SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 737-8K5, G-FDZX
No & Type of Engines:	2 CFM56-7B27/3 turbofan engines
Year of Manufacture:	2011 (Serial no: 37258)
Date & Time (UTC):	12 June 2023 at 1630 hrs
Location:	Manchester Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 181
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	7,500 hours (of which 6,000 were on type) Last 90 days - 175 hours Last 28 days - 55 hours
Information Source:	Aircraft Accident Report Form submitted by the commander and further enquiries by the AAIB

Synopsis

As the Boeing 737 was making an approach to Runway 05R at Manchester Airport a thunderstorm was approaching the airport. At decision height, visual reference with the runway was lost and the flight crew initiated a manually flown, manual thrust go-around. During the initial actions of the go-around the aircraft experienced a sudden loss of headwind which caused a loss of airspeed. The commander reacted to the loss of airspeed by reducing the pitch attitude which resulted in a slight descent, which triggered an EGPWS caution. The commander reacted appropriately to the caution and the aircraft climbed away without further incident.

The operator is taking action to raise awareness of the threat of thunderstorms in the UK and promote appropriate briefing to mitigate the threat, and is reviewing its guidance for manual thrust go-arounds.

History of the flight

The aircraft was flying back to Manchester Airport from Zakynthos in Greece. Thunderstorms had been forecast across most of the UK and the crew had taken extra fuel to account for possible extended routings or delays. The commander was the pilot flying.

As the aircraft approached Manchester the flight crew negotiated a routing to the north of the airport to avoid cumulonimbus clouds visible to the south. They were vectored onto the

ILS approach for Runway 05R. Their weather radar showed a thunderstorm cell moving left to right across the airport but they were below the base of the cloud and could see the runway. As the aircraft was handed from the approach controller to the tower controller they were advised that the previous aircraft had gone around. The tower controller cleared the aircraft to land, stating "05R, CLEARED TO LAND, WIND 160 19 KNOTS, RECENT GUST 27 KNOTS, HEAVY SHOWER ON THE THRESHOLD". The pilots could still see the runway so decided to continue the approach. They reviewed their missed approach actions.

As the aircraft reached the decision height of 390 ft amsl it entered heavy rain and the pilots lost visual reference. They described "hitting a wall of rain" and "it all going black outside". Both pilots called 'go-around' simultaneously. The commander pressed TOGA and manually advanced the thrust levers with the autopilot and autothrottle disconnected. Both pilots confirmed thrust was increasing. The co-pilot selected Flap 15 and with a positive rate of climb selected the landing gear UP. However, as the commander increased the pitch through 10°, he noticed the airspeed rapidly reducing. Concerned the aircraft may stall he applied a nose-down pitch input to prevent further speed loss. Initially he could not work out why the aircraft was not accelerating and climbing as he would expect during a go-around. He recalled that 'the airspeed was close to V_{REF}, the trend vector was touching the top of the red and black band and the aircraft felt slow to react'[1]. After a few seconds he realised the acceleration and climb had stagnated so he started to add additional thrust. The EGPWS system then announced 'DON'T SINK DON'T SINK', and 'PULL UP' was displayed on the PFD. The commander immediately applied full thrust and, as the speed increased, he increased the pitch attitude. Once safely climbing away they started to accelerate, retracted the flaps and reduced the thrust.

Once level at the missed approach altitude the pilots reviewed their options. They considered another approach to Manchester but ATC advised that subsequent aircraft had broken off the approach and the crew realised there would be a delay whilst the weather cleared. They decided to divert to Newcastle where the weather was clear. The remainder of the flight was uneventful.

Both pilots commented that they were startled by the sudden loss of visual reference.

Recorded information

The cockpit voice recorder was downloaded and used to assist in constructing the history of flight. Table 1 and 2 show the data obtained from the FDR and the operator's analysis of its FDM data.

Footnote

[1] The red and black band on the PFD speed tape indicates the speed at which the stick shaker (stall warning) will activate. The trend arrow indicates the predicted airspeed in ten seconds.

Altitude (above runway threshold elevation)	Aircraft recorded wind	Comment
1,000 ft	225° at 6 kt	Aircraft met the operator's stabilised approach criteria. The autopilot and autothrottle were engaged. Gear down and Flap 30. V_{APP} 156 kt. V_{REF} 143 kt.
800 ft	215° at 5 kt	Autopilot and Autothrottle disconnected. N_1 was 55%.
700 ft	175° at 10 kt	Wind begins to vary in direction and strength, becoming mostly a right crosswind. IAS increases to 165 kt (V_{APP} +9), thrust reduces to 30% N_1 and several right aileron inputs were made to maintain the localiser (localiser maintained within 0.5 dot deviation).
500 ft	115° at 21 kt	IAS 157 kt, thrust 33% N_1 and increasing. Rate of descent begins to increase (averaging 800-900 fpm) and the aircraft descends slightly low on the glideslope.
320 ft	105° at 23 kt	IAS 158 kt, thrust 49% N_1. Tracking the localiser but almost 1 dot low on the glideslope.
200 ft	090° at 23 kt	IAS 160 kt, thrust 40% N_1. Aircraft 0.5 dot low on the glideslope. Over the next 4 s, thrust is increased to 57% N_1, IAS reduces to a minimum of 148 kt (V_{APP}–8 & V_{REF}+5), rate of descent increases from 700 fpm to a peak of 1,000 fpm during this short period. There was little pitch change during this time.
140 ft	080° at 26 kt	Go-around is initiated and the TOGA switch is pressed. IAS 150 kt.

