheath for a weather update. He was informed that the weather was worse than that on departure and was continuing to worsen. The ATIS weather report obtained by the formation commander a few minutes later gave the main cloud base as 1,200 ft aal (above airfield level), but with some cloud at 800 ft aal. Shortly after this, about 50 nm north of the airfield, the aircraft began their minimum power descent at which time Tahoe 52 observed eight other aircraft on his datalink display operating in the Lakenheath area.

Initial contact with Lakenheath ATC was made at 1116 hrs when the aircraft were handed over from London Military Radar to the Lakenheath Approach controller. At this time the aircraft were maintaining their formation in VMC above a layer of cloud. The

aircraft were given a radar information service and were cleared to descend to FL070. The formation commander requested an ILS approach in trail to the active runway, Runway 06, and the aircraft were given radar vectors to the east for sequencing. When the formation was given vectors back towards the west the formation commander realised the spacing between the formation and the aircraft ahead had now extended beyond the minimum 10 nm spacing normally required by Lakenheath ATC. The formation was also informed by ATC that: "Arrival is busy".

Concerned by their low fuel state, at 1121 hrs, the formation commander asked ATC what the expected delay would be. ATC replied that there would be "NEGATIVE DELAY" and that they were now being turned onto the downwind leg. Thinking they would shortly be vectored onto the approach the formation commander decided to continue with his intention of landing at Lakenheath, both aircraft then having less than their planned diversion fuel for RAF Valley.

In order to expedite the approach for Tahoe 52, who had less fuel remaining than Tahoe 51, Tahoe 52 took the lead as the formation turned to the west. Tahoe 51 took up a position in trail using his aircraft's radar to maintain a 2 nm separation. Tahoe 52 then took it upon himself, without discussion with the formation commander, to take over the formation's radio transmissions with ATC. As a result of the change in lead aircraft, ATC also instructed Tahoe 52 to take over the formation squawk of 0407 on his transponder, at the same time instructing the formation commander to turn his transponder to standby. These instructions were acknowledged by the two pilots.

At 1122 hrs the formation requested, and were given, a radar advisory service in anticipation of going IMC

Footnote

¹ Supervisor of Flying: a pilot or weapon system officer in the control tower passing operational information to crews on a different UHF frequency to ATC.

as they continued their descent towards the cloud layer covering the Lakenheath area. At about this time the formation commander also requested an update on the latest airfield weather conditions from the SOF who reported a pilot observed cloudbase of between 300 and 500 ft aal.

The formation commander had expected to be turned by ATC onto a closing heading for the ILS by the time the aircraft were 13 nm west of the airfield, however the vectors given took them about 30 nm west. As a result he again questioned the expected delay with ATC and at 1127 hrs mentioned for the first time the possibility of having to divert to RAF Valley. Approach replied that they would be turned in another 5 nm and handed them over to the Lakenheath Arrival frequency. The formation checked in with Lakenheath Arrival at 1128 hrs and were given a vector back towards the airfield and clearance to descend to an altitude of 3,000 ft. ATC now reported that the aircraft were under a radar information service, the aircraft having been under a radar advisory service at the time they were handed over. This change was not questioned by either aircraft.

Listening to the radio transmissions between ATC and other aircraft on the Arrival frequency the formation commander became aware that the aircraft ahead of them was an F15E. This aircraft was following an F15C which was on finals. The F15E was only 6 nm behind the F15C, which was less than the 10 nm minimum separation required by Lakenheath ATC. The formation commander was aware that the F15E has an approach speed of about 180 kt whereas the lighter F15C has an approach speed of about 150 kt and that the gap between them was therefore likely to close. He expected that it was likely that the following aircraft would have to go around and he was then also aware of a different aircraft going around due to the weather. He stated that all this

indicated to him that ATC were under pressure. The formation commander called the SOF for another update and was advised that the cloudbase was now 300 ft aal and reducing; the SOF recommended that the formation divert to RAF Valley.

