

**SERIOUS INCIDENT**

<b>Aircraft Type and Registration:</b>	1) Citation 525, D-ITAN 2) Boeing 777 300ER, TC-JJA
<b>No &amp; Type of Engines:</b>	1) 2 Williams International FJ-44-1A turbofans 2) 2 GE90-115B1L turbofans
<b>Year of Manufacture:</b>	1) 2000 2) 2007
<b>Date &amp; Time (UTC):</b>	27 July 2009 at 1440 hrs
<b>Location:</b>	London TMA (terminal control area)
<b>Type of Flight:</b>	1) Civil (Executive) 2) Commercial Air Transport (Passenger)
<b>Persons on Board:</b>	1) Crew - 2                      Passengers - 1 2) Crew - 16                     Passengers - 232
<b>Injuries:</b>	1) Crew - None                 Passengers - None 2) Crew - None                 Passengers - None
<b>Nature of Damage:</b>	1) None 2) None
<b>Commander's Licence:</b>	1) Commercial Pilot's Licence 2) Airline Transport Pilot's Licence
<b>Commander's Age:</b>	1) 49 years 2) Not known
<b>Commander's Flying Experience:</b>	1) 4,300 hours (of which 1,250 hours were on type) Last 90 days - 60 hours Last 28 days - 30 hours 2) Not known Last 90 days - not known Last 28 days - not known
<b>Information Source:</b>	AAIB Field Investigation

**Synopsis**

The crew of D-ITAN were cleared to depart London City Airport on a DVR 4T SID, which required them to climb initially to 3,000 ft amsl. They read back their cleared altitude as 4,000 ft, an error that was not noticed by the Tower controller. At about the same time, TC-JJA was cleared to descend to an altitude of 4,000 ft while turning onto a southerly heading prior to intercepting the ILS for Runway 27R at Heathrow

Airport. D-ITAN climbed through 3,000 ft while turning right and passed TC-JJA on a nearly reciprocal heading approximately 0.5 nm away and 100 to 200 ft below. TC-JJA generated three TCAS RAs in short succession but the aircraft did not follow the commands. D-ITAN was unable to generate RAs. The crew of D-ITAN saw TC-JJA in time to take effective avoiding action. Five Safety Recommendations are made.

History of the flights

Cessna Citation 525; D-ITAN

D-ITAN was due to depart London City Airport on a DVR 4T Standard Instrument Departure (SID) from Runway 27 (see Figure 1). The procedure was to climb to and maintain an altitude of 3,000 ft until reaching a range of 25.5 nm on the 076° radial from the LON VOR, following which the aircraft would be cleared to climb to an altitude of 4,000 ft.

The crew requested clearance to start engines from the Tower controller but were given both start and ATC clearances in the reply. The ATC clearance was:

“DOVER FOUR TANGO DEPARTURE MAINTAIN ALTITUDE THREE THOUSAND FEET”

After a delay of five to six seconds the crew read back:

“FOUR TANGO DEPARTURE CLIMBING FOUR THOUSAND FEET”.

Although the Tower controller noticed and corrected the omission of the word ‘Dover’, he did not notice the incorrect readback of the cleared altitude. D-ITAN taxied to the runway and was cleared for takeoff at 1436 hrs.

