

ACCIDENT

Aircraft Type and Registration:	Boeing 777-336ER, G-STBL
No & Type of Engines:	2 General Electric Co GE90-115B turbofan engines
Year of Manufacture:	2014 (Serial no: 42124)
Date & Time (UTC):	15 June 2023 at 1740 hrs
Location:	Entering Bay of Bengal
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 17 Passengers - 244
Injuries:	Crew - 2 (Serious) Passengers - None 3 (Minor)
Nature of Damage:	None reported
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	17,678 hours (of which 1,662 were on type) Last 90 days - 156 hours Last 28 days - 47 hours
Aircraft Type and Registration:	Boeing 777-236, G-YMML
No & Type of Engines:	2 Rolls-Royce RB211 Trent 895-17 turbofan engines
Year of Manufacture:	2001 (Serial no: 30313)
Date & Time (UTC):	28 June 2023 at 1240 hrs
Location:	Beijing Daxing International Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 13 Passengers - 239
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	19,682 hours (of which 9,902 were on type) Last 90 days – 302 hours Last 28 days – 77 hours
Information Source:	Aircraft Accident Report Form submitted by the commander

Synopsis

Approximately 1 hour 50 minutes after departing Singapore en route London, G-STBL encountered severe turbulence over the Bay of Bengal and unsecured cabin crew were thrown around in the cabin. Two crew members were seriously injured and three sustained minor injuries. The aircraft returned to Singapore.

In a similar event, G-YMML encountered what the commander described as “moderate chop” around 15 minutes before landing at Beijing Daxing Airport and while manoeuvring to avoid convective weather seen on radar. The commander was informed after landing of a serious injury to one of the crew that had been sustained during the turbulence.

In both cases, the pilots took action to avoid areas of poor weather and turbulence but, nevertheless, their aircraft encountered turbulence of sufficient severity to injure unsecured crew. When route weather forecasts cover large areas and contain general predictions of the likelihood of encountering turbulence, pilots may not be able to identify specific areas in flight where it will actually be encountered.

History of the flight

G-STBL

The flight crew had access to a draft version of the flight briefing approximately four hours before they were due to be collected from their hotel in Singapore. The commander stated this allowed all of the pilots to examine the weather forecast at leisure. The crew noted warnings of cumulonimbus cloud (CB) and thunderstorms for the Bay of Bengal.

On the crew transport to the airport the operating co-pilot briefed the crew on the flight and included the weather warnings for the Bay of Bengal. The commander reiterated the forecast of thunderstorms for the first three hours of the flight and said he would turn the seatbelt signs on if necessary. He also stated that if at any time the cabin crew were uncomfortable with the situation in the cabin they should call the flight deck to ask for the seatbelt signs to be illuminated.

The crew arrived at the airport 1 hour and 20 minutes before departure and the pre-flight process was conducted without incident. After departure, the aircraft climbed to a cruise altitude of FL300.

As the aircraft approached the Bay of Bengal, the crew were cognisant of the threat of CB, as forecast in their weather briefing, and were aware that track deviations would probably be required to avoid hazardous weather. Soon after the aircraft entered Chennai airspace the crew heard a company aircraft ahead ask for a deviation of 20 nm left of track. ATC cleared that aircraft to manoeuvre up to 20 nm either side of track. At this point, although the incident aircraft was experiencing only “light chop” (turbulence) and only low intensity returns were visible on the weather radar, the commander switched on the cabin seatbelt signs as a precaution.

It was night and the crew could see flashes of lightning to the left of the aircraft’s track. The aircraft weather radar has the facility to check returns at selected flight levels and the crew

did this to assess the risk posed by the weather. Nothing significant was seen. When the crew heard another aircraft ahead request a deviation off track they decided it would be prudent to do the same and requested permission to deviate 20 nm right of track, which was approved by ATC.

The intensity and frequency of the turbulence increased slightly so the commander decided to contact the senior cabin crew member (SCCM). The commander called Door 2L but was told the SCCM was further aft. He stated that he told the cabin crew that it “could be worth sitting down in a few minutes as it could get bumpy.” He then called Door 5L, at the rear of the aircraft, where he found the second most senior cabin crew member. He asked them to pass the message of the bumpy conditions to the SCCM.

Less than two minutes later, at approximately 1730 hrs and with nothing significant visible on the weather radar, the aircraft experienced a severe turbulence episode lasting around 12 seconds. The commander described the situation by saying “There was just too much noise and vibration to take anything in. All I could do for a few seconds was check that the nose was at a safe attitude just above the horizon with wings level and that the engine power was reasonable”. There was a significant display of St Elmos Fire¹ around the cockpit windshields and the stall warning stick shaker was briefly triggered.