At 1129 hrs Tahoe 52, as instructed by the formation commander, advised ATC that the formation was diverting to RAF Valley and that it was turning onto a heading of 291°. The aircraft were now about 25 nm west of Lakenheath, passing an altitude of about 5,000 ft in the descent. Tahoe 52 had about 5,000 lb of fuel on board and the formation commander about 5,500 lb.

ATC asked for the call to be repeated. The formation commander informed Tahoe 52 that he, the formation commander, would now make the formation's ATC calls and informed ATC that the formation would be turning onto a heading of 300°. He also requested a hand over to London Military Radar. Although it was not discussed between the aircraft, Tahoe 52 maintained the formation squawk of 0407. The formation commander then used his auxiliary radio to instruct Tahoe 52 to carry out a climb at maximum 'dry' power to FL240. Seconds later Lakenheath Arrival instructed:

Arrival:	“TAHOE FIVE ONE CLIMB AND MAINTAIN FLIGHT LEVEL TWO THREE ZERO STAND-BY FOR CO-ORDINATION”
Tahoe 51:	“WILCO”

Then, using the auxiliary radio, the formation commander instructed Tahoe 52 to check his fuel load and requirements for the diversion. No mention was made of their cleared flight level nor his previous instruction to climb to FL240, although he did inform Tahoe 52 that he intended to request airways crossing clearance at FL300.

The formation commander also commenced climbing, at a rate of about 5,000 ft/min, and was aware of controlled airspace above his aircraft at FL195 from his avionic displays. He was increasingly concerned about the fuel state of Tahoe 52, who was by now about 5 nm ahead and to the west of his own position. The formation commander made several calls to Lakenheath Arrival to get a hand over to London Military Radar (callsign 'London Mil') for airways crossing clearance, which was more and more urgently needed due to their position. The first of these calls was at 1130 hrs:

Tahoe 51:	"ARRIVAL WOULD YOU PASS TO LONDON THAT WE'RE GONNA BE CLIMBING TO FLIGHT LEVEL THREE HUNDRED REQUESTING TO CROSS THE AMBERS AT FLIGHT LEVEL THREE HUNDRED"
Arrival:	"TAHOE FIVE ONE UH.... CORRECTION MAINTAIN FLIGHT LEVEL ONE FIVE ZERO EXPECT HIGHER WITH LONDON"
Tahoe 51:	"ROGER WOULD YOU PASS THAT MESSAGE TO LONDON PLEASE"
Arrival:	"TAHOE FIVE ONE WILCO"

The aircraft were by then climbing through FL 120.

At 1130:19 hrs the process of arranging a handover to London Military was begun through telephone conversations between the London Military allocator and the Lakenheath coordinator. Within 20 seconds, a London Military controller had been allocated to handle the "un-pre-noted UHF handover". The London Military controller asked the Lakenheath coordinator to instruct the formation to squawk 6143 for identification. This was acknowledged by the Lakenheath coordinator but the conversation about the formation's requests and intentions continued for about another 40 seconds,

interspersed with and interrupted by several messages between aircraft and the Lakenheath Arrival controller. At 1131:33 hrs the Lakenheath Arrival controller informed the formation that their handover to London Military had been arranged. The formation was instructed to turn onto a heading of north and to call London Military on 254.825 MHz. The 6143 transponder code acknowledged by the Lakenheath coordinator was not communicated to the formation.

Radar records showed that by this time Tahoe 52 was in the climb passing FL160. The frequency change to 254.825 MHz was correctly read back by the formation commander and he instructed his wingman to change to that frequency. However, the wingman did not acknowledge the leader's instruction so a few seconds later, using the aircraft's auxiliary radio (on a private frequency), Tahoe 51 then transmitted "TAHOE FIVE TWO COME UP TWO FIVE FOUR **ZERO** TWO FIVE" (instead of 254.825 Mhz). None of the crew in either aircraft noticed the mistake and the formation commander attempted to make contact with London Military on the incorrect frequency. Radar records show that at this time the Mode C squawk being transmitted by Tahoe 52 for the formation disappeared.