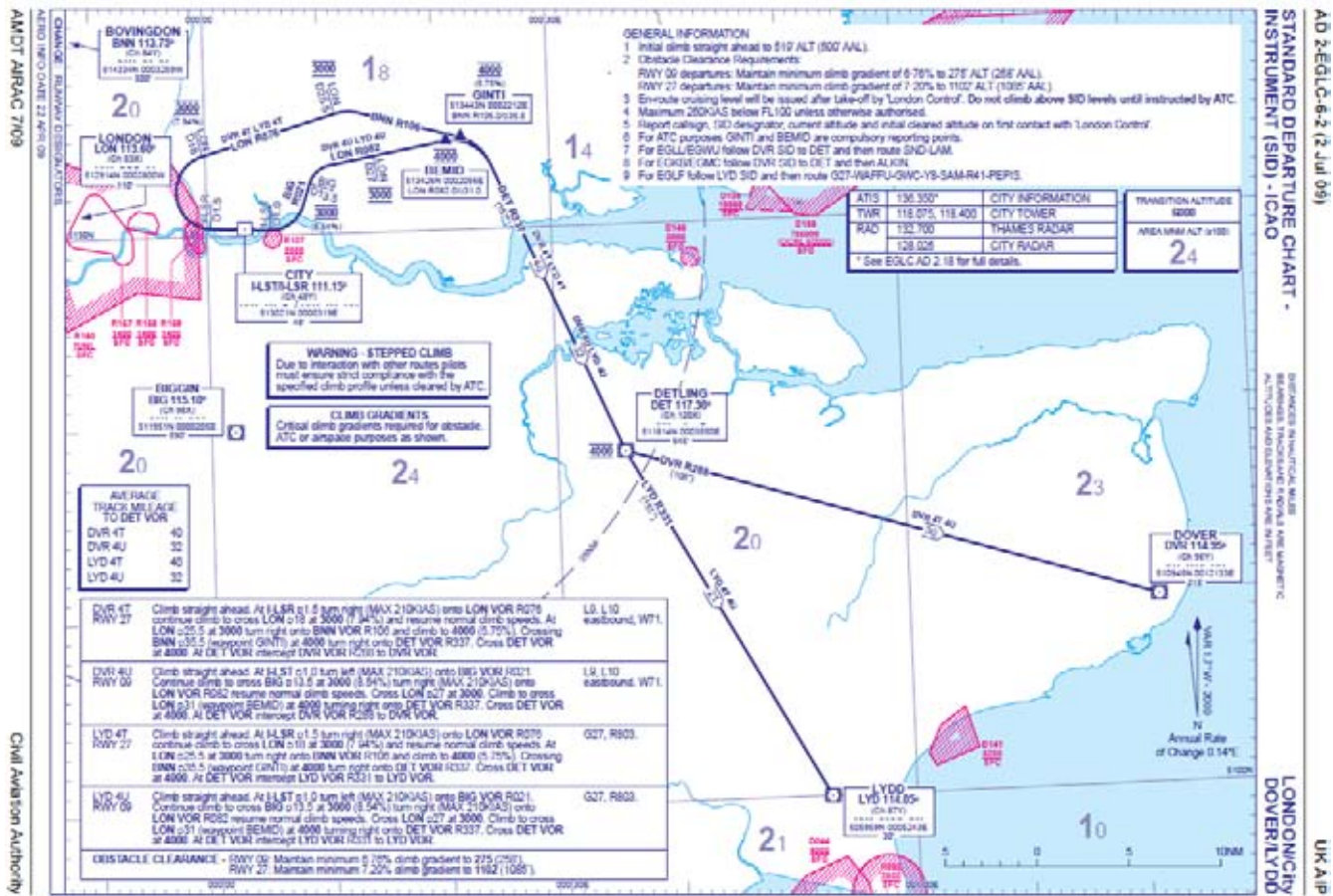


Figure 1  
DVR 4T SID

After takeoff, the aircraft maintained a heading of 270° until 1437:27 hrs when it began to turn right (Figure 2). As it passed an altitude of 1,300 ft, the aircraft was climbing at a rate of just under 3,000 ft/min and as it passed 3,000 ft, the rate was 3,300 ft/min. At 1437:28 hrs, the crew was instructed to contact Thames radar, which they did at 1438:16 hrs. During the intervening period, there were two gaps in radio transmissions, one of four seconds and one of two seconds. At 1438:19, D-ITAN was heading north at an altitude of between 3,800 and 3,900 ft when it passed TC-JJA on a nearly reciprocal heading. D-ITAN was approximately 0.5 nm to the west of TC-JJA and 100 to 200 ft below it. At 1438:32, the radar controller transmitted:

“DELTA ALPHA NOVEMBER REPORT YOUR ALTITUDE. DELTA ALPHA NOVEMBER DESCEND IMMEDIATELY DESCEND TO ALTITUDE THREE THOUSAND FEET”.

The crew of D-ITAN acknowledged and complied with the instruction although by then their aircraft was clear of TC-JJA. At 1439:40, the radar controller instructed D-ITAN to:

“CLIMB TO ALTITUDE FOUR THOUSAND FEET”

which was acknowledged by the crew.

#### *Boeing 777-300ER; TC-JJA*

TC-JJA, callsign Turkish Airlines 1991, was being vectored for an ILS approach to Runway 27R at London Heathrow Airport. The commander was the Pilot Not Flying (PNF) and the co-pilot, who was under training, was the Pilot Flying (PF). They were flying in VMC at 180 kt IAS and were cleared to descend to an altitude of 4,000 ft. At 1437:38 the aircraft was at an altitude of 4,900 ft and was instructed to turn right onto a heading of 185°. As the pilot transmitted his acknowledgement,

a TCAS Traffic Alert (TA) was generated. At 1438:05, he transmitted:

“WE HAVE A TRAFFIC ALERT”

but during the transmission a TCAS ‘crossing descend’ Resolution Advisory (RA)<sup>1</sup> was generated. The Heathrow controller replied:

“AFFIRM. HE’S BUST HIS LEVEL. CAN YOU CLIMB CLIMB<sup>2</sup> TO MAINTAIN FIVE THOUSAND FEET?”

During this transmission, a TCAS ‘increase descent’ RA was generated. Following this, a TCAS ‘reversal climb’ RA was generated between 1438:11 and 1438:15. TC-JJA levelled briefly at an altitude of 4,000 ft before starting to climb and it was while the aircraft was at 4,000 ft that it passed D-ITAN at 1438:19.

During a conversation with the controller at 1438:50, the pilot of TC-JJA transmitted:

“WE HAD TO DO A RESOLUTION HERE”

which was acknowledged by the controller.