At the time of the event the SCCM was in the aircraft’s business class galley and recalled that perhaps only one minute elapsed between the seat belt signs illuminating and the severe turbulence beginning. He saw a crew member across the galley leave the floor and hit the cabin ceiling. The SCCM went across to protect the other crew member from galley carts, which were insecure. The turbulence quickly subsided but the SCCM soon received phone calls from Door 5 to say that there were injuries among the crew. The SCCM informed the pilots of the situation and then went aft to Door 5 and found two crew injured on the galley floor. The crew enacted their medical action plan and were assisted by two doctors from among the passengers who volunteered their support. The doctors were able to use the comprehensive (professional use only) medical kit carried on board the aircraft and administer intravenous pain relief.

The SCCM went to the flight deck and took part in a conference call with the pilots, the contracted medical provider, and the operator’s maintenance control and operations department. The medical provider recommended a diversion on medical grounds and, following discussion, it was decided to return to Singapore. The return to Singapore would be through the same airspace as the outbound flight and so the commander made a public address (PA) to reassure the passengers, but only light turbulence was encountered during the return.

After this decision to return to Singapore was made, the SCCM returned to the cabin. One cabin crew member was seriously injured with an evident fracture of a leg and three others had less significant injuries. The able crew members were redistributed to look after the

Footnote

¹ St Elmo’s Fire is a visible luminous electrical discharge observed around parts of an aircraft when the electrical charge on the aircraft becomes sufficiently intense.

injured crew and the passengers. At 1920 hrs the crew member who had hit the cabin ceiling began to exhibit symptoms described as a possible concussion by the SCCM. They were given oxygen and another crew member was assigned to look after them. As the planned sector was long there were relief pilots on board and one assisted the cabin crew by manning an exit door for landing. The most seriously injured crew member remained on the floor near the rear of the cabin to avoid moving them to a seat and aggravating their injuries. The aircraft landed in Singapore at 2003 hrs and was met by paramedics and police. The injured crew were taken off the aircraft and transferred to hospital. One crew member was detained in hospital with a fracture to their lower leg. The others were released from hospital but on return to the UK a crew member still suffering issues with a leg injury attended hospital and was also diagnosed with a fracture. Both of the crew members that sustained fractures had been in the vicinity of Door 5 at the rear of the aircraft during the turbulence event.

G-YMML

The aircraft was approaching Beijing Daxing Airport. The commander stated that the aircraft weather radar showed areas of convective cloud along the arrival route. Around 25 minutes before landing and due to the convective weather the commander decided to switch on the FASTEN SEAT BELT signs, and at 20 minutes to landing a PA was made. The commander reported that the aircraft then encountered occasional light turbulence. As the aircraft descended the weather radar showed increasing amounts of cloud and CB build ups. The turbulence became continuous and the aircraft was given radar vectors to avoid the weather, resulting in a longer arrival route. The commander described the turbulence during the arrival as “occasional moderate chop”. From the pilots’ standpoint the approach and landing were uneventful, but after landing the SCCM informed the commander that one of the crew had sustained an injury to their ankle during the turbulence.

The SCCM reported that the FASTEN SEAT BELT signs were illuminated earlier than expected but it was assumed that the intent was for the cabin crew to secure the cabin for landing. Shortly after the signs illuminated, she recalled a PA from the pilots saying that there was 20 minutes to landing. The SCCM described the turbulence as initially “not too bad”, but described a brief episode of violent turbulence which left them struggling to remain standing. The SCCM sat down in her allocated crew seat and called the rear galley to ask if the cabin crew there were secure. The SCCM then received a call from Door 3 saying that one of the crew had fallen in the right passenger aisle near the rear galley during the turbulence and sustained an injury to their ankle. The injured crew member was now in a crew seat at the rear of the aircraft. As the injured crew would be unable to operate their door in the event of a further emergency, the SCCM sent a crew member from the front to the rear of the aircraft to fulfil the door duty and the injured crew member was relocated to a passenger seat. As the SCCM was aware the aircraft would shortly land in Beijing and that there was little the pilots could do to aid the injured crew, the SCCM decided to wait till after landing before informing the pilots of the event. During the approach a large number of the passengers were sick due to the turbulent conditions. After landing the SCCM told the commander that medical assistance for the cabin crew member would be required at the gate. There was a 35-minute delay before the aircraft was allocated a stand, but paramedics met the aircraft at the gate to attend to the injured crew member.

The paramedics immobilised the injured ankle, gave the crew member some pain relief and took them to the crew bus on a wheelchair. The crew member had to hop onto the bus and while doing so fell in the wet conditions aggravating their injury. From the crew hotel the injured crew member was transferred to hospital with the assistance of the SCCM who liaised with the operator's medical provider. The injured crew member required surgery on the injured ankle, which was expected to prevent her from operating for several months.

Recorded information

Flight data for the events to both aircraft are presented in Figures 1 and 2.

