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## Turbulence injuries, Boeing 747-443, G-VROM

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**Micro-summary:** This Boeing 747-443 encountered severe turbulence in which several people were injured.

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**Event Date:** 2005-07-26 at 2107

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

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

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  2. Readers are advised that each report is a glimpse of events at specific points in time. While broad themes permeate the causal events leading up to crashes, and we can learn from those, the specific regulatory and technological environments can and do change. ***Your company's flight operations manual is the final authority as to the safe operation of your aircraft!***
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**INCIDENT**

<b>Aircraft Type and Registration:</b>	Boeing 747-443, G-VROM
<b>No &amp; Type of Engines:</b>	4 General Electric CF6-80C2B1F turbofan engines
<b>Year of Manufacture:</b>	2001
<b>Date &amp; Time (UTC):</b>	26 July 2005 at 2107 hrs
<b>Location:</b>	Approx 100 nm north-east of Nassau, Bahamas
<b>Type of Flight:</b>	Public Transport (Passenger)
<b>Persons on Board:</b>	Crew - 18                      Passengers - 278
<b>Injuries:</b>	Crew - 14 (Minor)      Passengers - 10 (Minor)
<b>Nature of Damage:</b>	Minor cabin damage
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence
<b>Commander's Age:</b>	49 years
<b>Commander's Flying Experience:</b>	10,427 hours (of which 4,105 were on type) Last 90 days - 185 hours Last 28 days - 71 hours
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot

**Synopsis**

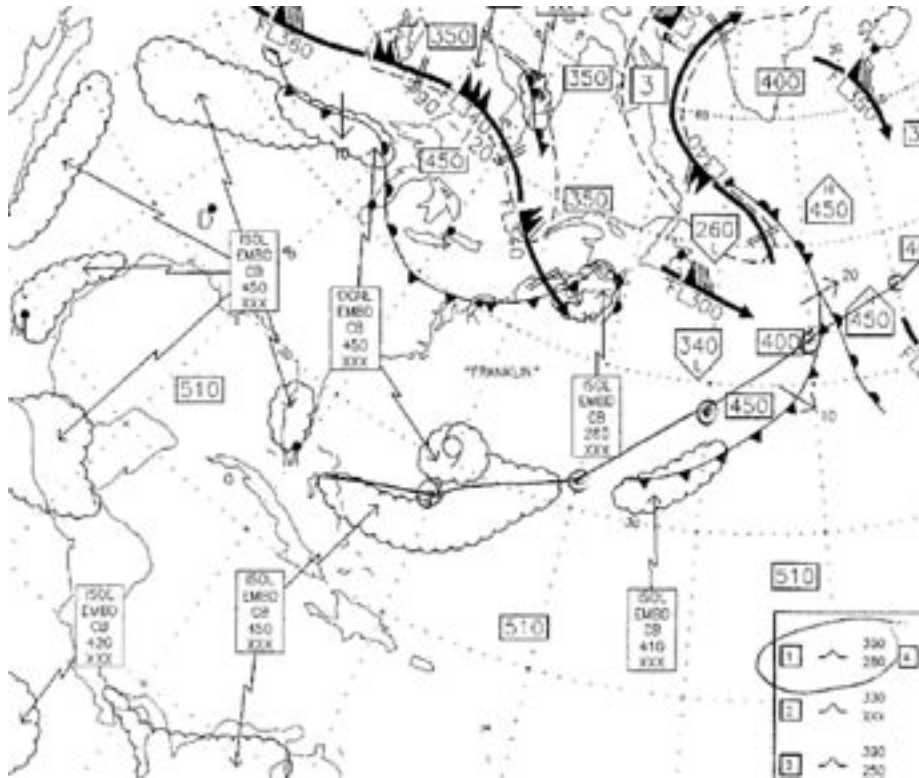
The aircraft encountered an area of unexpected severe air turbulence at FL310 during which some of the cabin crew and passengers received minor injuries.

**History of the flight**

The aircraft had departed Nassau, Bahamas in daylight on a scheduled flight to London Gatwick Airport. Push-back was at 2030 hrs and takeoff at 2047 hrs. The aircraft's planned route is shown at Figure 1, as plotted by the flight crew on the Significant Weather Chart. Tropical Storm Franklin was located approximately 600 nm northeast of the Bahamas. Associated with Franklin and to the south of it was a band of weather lying approximately north-east to south-west. This weather was forecast to contain isolated embedded cumulonimbus (CB) clouds. The intended track passed south of Tropical Storm

Franklin and initially north of the associated weather before passing through the eastern part of the band.