Unable to get a reply to his transmissions, the formation commander instructed Tahoe 52 to select a pre-set frequency and the formation made contact with London Military at 1132:20 hrs:

Tahoe 51:	"LONDON MIL TAHOE FIVE ONE"
London Mil:	"TAHOE FIVE ONE LONDON MIL PASS YOUR MESSAGE"
Tahoe 51:	"ROGER M'AM WE ARE FUEL DIVERT OFF OF LAKENHEATH DIRECT TO VALLEY I NEED CLIMB UP TO FLIGHT LEVEL THREE"

HUNDRED OR THREE ONE ZERO DIRECT TO VALLEY FOR FUEL”

London Mil: “TAHOE FIVE ONE CONFIRM YOUR LEVEL PASSING”

Tahoe 51: “ROGER MA’AM I’M AT TWO ZERO SEVEN AND I’D LIKE TO CLIMB UP TO FLIGHT LEVEL THREE HUNDRED”

London Mil: “TAHOE FIVE ONE AVOIDING ACTION TURN RIGHT HEADING NORTH TRAFFIC BELIEVED TO BE YOU...YOU HAVE TRAFFIC EAST THREE MILES AT FLIGHT LEVEL TWO ONE ZERO”

Tahoe 51: “ROGER I BELIEVE...I’VE GOT MY WINGMAN WITH ME AS WELL YOU MIGHT SEE HIM”

London Mil: “TAHOE FIVE ONE SQUAWK SIX ONE FOUR THREE WHAT TYPE OF RADAR SERVICE DO YOU REQUIRE”

At this time Tahoe 52 was approximately 5 nm north-west of Tahoe 51 at an unknown altitude. Also at this time London Area Control Centre received a radio transmission from the captain of a civil Embraer 145 flying at FL210 from west to east along Airway P155 in the area of the two military aircraft. The captain informed ATC that they had just seen an F15 aircraft pass the nose of their aircraft about one hundred feet below and “no more than about two hundred yards ahead, descending”.

Meanwhile the formation commander of the military aircraft was still in conversation with the London Military controller:

Tahoe 51: “SIX ONE FOUR THREE I WOULD LIKE RADAR CONTROL AND WE SAW CIVIL TRAFFIC OUR APOLOGIES THERE AND WE WOULD LIKE TO CLIMB UP TO FLIGHT LEVEL THREE ZERO ZERO”

London Mil: “TAHOE FIVE ONE NEGATIVE MAINTAIN YOUR LEVEL UNTIL IDENTIFIED”

Tahoe 51: “TAHOE FIVE ONE IS GOING TO SQUAWK EMERGENCY MA’AM WE HAVE EMERGENCY FUEL DIVERT FOR TAHOE FIVE TWO WHO IS WITH US WE NEED TO CLIMB TO THREE ZERO ZERO IF THAT WOULD HELP YOU BETTER WE WOULD LIKE TO GO AHEAD AND SQUAWK EMERGENCY NOW”

London Mil: “TAHOE FIVE ONE AFFIRM SQUAWK EMERGENCY”

The time of this transmission corresponds with the re-appearance of secondary data on radar for both Tahoe 51 and Tahoe 52, the formation commander now positioned about 10 nm to the east of his wingman flying on a divergent track. Both aircraft levelled shortly afterwards at FL230.