For G-STBL (Figure 1), the aircraft was cruising at FL300 and 315 kt CAS at the start of the event. The minimum and maximum recorded normal acceleration for the duration of the event (about five minutes) was 0.2 g and 2.3 g. These occurred within the first 10 seconds where the normal acceleration initially dipped to 0.7g and then spiked at 2.3 g in less than one second. A stick shaker activation was recorded during the 2.3 g spike. The recorded normal acceleration was between 0.5 g and 1.5 g for the remaining time during the event.

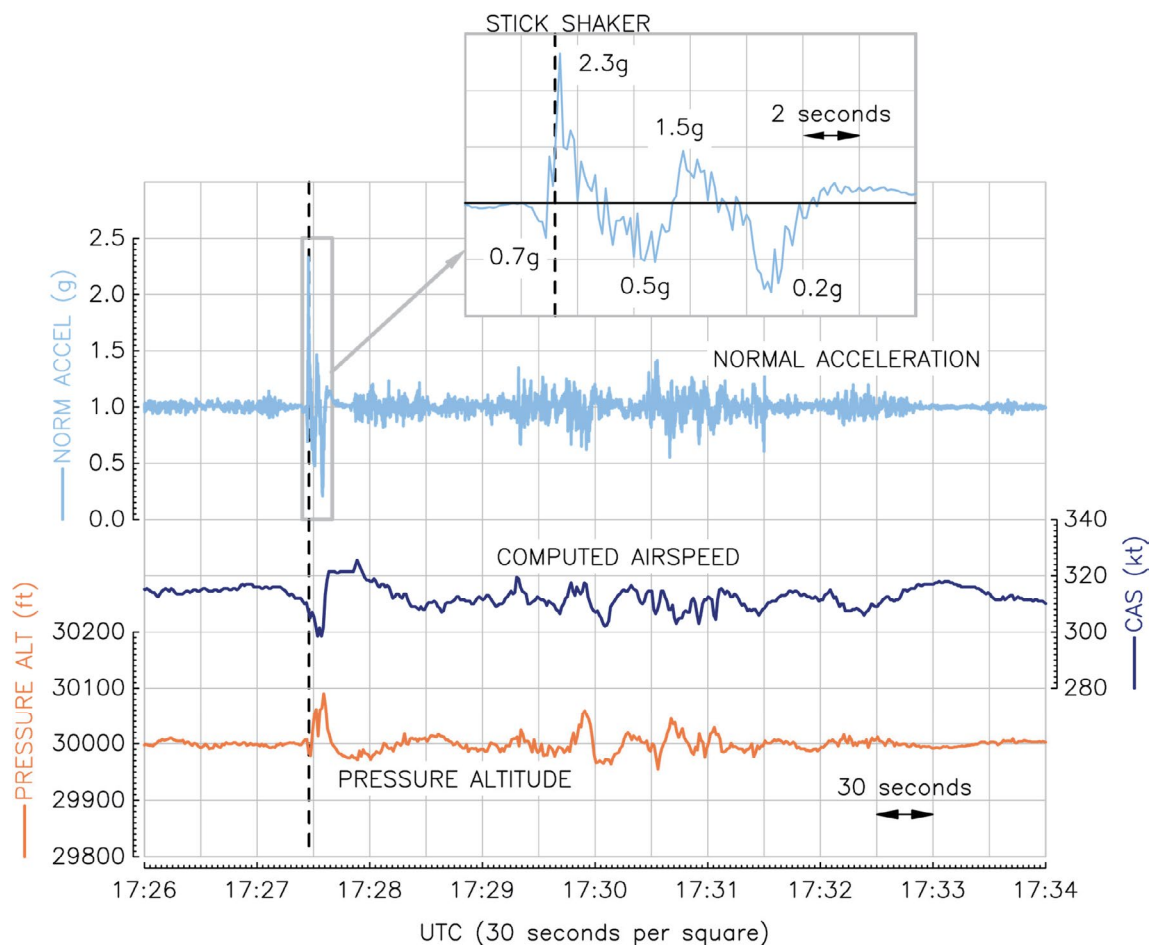


Figure 1
G-STBL flight data for turbulence event

For G-YMML (Figure 2), the aircraft was level at FL128 and at about 300 kt CAS at the start of the event. The minimum and maximum recorded normal acceleration for the duration of the event (about three minutes) was 0.5 g and 1.5g.