#### *London City Tower controller*

The London City Tower controller reported to the internal National Air Traffic Services (NATS) enquiry that he recalled D-ITAN requesting both start and ATC clearance at the same time, which was usual for private aircraft. The controller was not sure whether he mis-heard the pilot’s readback of the altitude restriction or whether he did not hear it at all due to his attention being focussed on correcting the omission of the word “Dover”.

---

#### **Footnote**

<sup>1</sup> An RA which takes the aircraft through the threat aircraft’s altitude.

<sup>2</sup> Intentional repeat of the word ‘climb’.

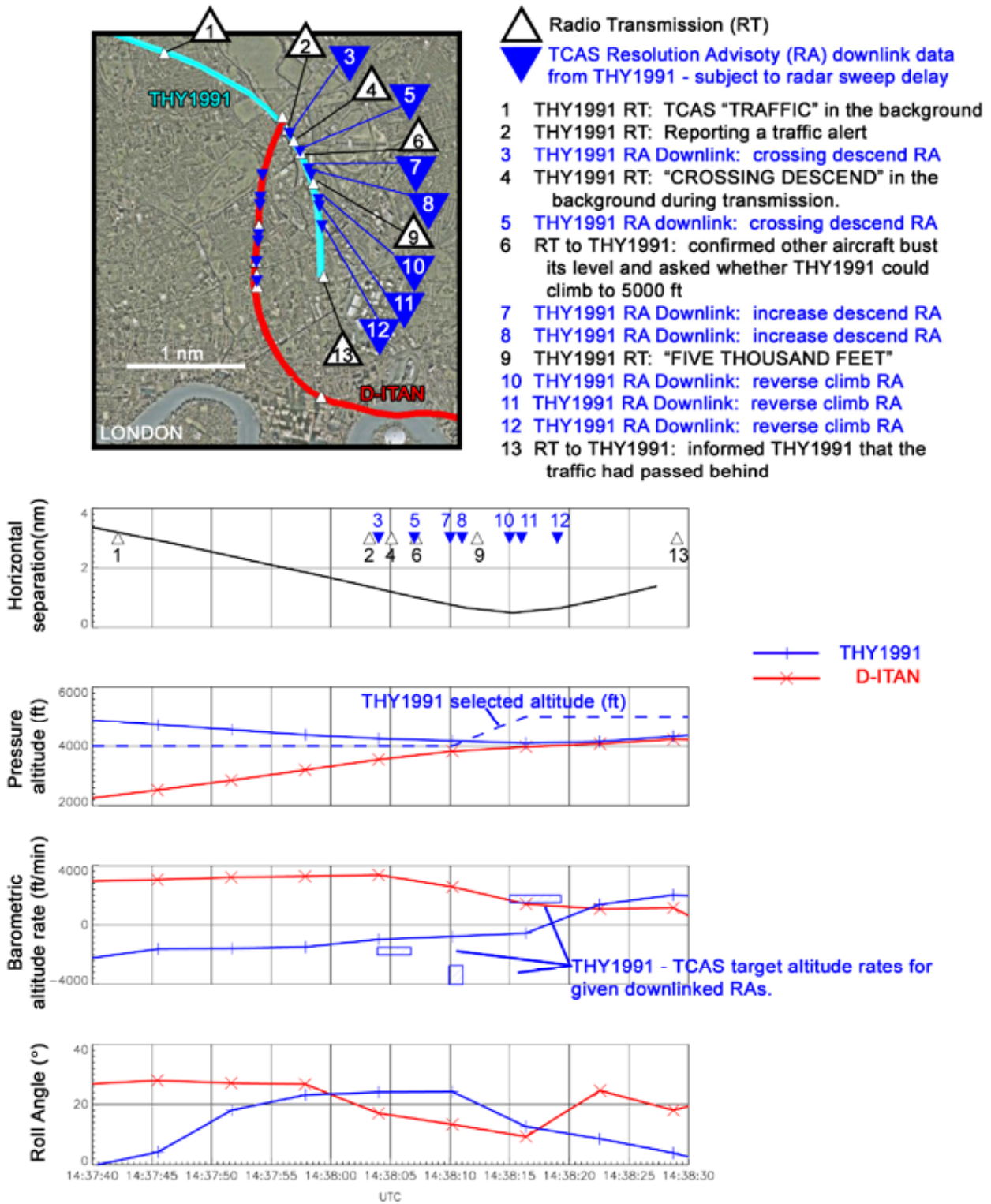


Figure 2

Salient radar data, downlinked data and RT extracts

### *Thames radar controller*

When D-ITAN took off, the Thames radar controller noticed its radar return but he did not recall looking at it again until its pilot reported on his frequency. At that time, he also saw that D-ITAN had triggered the high-level Short Term Conflict Alert (STCA)<sup>3</sup>. It was not unusual for aircraft departing London City Airport to trigger the STCA due to the high rate of climb required when flying the SID. The controller instructed D-ITAN to descend to 3,000ft considering that this was permitted since the pilot had not reported an RA.