The formation commander pressed ATC for a climb to FL300 which was denied due to conflicting traffic. The formation commander then asked London Military if there was a suitable airfield with good weather for them to divert to on the eastern side of the country, suggesting the military airfields at Cottesmore and Waddington. The controller was at this time on the telephone trying to arrange a hand over of the aircraft to Swanwick Military. Due to the loud volume of the telephone she misheard the transmission as a request to divert to Cottesmore. A further request by Tahoe 51 for the anticipated delay before they could climb was also misheard by the controller as a request to climb. Tahoe 51 made a further request for the weather at Cottesmore or Waddington but the request was not answered. Instead Tahoe 51 was asked to confirm he was the lead aircraft to which he replied that he was and that his wingman was to the west of him. London Military then gave clearance to climb:

London Mil: "TAHOE FIVE ONE CLIMB NOT ABOVE FLIGHT LEVEL TWO FOUR ZERO MAINTAIN YOUR LEVEL TAHOE FIVE TWO MAINTAIN FLIGHT LEVEL TWO THREE ZERO YOU'RE CO-ORDINATED AGAINST CIVIL TRAFFIC ON THE AIRWAY"

Tahoe 52: "TAHOE FIVE TWO FLIGHT LEVEL TWO THREE ZERO AND LOOKING FOR CLIMB AS SOON AS POSSIBLE"

London Mil: "TAHOE FIVE ONE FLIGHT CONTACT SWANWICK MIL TWO SEVEN FIVE DECIMAL THREE FIVE"

Tahoe 51: "TWO SEVEN FIVE DECIMAL THREE FIVE TAHOE FIVE ONE PUSH"

Tahoe 52: "TAHOE FIVE TWO IS UNABLE WE ARE EMERGENCY AIRCRAFT CLIMBING TO THREE ONE ZERO AT THIS TIME ER WE ARE HEADING THREE ZERO ZERO DIRECT VALLEY"

Swanwick Mil: "TAHOE FIVE TWO THAT'S UNDERSTOOD BOTH AIRCRAFT EXPEDITE CLIMB FLIGHT LEVEL THREE ONE ZERO MAKE YOUR HEADING TWO NINE ZERO BOTH AIRCRAFT ARE NOW UNDER RADAR CONTROL"

Both aircraft then switched frequency to Swanwick Military:

Tahoe 51: "LONDON MIL TAHOE FIVE ONE EMERGENCY AIRCRAFT FOR FUEL REQUESTING THREE ZERO ZERO DIRECT VALLEY"

Swanwick Mil: "TAHOE FIVE ONE SWANWICK MIL IDENTIFIED CLIMB FLIGHT LEVEL THREE ONE ZERO RADAR CONTROL REQUEST YOUR HEADING"

Tahoe 51: "ROGER MA'AM THE HEADING WILL BE TWO NINE ZERO"

Swanwick Mil: "TAHOE FIVE ONE COPIED TAHOE FIVE TWO ARE YOU ON THIS FREQUENCY"

Tahoe 52: "TAHOE FIVE TWO AFFIRMATIVE WE'RE PASSING TWO FOUR ZERO FOR THREE ONE ZERO"

Swanwick Mil: "TAHOE FIVE TWO NEGATIVE MAINTAIN YOUR CURRENT ER LEVEL FLIGHT LEVEL TWO FOUR ZERO REQUEST YOUR HEADING AND CONFIRM YOU'RE AN EMERGENCY AIRCRAFT AS WELL"

Both aircraft then climbed to FL310 and continued towards RAF Valley. During their transit Swanwick Military questioned Tahoe 52 to confirm that the aircraft also had a fuel emergency. The controller then confirmed the relative position of both aircraft and that each call sign was now that of a single aircraft and not a formation.

Four minutes after being cleared to climb to FL310, Tahoe 52 informed Swanwick Military that he was beginning his descent for RAF Valley. The reported cloudbase over the airfield was 1,300 ft with a visibility of 30 km. Both aircraft were guided onto precision radar approaches to Runway 32 at RAF Valley and made successful landings. Tahoe 52 had a low fuel warning approximately 40 nm from the airfield and landed with 1,100 lb of fuel remaining. Tahoe 51 landed slightly behind Tahoe 52 with 2,000 lb of fuel onboard.