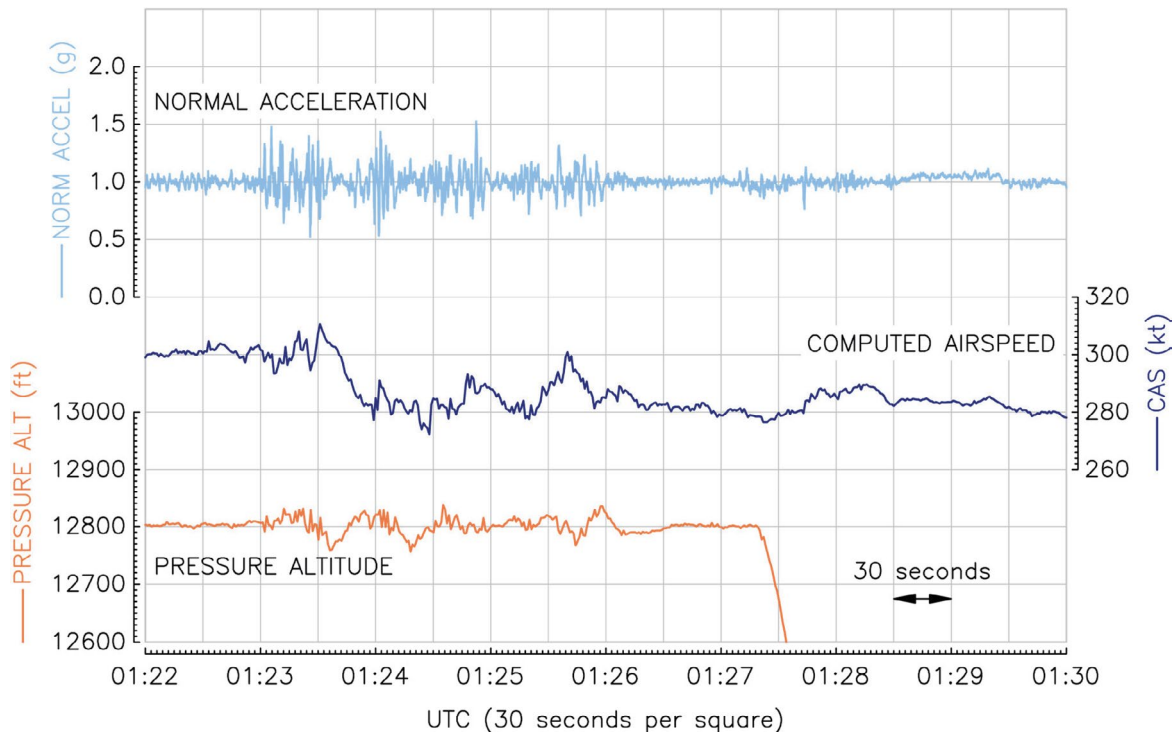


Figure 2
G-YMML flight data for turbulence event

Meteorology

G-STBL

A SIGMET had been issued and was valid until 1745 hrs on 15 June 2023. It, along with the significant weather chart (Figure 3), forecast isolated embedded thunderstorms on the aircraft's route. The chart indicated CB tops reaching FL480 and the SIGMET indicated CB tops to FL520. The explanatory note on the significant weather chart stated that the forecast of CB implies the presence of thunderstorms, hail, ice and moderate to severe turbulence.

The Met Office provided additional turbulence information to the AAIB which, while used to construct the forecast, was not available to the pilots on the flight. The additional information was based on Eddy Dissipation Rate, which is the ICAO standard for turbulence forecasting and is based on Graphical Turbulence Guidance developed by the National Centre for Atmospheric Research in the USA. The Eddy Dissipation Rate forecast for FL300, valid at 1800 hrs on 15 June 2023, (Figure 4), indicated that there would be light to moderate turbulence in the vicinity of the incident. The black dot shows the position of the incident and is near the eastern edge of any turbulence.