### *Heathrow Final Director*

The Heathrow Final Director was alerted to the conflict by the pilot of TC-JJA reporting the TA. The pilot did not report an RA but the controller was expecting there to be one because of the close proximity of the two aircraft on his display. The controller was aware that he should not issue instructions to an aircraft experiencing an RA event and this led him to ask whether TC-JJA was able to climb to 5,000 ft, rather than to issue an instruction to do so.

### **Airprox report by the crew of D-ITAN**

The commander of D-ITAN filed an Airprox report in which he stated that the crew received a clearance from “City Radar” to climb to an altitude of 4,000 ft. He was familiar with the usual departure procedure but interpreted this as a clearance to climb “directly” to 4,000 ft because he had TC-JJA in sight “all the time”. Initially, he thought his aircraft would be “well above” TC-JJA as he crossed its track. Subsequently, he realised that the two aircraft would be quite close when they crossed and he recalled changing the aircraft’s heading

#### **Footnote**

<sup>3</sup> STCA is a ground-based safety net intended to assist the controller in preventing collisions between aircraft by generating an alert of a potential or actual infringement of separation minima.

“about 30 degrees to the left” to pass behind TC-JJA. He believed there had been no risk of collision.

### **Further information from the crews**

#### *D-ITAN*

The commander of D-ITAN later stated that he interpreted the ATC clearance from London City Airport as a climb to 4,000 ft “non-standard to the published outbound departure route”. He believed his TCAS equipment was serviceable and stated that at no time did it display a TA<sup>4</sup>.

#### *TC-JJA*

The commander of TC-JJA stated that on receiving the TA he adjusted the range scale on his display and tried to acquire the traffic visually. He recalled a “very brief RA to descend” but noticed from the TCAS display that the traffic was passing the three o’clock position and climbing, and he judged that a descent would only increase the risk of collision. The commander reported that, on receipt of the reversal climb RA, he took control, disengaged the autopilot and followed the RA guidance. The only person to see D-ITAN was a pilot occupying the right observer seat who saw it pass west of them at an estimated 100 to 200 ft below.

### **Flight Data Recorder information**

#### *Flight recorders*

TC-JJA, callsign THY1991, was fitted with a Cockpit Voice Recorder (CVR), Flight Data Recorder (FDR) and a Quick Access Recorder (QAR). The initial delay in notification of the event to the AAIB and the subsequent delay in communications with the operator meant that data recorded by the FDR and CVR was overwritten.

#### **Footnote**

<sup>4</sup> The aircraft was fitted with TCAS I equipment which does not generate RAs.

The QAR should have had sufficient storage not to have been overwritten but the data was lost due to system failure.

D-ITAN was not fitted with, or required to be fitted with, crash-protected recorders or flight data monitoring recorders. Neither TCAS unit fitted to the aircraft involved had capability to record event data.

Primary and secondary radar tracks for both aircraft were recorded by the Debden and Heathrow radar installations. Mode S datalink recordings of both aircraft were also recorded by Debden radar. This provided the following parameters with a refresh rate corresponding to the 6-second rotation rate of the radar antenna:

- Altitude with a 25ft resolution
- Roll angle
- True track angle
- Ground Speed
- True Airspeed
- Heading
- Indicated airspeed
- Mach
- Barometric altitude rate
- Selected altitude (TC-JJA only)

THY1991 also transmitted TCAS-related messages via Mode S. These messages were also subject to a delay due to the rotation rate of the radar antenna but were received by a number of radar heads. The content of the messages indicated that the TCAS fitted to THY1991 had incorrectly identified D-ITAN as not being Mode S equipped, whereas NATS radar had received Mode S data direct from D-ITAN. The cause of this discrepancy was not found but it would have had little effect on the outcome of these particular events.

ATC voice communications were also made available to the investigation.

Figure 2 is an amalgamation of these data sources. The recordings showed that TCAS was fully operational on THY1991. A traffic alert was issued to the crew whilst descending to a selected altitude of 4,000 ft and the crew passed this information to the controller. Shortly after this, TCAS issued a “CROSSING DESCEND” RA. This was evident in the background of a transmission by THY1991, though may not have been noticeable to the controller, and was also downlinked via Mode S but this was not available to the controller. The RA required an increased descent rate; the descent rate was reduced. The controller asked whether THY1991 could climb to 5,000 ft. This was followed by a downlink of an ‘increase descent RA’, requiring a descent rate of greater than 2,500 ft/min. The crew read back “FIVE THOUSAND FEET”. The next RA downlinks indicated a reversal to a climb RA. This was followed by an increase in the selected altitude of the aircraft. The aircraft then passed abeam each other with a lateral separation of 0.5 nm and a vertical separation of 164 ft.

Simulations carried out by NATS and Eurocontrol confirmed that the TCAS of THY1991 provided the expected commands.