After departure the co-pilot, who was the pilot flying, climbed the aircraft in VMC towards the initial cruising level of FL310. The aircraft's weather radar was used during the climb; weather returns are displayed on the pilots' Navigation Displays (ND) which also display the intended track. Although some CB activity was shown on the weather radar, it was well away from the aircraft's intended track. No weather or turbulence was encountered and no weather avoidance was required. Because the flight conditions were smooth, the seat belt signs were switched OFF and passengers were permitted to move around the cabin.



**Figure 1**

The aircraft's planned route marked on the Significant Weather Chart

The flight crew had discussed the possible effects of the weather, particularly Tropical Storm Franklin, and they had marked on the Mid-Atlantic Plotting Chart, two SIGMET<sup>1</sup> areas received from New York. A copy of the chart is shown at Figure 2 with the SIGMET areas annotated by the crew as E3 and K23. These were areas of moderate turbulence associated with Tropical Storm Franklin. Area E3 was advised before departure whereas the flight crew were not informed of area K23 until after the turbulence encounter.

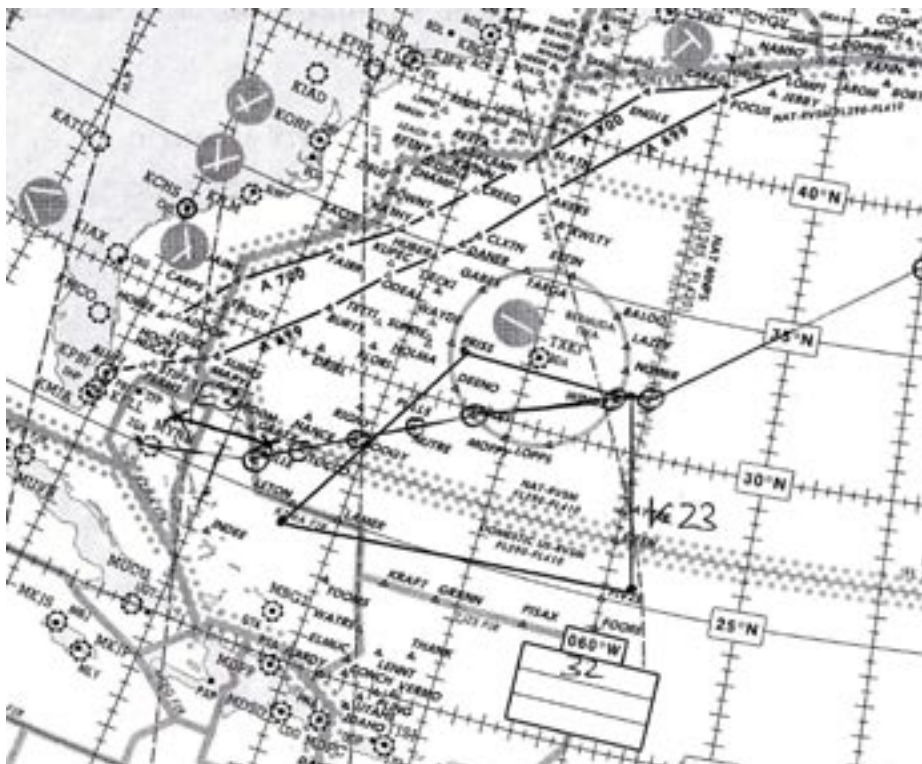
The aircraft was established in the cruise at FL310 and the weather radar was in use. Again, CB activity was seen on the radar at long range but none that affected the aircraft's intended track. The commander recalled

entering an area of cirrus cloud followed by some light turbulence which he described as 'a gentle rumble'. He switched ON the seat belt signs as a precautionary measure and shortly afterwards, the aircraft encountered severe turbulence. The autopilot remained engaged and about 15 seconds later the turbulence ceased.

Some passengers and cabin crew had received minor injuries. Doctors were travelling on the aircraft and assisted with treating the injured. The commander, in consultation with the Flight Service Manager, agreed that none of the injuries required the aircraft to divert. The three flight crew carried out a check of the aircraft systems and available data. Following discussions with company Operations and Maintenance Control, who had received ACARS data relating to the turbulence encounter, the aircraft was found to be fully serviceable. The flight was continued to Gatwick without further incident.