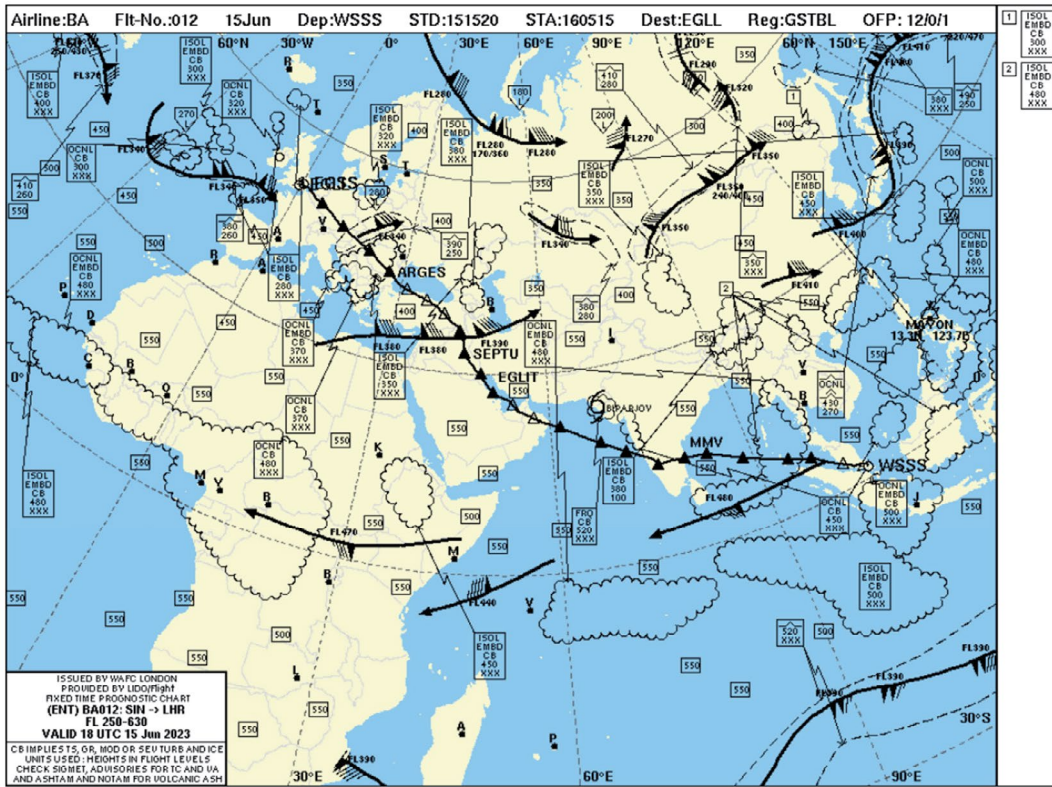


Figure 3
 Significant weather chart from the crew briefing pack

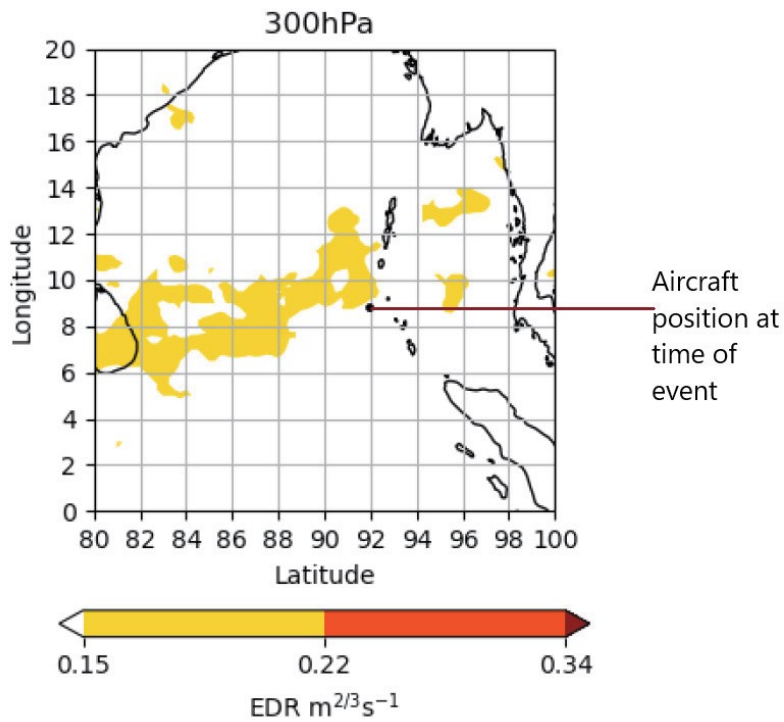


Figure 4
 Eddy Dissipation Rate for 300 hPa (approximately FL300) valid at 1800 hrs on 15 June 2023

The forecast of the extent of CB is shown on the image in Figure 5. This indicated a large area of CB across the Bay of Bengal with over 60% of the sky affected by CB. The information supplied to the crew was based on a forecast model run at 1800 hrs on 14 June 2023. The CB extent shown in Figure 5 was drawn from a model run at 1200 hrs on 15 June 2023. Later forecast charts than those supplied to the crew showed greater amounts of CB over the Bay of Bengal.