### **Standard Instrument Departures (SIDs)**

#### *DVR 4T SID*

The DVR 4T SID is a ‘step-climb’ SID with an initial climb to an altitude of 3,000 ft. The departure is in close proximity to obstacles and requires an initial minimum climb gradient of 7.94%; no maximum gradient is stipulated. The departure track of the SID crosses the tracks of aircraft being vectored for approach to Runways 27L or 27R at Heathrow airport. Traffic inbound to Heathrow Airport is not cleared

below an altitude of 4,000 ft in this region to ensure vertical separation from traffic on the SID. A warning on the SID states:

*'Due to interaction with other routes pilots must ensure strict compliance with the specified climb profile unless cleared by ATC.'*

NATS reported that, since January 2004, there have been 21 occasions when aircraft departing London City Airport have climbed above the step altitude of 3,000 ft published in the SID. A third of the incidents led to a loss of ATC separation. Evidence from London Stansted Airport showed that removing the step-climb element of the CPT/BUZ SIDs led to a reduction in the number of aircraft that climbed through the first cleared altitude after takeoff. There were 12 'level busts' reported on the SIDs in the 24 months before the end of 2005 when the step-climb was removed. There were 5 level busts in the following three years and seven months.

It was standard practice when issuing DVR 4T departure clearances for controllers to instruct crews to maintain 3,000 ft after takeoff. Since the incident, the instruction to maintain 3,000 ft is given separately from the remainder of the clearance and requires a separate readback from the crew. Operators flying from the airport have also been asked to reiterate to their crews the importance of levelling off at 3,000 ft.

#### *SID procedures and phraseology*

A change to 'International Civil Aviation Organisation (ICAO) Doc 4444 (PANS-ATM)' in November 2007 introduced revised procedures and phraseology associated with climb instructions issued to aircraft following a SID. The document stated that:

*'When a departing aircraft on a SID is cleared to climb to a level higher than the initially cleared level or the level(s) specified in a SID, the aircraft shall follow the published vertical profile of a SID, unless such restrictions are explicitly cancelled by ATC.'*

An example of the phraseology is: 'climb to FL120 level restrictions (*SID designator*) cancelled'.

As a result of concerns raised by member States and industry, ICAO acknowledged that States had encountered difficulties implementing the new procedures and undertook to consult further. The UK did not implement the revised procedures and phraseology for reasons explained in the CAA's 'Flight Operations Division Communication (FODCOM) 16/2009'. In the UK, for all stages of flight, an instruction to climb or descend cancels any previous restrictions unless they are reiterated as part of that instruction. For aircraft on a SID, the word 'now' is added to climb clearances above the SID profile eg 'climb now FL120' is an instruction for an aircraft to climb directly to FL120 ignoring the vertical profile of the SID.

The CAA issued a Supplementary Instruction (SI) to 'CAP 493 Manual of Air Traffic Services (MATS) Part 1' on 24 April 2009. The SI clarified UK SID procedures and phraseology and gave guidance to controllers on the recent developments. It stated:

*'Controllers must remain alert to the potential for incorrect or unexpected interpretation of ATC instructions by non-UK aircraft operators and take appropriate action to ensure any required separation.'*

Germany, the State of Registry of D-ITAN and the State of its operator, implemented the revised ICAO



procedures and phraseology on 18 December 2008 through amendment to its 'Manual of Operations Air Traffic Control Services'.

On 31 March 2010, the CAA issued 'FODCOM09/2010', which referred to the results of the ICAO consultation on the revised procedures. The FODCOM stated:

*'From the State responses, ICAO has identified that their current provisions have not provided the intended simplicity, efficiency, and global standardisation to ensure flight safety.'*

Consequently, ICAO recommended that States promulgate, as a matter of urgency, any difference from the PANS-ATM SID/STAR provisions in the national AIP. ICAO reported that it would work expeditiously to determine the optimum solution to the current situation.

### **Airborne Collision Avoidance System (ACAS)**

#### *Rules for the carriage of ACAS*

ACAS is a set of standards for aircraft-based equipment. ACAS I issues TAs, which alert crews to the presence of potential threat aircraft. ACAS II also issues RAs, which instruct crews to manoeuvre the aircraft in the vertical plane in order to resolve a conflict. The only equipment currently able to meet the requirements of ACAS II is TCAS II. Turbine jet aircraft flying in the UK are required to carry ACAS II if they have a maximum takeoff weight exceeding 5,700 kg, or a maximum approved passenger seating configuration of more than 19. The Boeing 777 was fitted with TCAS II. The Cessna Citation 525 was not required to carry ACAS although it was fitted with TCAS I.

#### *ACAS II RAs*

The procedures to be followed by pilots in the event of an RA are detailed in 'ICAO PANS-OPS (Doc 8168)'. When an ACAS II RA is generated, pilots are expected to:

*'Respond immediately by following the RA as indicated, unless doing so would jeopardize the safety of the aeroplane.'*

For RAs requiring a change in vertical speed, the pilot is expected to respond correctly within five seconds of the RA being displayed. Compliance with the RA will generally require a vertical speed of approximately 1,500 ft/min, corresponding to an initial vertical acceleration of 0.25g, but this may vary according to the event. The RAs of two TCAS II equipped aircraft will generate a miss distance in the vertical sense that is coordinated through a Mode S data link. An RA can be generated by TCAS II against a threat aircraft not fitted with TCAS II, providing such an aircraft is equipped with an altitude-reporting transponder. The safety benefit will be reduced, however, because there will be no coordination between the aircraft and the threat aircraft will be incapable of generating its own RA. During a TCAS alert, the RA may require an increase or decrease in vertical speed or may reverse its sense. In such cases a response is required from the pilot within two and a half seconds. Doc 8168 notes that:

*'Visually acquired traffic may not be the same traffic causing an RA. Visual perception of an encounter may be misleading, particularly at night.'*

Consequently, pilots are discouraged from making their own judgements about resolving a conflict once an RA has been triggered. Apart from possibly considering the wrong threat aircraft, their action might invalidate any



coordination that is taking place, thereby making the situation worse. The document also notes that:

*'The ability of ACAS to fulfil its role of assisting pilots in the avoidance of potential collisions is dependent on the correct and timely response by pilots to ACAS indications. Operational experience has shown that correct response by pilots is dependent on the effectiveness of the initial and recurrent training in ACAS procedures.'*

#### *The effect of TCAS II on ATC operations*

'CAP 493 MATS Part 1' includes instructions for ATC controllers on dealing with aircraft responding to TCAS RAs. When a pilot reports an RA:

*'Controllers shall not attempt to modify the aircraft flight path until the pilot reports "clear of conflict".'*

Once an aircraft departs from an ATC clearance in compliance with an RA, or a pilot reports an RA, the controller ceases to be responsible for providing separation between that aircraft and any other aircraft affected by the manoeuvre induced by the RA. The controller resumes responsibility for providing separation when the aircraft has resumed the current clearance, or the crew reports they are resuming the current clearance and the controller issues an alternative clearance.

#### *ACAS phraseology*

Specific ACAS phraseology, contained in 'ICAO PANS-ATM (Doc 4444)', has been adopted to provide the means to ensure that pilots and controllers have a clear understanding of the progression of an RA manoeuvre, and the means to delineate the point at which responsibility for the separation of aircraft transfers from controller to pilot and back to controller. The crew should notify the

appropriate ATC unit as soon as possible, as permitted by workload, of any RA which requires a deviation from the current ATC clearance by transmitting:

"TCAS RA".

After the RA response is completed and a return to the ATC clearance is initiated, the pilot should transmit:

"CLEAR OF CONFLICT RETURNING TO (assigned clearance)".

When the ATC clearance has been resumed, the pilot should transmit:

"CLEAR OF CONFLICT (ASSIGNED CLEARANCE) RESUMED".

#### *Automatic notification of TCAS RAs*

Eurocontrol estimates that 25% of RAs are never reported to the controller and 25% are notified 'very late'. Pilot reports (when they happen) are often 'lengthy, unstructured, incorrect or incomplete, requiring repetition or clarification from the controller'. If controllers do not know that the aircraft is responding to an RA, they might issue an instruction in an attempt to resolve the conflict and that instruction could contradict the RA.

Automatic notification of RAs to controllers' screens (RA downlink) has been contemplated for some time. Eurocontrol carried out a 'Feasibility of ACAS RA Downlink' Study (FARADS project), which found that currently an en-route controller would on average be aware of an RA 30 seconds after it was presented to the pilot. Controllers would be aware of RAs within 10 seconds in 95% of cases where aircraft were using Mode S transponders to downlink the RA information. The potential benefits of RA downlink would be: the reduced likelihood of contradictory clearances;

improved situational awareness; more up-to-date traffic information, especially to other aircraft in the vicinity; and better post-conflict traffic planning.

The International Federation of Air Traffic Controllers Associations (IFATCA) is opposed to RA downlink. However, should it be implemented, IFATCA is concerned that there must be clear and unambiguous legal responsibilities for controllers with no delay in the downlink (for example due to antenna rotation) and nuisance and false alerts being kept to a minimum. The International Federation of Airline Pilots' Associations (IFALPA) supports the concept in principle but requires the data update rate to be not less than one report per second.<sup>5</sup>

Increasing the update rate of information within the system is technically feasible although not yet implemented. However, the functionality to display RAs to the controller using Mode S transponders already exists in commercial ATC systems; some states have implemented the functionality and some others are considering doing so. Eurocontrol is concerned that a Europe-wide concept of operations should be developed to avoid a proliferation of national concepts.

### **NATS investigation report**

An assessment of the performance of TCAS was provided by NATS's ACAS 'Interactive Collision Avoidance Simulator' (InCAS) team. The pilot of D-ITAN reported that his TCAS equipment did not generate any TAs, which was unexpected given the alerts known to have been generated in TC-JJA. No technical explanation for this was established due to a lack of recorded data. TC-JJA did not treat D-ITAN as being Mode-S equipped.

The pilot was aware that a clearance to climb to 4,000 ft was non-standard but did not query the clearance. Radar data indicated that D-ITAN complied with the rate of climb stipulated in the SID but the high rate of climb reduced the time available for the error to be detected. There was no downlink from D-ITAN of the flight level selected on the autopilot and so the level-bust could not be anticipated by the controller. D-ITAN did not report on the Thames radar frequency until so close to the point of minimum separation that the controller did not have time to take effective action to resolve the situation. The report concluded that the event was not resolved by ATC.