Weather

Weather information at Lakenheath was provided by USAF meteorological resources. The Terminal Approach Forecast (TAF) for Lakenheath available at the time the flight was planned was as follows:

EGUL 270404 36010KT 9999 VCSH SCT020
BKN030 OVC050 QNH3026INS

TEMPO 0410 36010G15KT 9999 -SHRA
 BKN015 OVC030 BECMG 0910 35010G15KT
 9999 -SHRA FEW020 BKN030 OVC050
 QNH3023INS BECMG 1516 34010G20KT 9999
 -SHRA FEW010 BKN0

The TAF had been updated by the time the aircraft began their return from Otterburn range to:

EGUL 271004 36010KT 8000 -DZ FEW006
 BKN010 OVC025 QNH3023INS TEMPO 1114
 3200 -DZ BKN007 OVC015 BECMG 1516
 34010G20KT 9999 -RA FEW010 BKN020
 OVC050 QNH3020INS BECMG 1920
 35010G20KT 9999 -RA BKN010 OVC030

The actual conditions (METAR) for Lakenheath at the time of takeoff were:

EGUL 270955Z 36007KT 8000 DZ BR FEW006
 BKN018 OVC027 06/03

The actual conditions (METAR) at Lakenheath when the aircraft began their return flight from Otterburn range were:

EGUL 271055Z 00008KT 5000 -DZ BR SCT008
 BKN010 OVC015 05/04

The formation commander also stated that the aircraft experienced a tail wind component of 40 to 50 kt during their return transit to Lakenheath.

The METARs for RAF Cottesmore and RAF Waddington at the time of the diversion were:

RAF Cottesmore:

EGXJ 271050Z 36010KT 9999 -RADZ SCT005
 OVC008 05/05 Q1027
 EGXJ 271150Z 35010KT 2300 DZ SCT003
 OVC006 05/05 Q1026

RAF Waddington:

EGXW 271050Z 34007KT 2500 -RADZ BKN004
 OVC014 06/05 Q1027
 EGXW 271150Z 34009KT 9000 -DZ SCT004
 BKN008 OVC015 06/06 Q1026

Aircraft description and operating procedures

The F15E is a twin-engined fighter ground attack jet aircraft operated by a pilot and a weapons systems operator. The aircraft are operated in the UK by the United States Air Force at various bases, including Lakenheath in Suffolk. The F15C is a lighter, single seat fighter version of the aircraft.

The aircraft involved in this incident were equipped with a datalink which allowed the position of all aircraft operating the system to be shown on a display selectable by either crew member. In addition, they were equipped with radar capable of identifying the position of other aircraft. They were also fitted with an auxiliary radio which allowed communication between the two aircraft on a discrete frequency.

Fuel consumption is dependent on numerous factors but estimated figures for the aircraft involved in this incident indicate a fuel burn of between 7,000-10,000 lb/hr in the cruise and for the range exercise, reducing to 1,500 lb/hr in the idle descent. Standard operating procedures state a minimum required fuel quantity on landing of 1,200 lb and the declaration of an emergency fuel state when a landing at 800 lb or less is predicted. Tables carried by

the aircrew gave a planned diversion fuel requirement for RAF Valley from Lakenheath of 6,900 lb and a 'SNAP' diversion² requirement of 3,200 lb plus landing fuel (approximately 1,000 lb).

The formation commander had an A category instrument rating which allowed an approach to the published minimums, which for Runway 06 at Lakenheath were 200 ft aal and 800 m RVR. The wingman had a cat B instrument rating which allowed an approach to 300 ft aal and 1 nm (1854 m) RVR.

Radar data

Civilian air traffic control radar recordings were obtained covering the time of the incident. They show that at 1131 hrs the formation began squawking the emergency Mode A code 7700 with a concurrent Mode C altitude of 16,800 ft. Twenty five seconds later both the Mode A and C squawks disappeared, the last Mode C altitude recorded being 18,500 ft. The Mode A emergency squawk 7700 then reappeared 1 minute and 21 seconds later concurrent with a Mode C altitude of 22,400 ft.