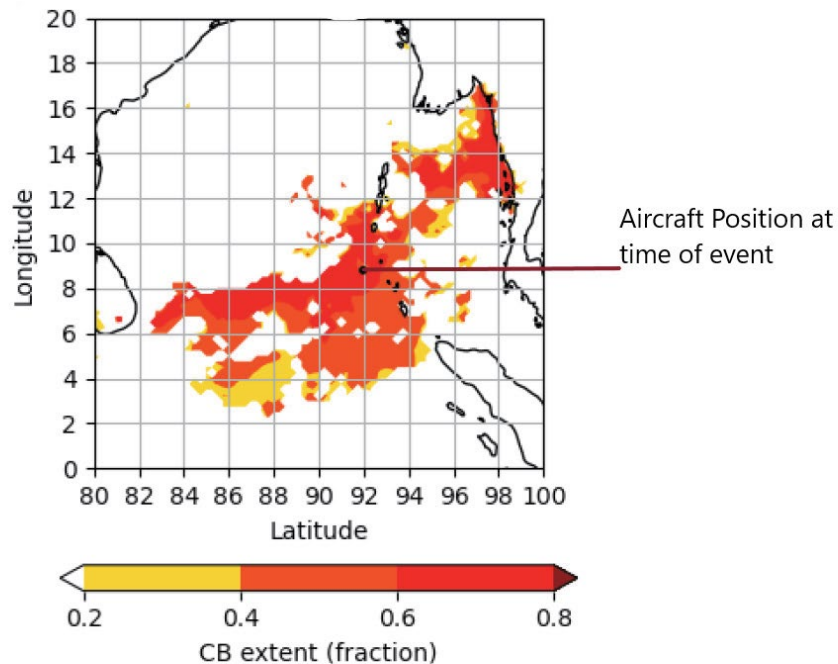


Figure 5

Forecast extent of cumulonimbus clouds

Overshooting tops are areas of a CB where the cloud top is higher than would normally be expected through thermal equilibrium. Normally, the rising warm air within a CB will stop rising when its temperature equals the temperature of the surrounding air. However, rapidly rising air will have built up a momentum that allows it to rise further above the normal anvil top of the cloud. The evidence of an overshooting top is indicative of strong updraughts within the cloud structure. The satellite imagery in Figure 6 is indicating in yellow, areas where there is evidence of overshooting tops. This area is in the vicinity of the incident.

The Met Office summarised the situation as follows:

'There was an extremely active system in the vicinity of the incident location. Evidence from Figure 6 suggests that there were significant updraughts within the cloud, with cloud tops extending up to FL480. In addition, there would also be significant downdraughts in the region immediately ahead of the system. There was no Clear Air Turbulence forecast in the area.'