The pilot of TC-JJA did not use the correct phraseology to inform the Heathrow Final Director that he had received an RA. The aircraft flightpath did not appear to change in compliance with the first two RAs to descend. The flightpath did change after the climb RA was triggered but this was not apparent from the radar data until after the two aircraft were passing each other. The report concluded that the event was not resolved by TCAS.

Both aircraft were in VMC but D-ITAN was not seen by either operating pilot in TC-JJA and so no action was taken on this aircraft to resolve the situation. The crew of D-ITAN reported that they were in visual contact with TC-JJA and adjusted their aircraft's flightpath in order to avoid it. The report concluded that the conflict was resolved by the crew of D-ITAN.

The report noted that departures from London City Airport require crews to make full power takeoffs before levelling off less than one minute after leaving the ground, which is unusual. It is critical that aircraft comply with the level-off because there is a high probability that the departing traffic will cross the track

---

#### **Footnote**

<sup>5</sup> Report on the Eurocontrol 'RA Downlink Workshop' dated 20 November 2009.

of an aircraft inbound to Heathrow Airport, which might be only 1,000 ft above.

The NATS investigation report recommended that:

- 1) all SIDs from London City Airport should terminate at an altitude of 3,000 ft, and
- 2) lateral interaction should be eliminated between the SIDs and the base leg turn for aircraft positioning to land at Heathrow Airport.

### **Subsequent comments by NATS**

Following further assessment, managers within NATS concluded that the recommendation (2, above) regarding the London City Airport SID track could not be accepted. The track could not be moved effectively as the interaction with aircraft positioning to land at Heathrow Airport occurs almost immediately after departure. Moving the Heathrow Airport arrival track significantly to the west would result in aircraft joining the approach from above the glideslope, which would increase the risk of aircraft making unstable approaches. Descending aircraft early, so that they joined the approach from beneath the glideslope, would increase noise and fuel burn. NATS also reported that there would be increased difficulty in applying wake turbulence procedures. However, NATS stated that new procedures had been trialled that would mitigate the risk resulting from a level bust in the area concerned.

### **Analysis**

#### *Communication*

The initial event in this incident was the miscommunication between the crew of D-ITAN and the aerodrome controller. The delay in their reply suggested the crew were probably not expecting to receive their

departure clearance when they called for start clearance, and this might have contributed to them writing down the incorrect altitude. Subsequently, although they were aware that a climb to 4,000 ft was unusual, they did not query the clearance. The controller missed the incorrect readback of the cleared altitude, which meant that the crew took off prepared to climb through the step altitude on the SID. The new communication procedures implemented at London City Airport since this incident are designed to ensure that crews understand and comply with the requirement to level off at 3,000 ft.

The commander of TC-JJA notified ATC that his aircraft had generated a TA, which he was not required to do. His transmission and the subsequent reply from ATC were made at the same time as the first two RAs, which might have made the warnings more difficult to hear than otherwise. The commander took control from the co-pilot to respond to the reversal climb RA and it was unclear whether or not responsibility for communication had moved to the co-pilot. The “TCAS RA” call to ATC was omitted, which resulted in the controller being unsure whether a TCAS event had occurred. The “CLEAR OF CONFLICT” transmission was also omitted and the phraseology used subsequently to inform ATC about the RA was incorrect.

#### *Airspace management*

On the DVR 4T SID, although the departure track crosses the base leg turn of traffic inbound to Heathrow Airport, aircraft in the same position laterally should still be separated vertically by a minimum of 1,000 ft. Because of the overlapping tracks, one third of aircraft which climb through their cleared altitude are likely to cause a loss of ATC separation but it is not practicable to remove the lateral interaction. NATS has trialled new procedures which, it believes, will mitigate the risk resulting from a level bust in this area. Therefore:

**Safety Recommendation 2010-056**

It is recommended that NATS demonstrates to the Civil Aviation Authority (CAA) that appropriate mitigation has been put in place to reduce significantly the risk of an accident resulting from a level bust by an aircraft departing London City Airport or on the base leg turn positioning to land at Heathrow Airport.

Prior to the incident, the DVR 4T SID was issued along with an instruction to maintain 3,000 ft but, despite this, some aircraft still failed to level off at the step altitude. The high rate of climb associated with the SID, while necessary to provide clearance from nearby obstacles, reduces the time for corrective action should an aircraft climb through the step altitude. Evidence from Stansted Airport suggests that removing the step-climb from the SID, and terminating the SID at 3,000 ft, is likely to result in fewer incidents of aircraft climbing through 3,000 ft. However, it would probably be unwise to have one SID terminating at 3,000 ft while the others terminated at 4,000 ft. Therefore this AAIB investigation endorses the NATS investigation, and makes the following two Safety Recommendations:

**Safety Recommendation 2010-057**

It is recommended that London City Airport amends all Standard Instrument Departures (SIDs) so that they terminate at an altitude of 3,000 ft.