The recordings showed a minimum lateral separation between Tahoe 52 and the Embraer 145 of 0.53 nm and a minimum lateral separation between Tahoe 51 and the Embraer 145 of 1.18 nm. No Mode C altitude information is displayed for either of the military aircraft during this period and it has not been possible to verify the minimum vertical separation.

Footnote

² The SNAP diversion fuel is that required to fly direct from runway to runway in still air at the optimum altitude, arriving overhead the destination at 1,000 ft with zero fuel remaining. In practice, the fuel required to divert is greater to allow sufficient fuel for an approach and landing with a minimum fuel remaining of 800 lb on touchdown.

Analysis

When the crews carried out their fuel planning the weather conditions for Lakenheath were forecast to deteriorate with temporary light showers and a cloudbase of 1,500 ft predicted for around the time of their return. However when they took off the weather conditions were already worse than forecast with drizzle, mist and a cloudbase as low as 600 ft in parts. The worse than forecast conditions were reflected in the updated forecast promulgated later that morning but it was not available until after the two aircraft had departed.

The formation commander stated he had wished to remain at the range as long as possible in order to make use of the unusual opportunity presented by the presence of ground controllers at the range. Once his wingman had called at 'BINGO' fuel the formation commander had used his experience to re-calculate the minimum fuel required. This was done in the knowledge that fuel would be saved due to the tail wind on their return flight and by carrying out a minimum thrust descent, but importantly also under the misconception that there would be no problem with the weather on their return and that they would not be delayed by other aircraft trying to land. As a result Tahoe 52 had significantly less than the required fuel when the formation began its transit back to Lakenheath.

The request by Tahoe 52 to slow down in order to conserve fuel during their return was rejected by the formation leader because he was concerned that by doing so they would not complete the flight within the ASD. The ASD forms part of the flying hour program, a system allocating time to sorties in order to ensure that all squadrons were provided with sufficient flying time to complete their annual training requirements. Had this ASD been overflowed then the system would have

required a cut in the duration of another sortie. The formation commander had another flight that afternoon and did not wish to reduce its duration by exceeding the ASD in the morning, nor did he want the additional time to be deducted from a colleague's sorties instead.

The formation commander considered they were also unable to conserve fuel by flying at a higher altitude as this would have put the aircraft into upper airspace and therefore under radar control, with any vectors imposed outweighing the benefit of any fuel saving at this altitude.

It was quite normal for the wingman in a formation to use more fuel than the formation leader due to the necessity to manoeuvre more in order to maintain position. In this incident, whilst the main fuel problem existed with Tahoe 52, the formation commander was also below his required fuel state during the return transit.

By the time the formation was about 50 nm from Lakenheath the formation commander was aware of the worse than expected weather conditions, including the fact that the cloudbase was now as low as 800 ft. Furthermore, he was aware that there were eight other aircraft operating in the area of the airfield. The formation commander however continued to believe that the aircraft would be able to land at Lakenheath despite the conditions and their low fuel state. The pressure started to increase when the formation was given extended radar vectors by ATC in order to provide adequate spacing between aircraft recovering to the airfield. This had not been anticipated by the formation commander and he received conflicting information from ATC as to the extent of the delay. Crucially, ATC had responded at one point that there would be "negative delay" and this contributed to his continuing view that they would have adequate fuel to land at Lakenheath.

It appears that Lakenheath ATC were under pressure due to the deteriorating weather. Their requirement to maintain a 10 nm separation between landing aircraft (excepting those within the same formation) provided protection of approach aids for aircraft carrying out instrument approaches. The formation commander considered the reduced separation of 6 nm between his wingman and the F15C was likely to lead to a go-around. He decided to divert when he heard another aircraft go around at the same time as the SOF advised that the cloudbase was at 300 ft aal and reducing.