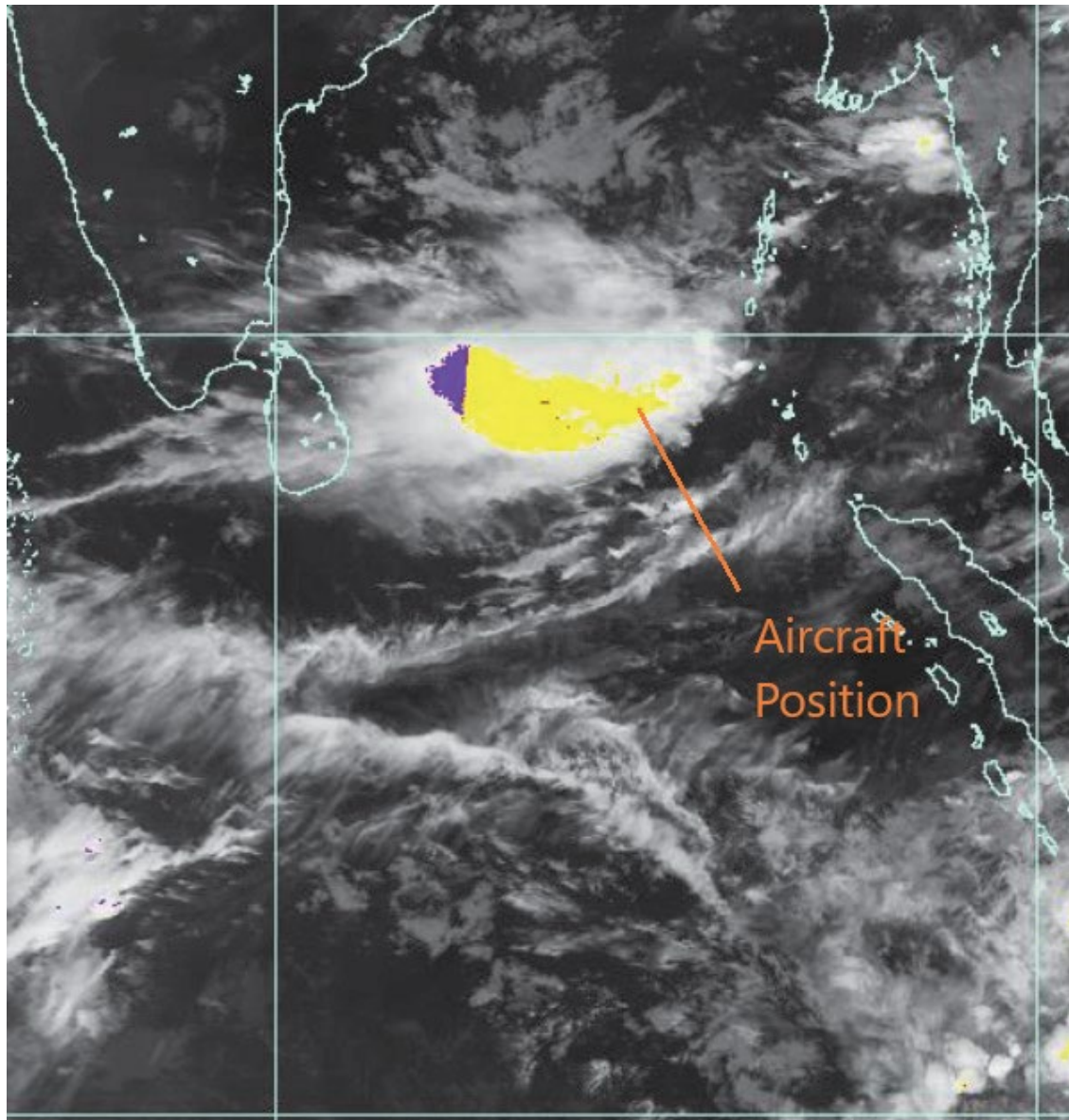


Figure 6

Satellite imagery indicating areas of overshooting cloud tops

G-YMML

G-YMML was approximately 20 minutes from landing at Beijing Daxing Airport when it encountered turbulence. The crew's forecast weather chart for the arrival section of the route is at Figure 7. The route crossed a forecast area of CB with tops up to FL420 just before Beijing. The crew recalled weather consistent with the forecast being visible on weather radar during the aircraft's descent toward Beijing. After discussion with ATC, they changed course to avoid the weather shown on radar.

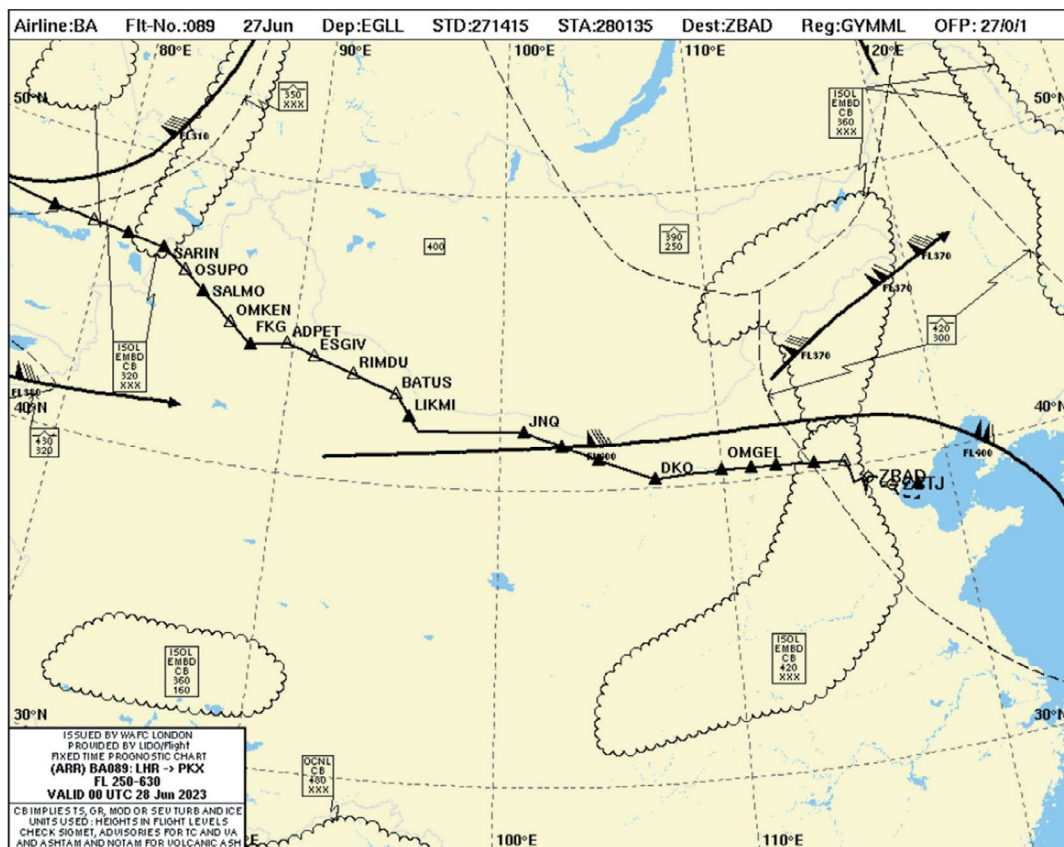


Figure 7
Beijing Daxing Airport arrival weather chart

However, despite manoeuvring clear of weather returns on radar the aircraft encountered a significant turbulence event which, though described as moderate by the pilots, had a serious impact in the cabin.

Description of levels of turbulence

The various levels of turbulence can be described as follows:

- Light turbulence is the least severe, with slight, erratic changes in attitude and/or altitude.
- Moderate turbulence is similar to light turbulence, but of greater intensity - variations in speed as well as altitude and attitude may occur, but the aircraft remains in control all the time.
- Severe turbulence is characterised by large, abrupt changes in attitude and altitude with large variations in airspeed. There may be brief periods where effective control of the aircraft is impossible. Loose objects may move around the cabin and damage to aircraft structures may occur.
- Extreme turbulence is capable of causing structural damage and resulting directly in prolonged, possibly terminal, loss of control of the aircraft.