**Safety Recommendation 2010-058**

It is recommended that London City Airport removes Step Climb procedures from its Standard Instrument Departures (SIDs).

*TCAS*

Because there was no Mode S downlink of D-ITAN's selected flight level, there was no opportunity for the radar controllers to anticipate the conflict and take appropriate action. D-ITAN did not generate any TAs, which was unexpected given the geometry of the encounter. The lack of a TA could not be explained because no recorded data from either aircraft was available to the investigation, and the serviceability of D-ITAN's TCAS equipment could not be confirmed after the flight.

TC-JJA's flightpath during the two descent RAs was consistent with it levelling off at the cleared altitude of 4,000 ft rather than it following the RAs. The aircraft then climbed towards 5,000 ft, which was consistent both with the climb RA and the controller's suggestion that a climb would be appropriate. The commander faced a rapidly changing TCAS encounter with two RAs generated within six seconds and three in less than 10 seconds. Pilots are expected to react to a first RA within five seconds and it is likely that the second, increase descent, RA was generated because of a lack of response to the first RA. The commander was only briefly aware of the requirement to descend but judged that a climb would be better. In this case, his judgement was based on the correct threat aircraft and was in the same sense as, and coincident with, the climb RA.

The Heathrow Final Director was unsure whether an RA had been triggered within TC-JJA because of the use of incorrect and late TCAS phraseology by its crew. The controller asked whether TC-JJA was able to climb, a transmission which, although not an instruction, was in the opposite sense to the 'increase descent' RA that was generated at the same time.

It was 45 seconds from the first RA, and 35 seconds from the last, before the controller was told that there had been an RA event. ATC systems utilising RA downlink based on Mode S would be expected to reduce this delay to within 10 seconds. Had the delay been 10 seconds in this incident, the controller would still not have known there was an RA event until just after the ‘climb RA’ was generated and so the sequence of events was unlikely to have changed substantially. Both IFATCA and IFALPA require delays that are significantly shorter than 10 seconds before they will support the concept in practice. Eurocontrol is therefore attempting to develop a European concept of operations in the knowledge that RA downlink systems are already being implemented, even though the professional bodies of the system operators have reservations about their use. The arguments for and against implementation are not clear cut and, as Eurocontrol is already considering the issue, no recommendations are made in this regard.

During this incident, the crew of D-ITAN saw TC-JJA in time to take effective avoiding action. Had the aircraft been in IMC, this would not have been the case and TCAS would have been the only barrier to a potential mid-air collision. The incident was not resolved by TCAS for two reasons, the first being that the crew of TC-JJA did not respond to the RAs in time to affect the geometry of the incident. It has been shown that correct crew response to ACAS is dependent on the effectiveness of initial and recurrent training and therefore:

#### **Safety Recommendation 2010-059**

It is recommended that the Directorate General of Civil Aviation of Turkey ensures Turkish Airlines TCAS training complies with the Airborne Collision Avoidance System Training Guidelines contained in ‘ICAO PANS-OPS (Doc 8168)’.

The second reason that TCAS did not resolve this incident was that D-ITAN did not have TCAS II, which meant that the increased safety benefit of coordinated RAs was not available. The new procedures already implemented at London City Airport, and the recommendations regarding SIDs made in this report, should reduce the risk of a level bust occurring in the future. Should a level bust recur despite these changes, the procedures trialled by NATS should mitigate the risk of an accident. However, the consequences of a midair collision in this part of the London TMA would be particularly serious because of the population density below, and further mitigation of the risk could be achieved by mandating the carriage of TCAS II. An assessment of whether such action would be proportionate to the residual risk of loss of separation is beyond the scope of this report and therefore:

#### **Safety Recommendation 2010-060**

It is recommended that the Civil Aviation Authority considers whether the carriage of TCAS II should be mandated for aircraft operating in those parts of the London TMA where London City Airport SIDs interact with traffic positioning to land at Heathrow Airport.

#### *ICAO procedures*

The note on the SID required strict compliance with the climb profile unless cleared otherwise by ATC. At the time of the incident, the crew of D-ITAN believed their ATC clearance was to climb directly to 4,000 ft without levelling off at the intermediate SID altitude of 3,000 ft. Contrary to the commander’s recollection, there was no reiteration of the clearance to 4,000 ft from any ATC agency prior to the point where D-ITAN passed TC-JJA. The clearance to climb to 4,000 ft was issued by Thames Radar after D-ITAN had climbed above, and been instructed to descend back to, 3,000 ft. The intention to climb directly to 4,000 ft was, therefore,

based solely on the crew's (incorrect) understanding of their ATC clearance. Had the revised ICAO procedures been adopted by the UK, it is likely that this incident would have been prevented because D-ITAN would have levelled off at 3,000 ft regardless of its cleared altitude.

The arguments for and against implementation of the revised procedures are beyond the scope of this report and, since ICAO is already working to resolve the situation, no recommendations are made on this topic, as a result of this incident, beyond endorsing the need for urgency in reaching a resolution.