**Footnote**

<sup>1</sup> Weather advisory service to warn of potentially hazardous (significant) extreme meteorological conditions dangerous to most aircraft, eg extreme turbulence, severe icing, squall lines and dense fog.



**Figure 2**

Chart with SIGMET CAT areas annotated by the crew as E3 and K23

### **Turbulence encounter**

Data for the turbulence encounter was recovered by the operator from the aircraft's Flight Data Recorder and a report was made available to the AAIB investigation.

After levelling at FL310 the aircraft was established in the cruise at M 0.855 with the right autopilot engaged in VNAV (Vertical Navigation). The SAT (Static Air Temperature) was a constant  $-30^{\circ}\text{C}$  and the wind was from  $031^{\circ}$  at 11 to 15 kt. The aircraft began to enter light turbulence at 2105:08 hrs which increased in frequency and amplitude. During the first 16 seconds, the minimum and maximum vertical acceleration values were between  $+0.94$  and  $+1.11$  g. In the same period, the SAT reduced to  $-31.8^{\circ}\text{C}$  and the wind direction began to veer to  $056^{\circ}$ , with the wind speed varying between 9 and 29 kt.

At 2106:50 hrs the SAT had reduced to  $-33.8^{\circ}\text{C}$  and the amplitude of the vertical acceleration was still increasing to between  $+0.82$  and  $+1.44$  g. At that point the autopilot mode changed to ALT HOLD (Altitude Hold) and the speed window opened initially at Mach 0.862 (the instantaneous speed at the time of mode change) before being selected to Mach 0.844. The aircraft entered the peak 'g' encounter at 2107:02 hrs. The maximum recorded vertical values were between  $-0.58\text{g}$  and  $+2.13\text{g}$  which occurred over 3 seconds. Just after the peak vertical acceleration was recorded, the SAT had reduced to  $34.5^{\circ}\text{C}$ . The maximum speed during the encounter was Mach 0.876, with the minimum recorded as Mach 0.839. At the heart of the encounter, the wind direction varied between  $024^{\circ}$  and  $064^{\circ}$  and the wind speed varied between 21 and 13 kt.

The maximum and minimum altitude deviations during the encounter were  $+115$  ft and  $-75$  ft from the selected

datum. Following the encounter the aircraft returned to normal flight conditions for the remainder of the flight.

### **Flight planning**

The selection of the route a flight should take is produced initially by the operator's Flight Planning Department. A computer programme identifies the most expeditious route based on the upper winds and routing restrictions such as NOTAMs. The flight planning officer then reviews the route and considers any significant weather obtained from the meteorological services. The route may then be varied depending on the weather.

The proposed route is passed to the departure point of the flight. As part of their pre-flight preparation, the flight crew review the route, taking into account the weather, NOTAMs and any SIGMETs. If the crew wish to vary the route, this instruction is passed to the flight planning officer who then reissues the flight plan and briefing.

On the incident flight, the flight planning officer re-routed the track to the south of Tropical Storm 'Franklin'. Although an alternative route to the north of 'Franklin' was available, the Storm was moving towards this route. The re-routing of the flight by the flight planning officer was annotated on the flight plan.

There is no stipulated training syllabus or qualification set out by the CAA for flight planning officers. The operator provides appropriate training and limits the individual to certain routes under supervision. As experience is gained and ability proven, limitations are gradually lifted. The flight planning officer who

performed the planning for the incident flight was an experienced, senior flight planning officer. Only senior flight planning officers are permitted to plan Caribbean routes when tropical storm or hurricane activity may be present. The flight planning manager confirmed that the route planned and offered to the flight crew was consistent with the operator's normal practice.

### **Analysis**

The flight crew had considered the forecast weather and the SIGMETs in relation to their allocated routing. It was decided not to route to the north of Franklin but to use the weather radar and reports from other aircraft to avoid or anticipate areas of turbulence. This was in accordance with normally accepted practice. Also, they were not alerted to the presence of significant turbulence in area K23 (south of Bermuda) before they entered that area.

The onset of the clear air turbulence was gentle and the commander's action in selecting the seat belt signs ON was a routine procedure. The severity of the turbulence increased rapidly and so cabin crew and a third flight crew member were not able to return to their seats before the peak turbulence. Although all the passengers were seated, not all of them had managed to fasten their seatbelts securely before the turbulence encounter reached its peak.

The doctors onboard were able to provide expert opinion on the nature of the injuries and the decision not to divert was medically based.