When the formation elected to divert, Tahoe 52 had 1,900 lb less than the planned diversion fuel of 6,900 lb and only about 1,000 lb above the SNAP diversion fuel requirement. Tahoe 51 had an additional 200 lb of fuel on board. It is understandable, therefore, that foremost on their minds was the need to divert to RAF Valley without further delay, by the most direct route and at a suitably high altitude in order to conserve the remaining fuel. Communications taking place between the two aircraft at this time are unclear but they appeared to have ceased operating as a formation, both aircraft setting off on different tracks and soon becoming separated by several miles.

The handover to London Military took one minute to arrange during which time the formation commander had instructed Tahoe 52 on the auxiliary radio to climb to FL240 followed by Lakenheath ATC instructing both aircraft to climb to FL230, later corrected to FL150. None of the replies to these transmissions included the cleared level in the read back, a fact that went unchallenged. Despite replying to the transmission correcting their cleared level to FL150, by the time the aircraft were handed over to London Military Tahoe 52 was already passing FL160 in the climb and both aircraft continued until level at FL230, suggesting the clearance was either misunderstood or ignored.

The formation commander then mistakenly selected the wrong frequency when handed over to London Military. He thought this might have happened as the frequency selection keypad had the '8' button positioned immediately above the '0' button. However, his mistake was not corrected by the other three flight crew. The resulting delay in having to free call another frequency and then getting the aircraft identified on radar meant that the controller had insufficient time to provide adequate separation between the two military aircraft and the commercial aircraft on the airway.

London Military's attempt to identify the two F15E aircraft was complicated by the fact that on handover neither of them was displaying any secondary radar information. The decision by Tahoe 52 to stop transponding was possibly linked to the fact that Tahoe 51 had resumed responsibility for making the radio calls. Equally, no information was provided explaining why Tahoe 52 had taken over the radio calls during the approach into Lakenheath, except that at the time this happened he had just become the lead aircraft. Certainly it would appear that Tahoe 52 did not inform the formation commander of his intentions or actions on either occasion. The re-appearance of the Mode A and Mode C squawks on both aircraft coincided with the formation leader's request to ATC to squawk emergency.

Comments received raise concerns about the fact that the secondary radar data disappeared as the aircraft entered controlled airspace and only re-appeared once the aircraft had cleared the airway. From the radio transcripts this does not appear to have been intentional on the part of the pilots. In addition it has been suggested that the disappearance was due to a failure of the ground radar, however because the secondary data from the F15E disappeared on more than one ground radar but

other aircraft were unaffected, this does not seem to be the case. The absence of the secondary data, through whatever cause, effectively disabled both the ground radar's short term conflict alert and the Embraer 145's TCAS, representing a serious loss in conflict warning and resolution ability for all the aircraft and ATC.

Because Mode C data from the F15E aircraft was not available when the controller warned of the potential conflict, it has not been possible to determine which of the two F15s was seen by the crew of the commercial aircraft. The controller's comment that the conflicting traffic was to the east seems incorrect, whether the comment referred to Tahoe 51 or Tahoe 52, because for both aircraft the commercial traffic was approaching from the west. Reports filed by the military pilots state that the commercial aircraft was not seen at all by Tahoe 52 and that when seen by Tahoe 51, the commercial aircraft was about 1,000 ft below at a range of about 1 to 2 nm. The Embraer 145 commander's view that the F15 seen was only 200 yards away would suggest that he saw Tahoe 52, the closer of the two aircraft, although his impression that the F15 was descending seems to be incorrect.

When asked whether he was aware of the airway, the formation commander stated that he was but that he believed he would have been to the north of it by the time he had climbed through its level. He also stated that he was busy looking out and so was paying little attention to his airborne radar or navigation display and that the systems operator was busy reprogramming the navigation computer for their diversion. This might explain why neither military pilot claimed to have seen the Embraer 145 on their radars. Information available suggests that the formation commander was working particularly hard to try and rectify a rapidly worsening situation, with little evidence of help from the other crew members in the formation.