Organisational information

The operator has guidance for crew in responding to turbulence events in the 'General Procedures' section of its operations manual. The manual considers turbulence in two main cases, either Anticipated or Unanticipated and the guidance is as follows:

'Anticipated: Turbulence can sometimes be anticipated. In such situations the flight crew will advise the SCCM with regard to timing of cabin service, securing of galleys and cabin equipment and whether the level of turbulence is expected to require the crew to sit down and fasten their harnesses. Instructions must be clear and unambiguous. Unless otherwise instructed, the service should continue normally but must not include the serving of hot beverages or use of hot water equipment while the seat belt sign is on.

If turbulence is imminent, use of the PA will ensure a clear, undiluted message reaches all cabin crew members in the shortest possible time. The flight crew will switch on the seat belt sign prior to entering the area of turbulence.

Unanticipated: Often turbulence is not forecast or anticipated. In such instances, flight crew will attempt to alert crew by switching on the seat belt signs as soon as practicable. Cabin crew must react proactively to turbulence when encountered and take steps to secure their immediate safety.'

Analysis

G-STBL

The weather forecast provided to the crew indicated the presence of CB in the area of the event and hence, implicitly, the likelihood of moderate to severe turbulence. The aircraft weather radar did not display to the pilots any significant weather returns. However, the pilots could see lightning flashes to the left of the aircraft's track and heard another aircraft ahead divert to the right of track. At this point, although the turbulence was light the commander switched on the FASTEN SEAT BELT signs. The commander also decided to divert to the right of track as a pre-emptive measure to avoid the visible weather.

As the intensity of the turbulence increased, the commander called the cabin to tell the cabin crew it "could be worth sitting down in a few minutes as it could get bumpy". Shortly after this call and with no weather in the vicinity visible on radar, the aircraft experienced a severe turbulence event lasting approximately 10 seconds during which the normal acceleration dipped to 0.7 g and increased to 2.3 g in less than one second. The aircraft stall warner was triggered. The commander described levels of noise and vibration that overwhelmed his senses and left him with limited capacity to control the aircraft. His focus was on maintaining the wings level, keeping the aircraft nose just above the horizon and maintaining a reasonable power setting. The commander's description of the event is

consistent with the descriptor for severe turbulence. The cabin crew were not secure when the event occurred and a number of them were thrown from their feet by the violent motion. The most serious injuries occurred near the rear of the aircraft. The B777 is a long aircraft and motion is more pronounced toward the rear.

The weather information supplied to the crew did indicate an area of CB with the concomitant warning of moderate to severe turbulence. However, the forecast covered a vast area and only forecast isolated thunderstorms.

After the event and with the severity of the injuries evident, the crew consulted with the operator and the operator's medical provider on options for a diversion and it was decided to return to Singapore.

G-YMML

As the aircraft made its descent toward Beijing Daxing Airport, the pilots were aware of convective weather indicated on radar. The chart in their weather briefing forecast a large area of isolated embedded CB with cloud tops to FL420 just to the west of the airport. As before, CB implies moderate or severe turbulence.

Approximately 25 minutes from landing the commander switched on the FASTEN SEAT BELT sign and made the landing PA. This is normally made 20 minutes before landing and directs the crew to secure the cabin for landing. As a result, the cabin crew did not interpret the illumination of the FASTEN SEAT BELT as a warning of turbulence and carried on with their normal duties. The commander described the turbulence as "occasional moderate chop" and did not report that it presented any significant difficulties during the arrival. The range of normal acceleration values during the turbulence was 0.5 to 1.5 g, less than with G-STBL. However, shortly after the PA was made the cabin crew reported that the turbulence in the cabin was so pronounced that it became difficult to stand, and one of the cabin crew fell and injured their ankle. While it was swollen and painful the extent of the injury was not apparent until the crew member received medical treatment later.

The SCCM was made aware of the injured crew member and redeployed other crew to ensure all emergency exits were attended for landing. In order not to disturb the pilots during a critical phase of flight and aware that there was nothing they could do to assist the situation, the SCCM elected to inform the commander of the incident after landing.

Conclusion

Although the pilots of both aircraft were taking action to avoid weather, each aircraft suffered a turbulence event of sufficient severity to cause injuries amongst the unsecured cabin crew. Route weather forecasts give a general prediction that turbulence is likely but often cannot reflect actual conditions in sufficient detail to enable pilots to avoid specific instances of turbulence. G-YMML was approaching its planned destination and so landed there. G-STBL returned to its airfield of departure on receipt of medical advice. The safety of the aircraft was not jeopardised.