Once the F15s had cleared the conflicting traffic, the controller had the task of identifying each aircraft, confirming the full nature of each one's emergency and trying to hand them over to Swanwick Military in order to clear them for further climb. The difficulty in doing so was compounded by trying to ascertain whether the callsign "Tahoe 51" related to a single aircraft or to a formation, and why Tahoe 52 was now ahead by some 10 nm and flying on a different track. This was complicated still further by the audio volume of the landline used in trying to co-ordinate a handover and the pressing need of the aircraft to continue their climb in order to conserve fuel. As a result the formation commander's attempt to select a closer diversion was, in the end overlooked, although the weather at both RAF Cottesmore and Waddington appears to have been unsuitable.

The confusion was not restricted to ATC, who were by then treating both aircraft as single callsigns. When Tahoe 51 was cleared to climb to FL300, Tahoe 52 also began a climb despite being miles away and cleared only to maintain FL230. Finally, ATC were able to provide the necessary clearance to both aircraft to climb to their required level and there seems to have been no further reported problems during their recovery into RAF Valley.

Previous events

In carrying out this investigation it has become apparent that there have been previous incidents involving loss of separation between aircraft due to confusion between ATC and military aircraft operating in formation. In particular the AAIB carried out an investigation (Ref: EW/C2000/11/05) in November 2000 in which an Airprox occurred between a civilian airliner in controlled airspace and an F15E. This investigation made recommendations about radio and secondary radar procedures for military aircraft transiting in formation.

As a result, military aircraft within the UK are required to fly within 100 ft vertically and 1 nm horizontally of each other when operating as a formation, using one callsign and one transponder only.

A further incident was highlighted (Airprox Report No 102/02) in which an RAF Jaguar aircraft pulled up from low level in order to conserve fuel when returning to base at minimum fuel level without first being identified by ATC. This too resulted in an Airprox with a civilian airliner.

Conclusion

On departure from Lakenheath there was cloud significantly lower than the 1,500 ft forecast lowest cloud for the time of take-off in the TAF issued to the crews to plan their mission. This unforecast weather deterioration could have been assessed as reinforcing the plan to depart Otterburn with Valley diversion fuel. However, the incorrect assessment of the weather conditions for the aircrafts' return led to their departure from Otterburn range with less than the planned diversion fuel requirements, but sufficient fuel for a 'SNAP' diversion.

The decision to divert due to the unforecast poor weather and extended ATC vectoring encountered on their return was left too late. The formation commander continued in the hope that they would be able to land at Lakenheath despite their obviously low fuel state, delayed approach and deteriorating weather. This in turn resulted in an extremely high workload for the crews, in particular for the formation commander.

Lakenheath ATC's shortfall in not communicating the transponder code change requested by London Military contributed to the subsequent radar identification problems near civil controlled airspace. Moreover, working under pressure, the formation commander

instructed the wingman to switch to the assigned frequency for London Military. Then, on not receiving the appropriate acknowledgement from his wingman, he inadvertently instructed him to change to the wrong frequency using an auxiliary radio. This confusion delayed the handover of positive control between Lakenheath and London Military at a crucial stage of the diversion. Most notably, because they were critically short of fuel, the aircraft climbed through their cleared flight level, without transponding, entered controlled airspace and conflicted with the Embraer 145.

Inadequate transmission and acknowledgement of clearances within the formation plus the crews'

inability to fly either as a coherent formation or as two independent aircraft during the diversion were major contributory factors to the ensuing general confusion. Also, poor use was made of the highly sophisticated aids available to the crews in monitoring fuel loads, monitoring ground position and using airborne radar. Whilst it is accepted that aircraft such as the F15E necessarily operate at times close to their minimum fuel requirements, this places an even greater emphasis on the need to make early decisions when a deteriorating weather situation makes a diversion more probable. This is especially so when the diverting aircraft are required to negotiate some of the UK's busiest areas of civil controlled airspace.