Table 1

Data from the approach

Altitude *(above runway threshold elevation)*	Aircraft recorded wind	Comment
140 ft	080° at 26 kt	N_1 increases to 86%, pitch increases to 10° and Flap 15 was selected (max go-around thrust was 98.7% N_1). LNAV engages automatically and the target speed bug aligns to the flap limit speed. Minimum IAS recorded is 141 kt (V_{REF}-2) as the aircraft reaches a maximum pitch attitude of 10° and a calculated rate of climb of less than 1,000 fpm.
200 ft	120° at 13 kt	N_1 86%, the landing gear is retracted and the pitch decreases to 7.5°, then 5°, followed by 4°. During the pitch change the flaps complete retraction to Flap 15 and the speed bug automatically changes to 174 kt and the thrust is manually increased to approximately 90% N_1. The aircraft flies level then begins a shallow descent over a period of 6 s, the minimum height reached is 150 ft ARTE, a total height loss of 50 ft. This is followed by an EGPWS caution "DON'T SINK, DON'T SINK". Full thrust is applied immediately.
Climb to 3,500 ft		The aircraft climbs away with N1 99%, rate of climb greater than 2000 fpm, increasing to greater than 3,000 fpm. HDG SEL is engaged passing 400 ft aal. Passing 1,000 ft aal, thrust is reduced to 88% N1. Passing 3,200 ft amsl the pitch is reduced and flap retraction commences and is completed by 3,500 ft amsl. The autopilot and autothrottle are re-engaged in HDG SEL and ALT HOLD.

Table 2

Data from the go-around

Meteorology

The forecast issued for Manchester Airport before G-FDZX took off and valid at the time of arrival was:

- Surface wind from 070° at 7 kt, visibility greater than 10 km and cloud scattered at 4,500 ft.
- Temporarily from 1200 hrs until midnight visibility 7 km in rain showers,
- 40% chance that temporarily between 1200 hrs and 2100 hrs, surface wind variable at 15 kt gusting 25 knots, visibility 3 km in heavy rain shower, thunderstorms and hail,
- 30% chance from midnight until 0600 hrs visibility 7 km.

The following actual weather reports were issued around the time of the incident.

At 1720 hrs:

- Surface wind from 210° at 5 kt varying from 180° to 240°, visibility greater than 10 km and cumulonimbus cloud, temperature 26°C, dew point 18°C and sea level pressure 1013 hPa.
- Temporarily rain showers.

At 1750 hrs:

- Surface wind from 200° at 5 kt varying from 130° to 240°, visibility greater than 10 km, light thunderstorm and rain, cumulonimbus cloud, temperature 21°C, dew point 17°C and sea level pressure 1014 hPa.
- Recent thunderstorm, hail and rain.
- Temporarily visibility 4 km, thunderstorm and rain.

When ATC cleared the aircraft to land, the controller reported the wind was from 160° at 19 kt with a recent gust to 27 kt. He gave a further wind check as the aircraft approached 50 ft above their decision height of 190° at 15 kt (decision altitude was 386 ft amsl / 200 ft aal). As the pilots were initiating the go-around the controller reported another wind check with a direction of 180°. The wind strength was not audible on the CVR.

Operator procedures

The operator's Operations Manual (OM) Part A contains the following recommendations concerning thunderstorms during takeoff and landing:

'The following recommendations shall be observed:

- *Do not land or take off in the face of an approaching thunderstorm. A sudden wind shift or low-level turbulence could cause a loss of control.*
- *On arrival hold clear if a thunderstorm is overhead or in the approach path. Divert if necessary.*
- *Avoid severe thunderstorms even at the cost of diversion or an intermediate landing.'*

The Boeing 737 QRH provides guidance on the recognition of windshear in the absence of an alert. It states that '*unacceptable flight path deviations*' are an indication the aircraft is in windshear. It states:

'Unacceptable flight path deviations are recognised as uncontrolled changes from normal steady state flight conditions below 1000 feet AGL, in excess of any of the following:

- *15 knots indicated airspeed*
- *500 fpm vertical speed*
- *5° pitch attitude*
- *1 dot displacement from the glideslope*
- *Unusual thrust lever position for a significant period of time.'*

The operator's OM Part B Volume 1 describes the go-around procedure. An extract is shown in Figure 1.

Aircraft manufacturers findings

The aircraft manufacturer reviewed the FDR data and commented:

'Lowering the nose is not consistent with published guidance in this scenario. A windshear escape manoeuvre[2] is expected when unacceptable flight path deviations occur, which includes applying maximum thrust and rotating towards an initial pitch attitude of 15 degrees.'

Startle and surprise

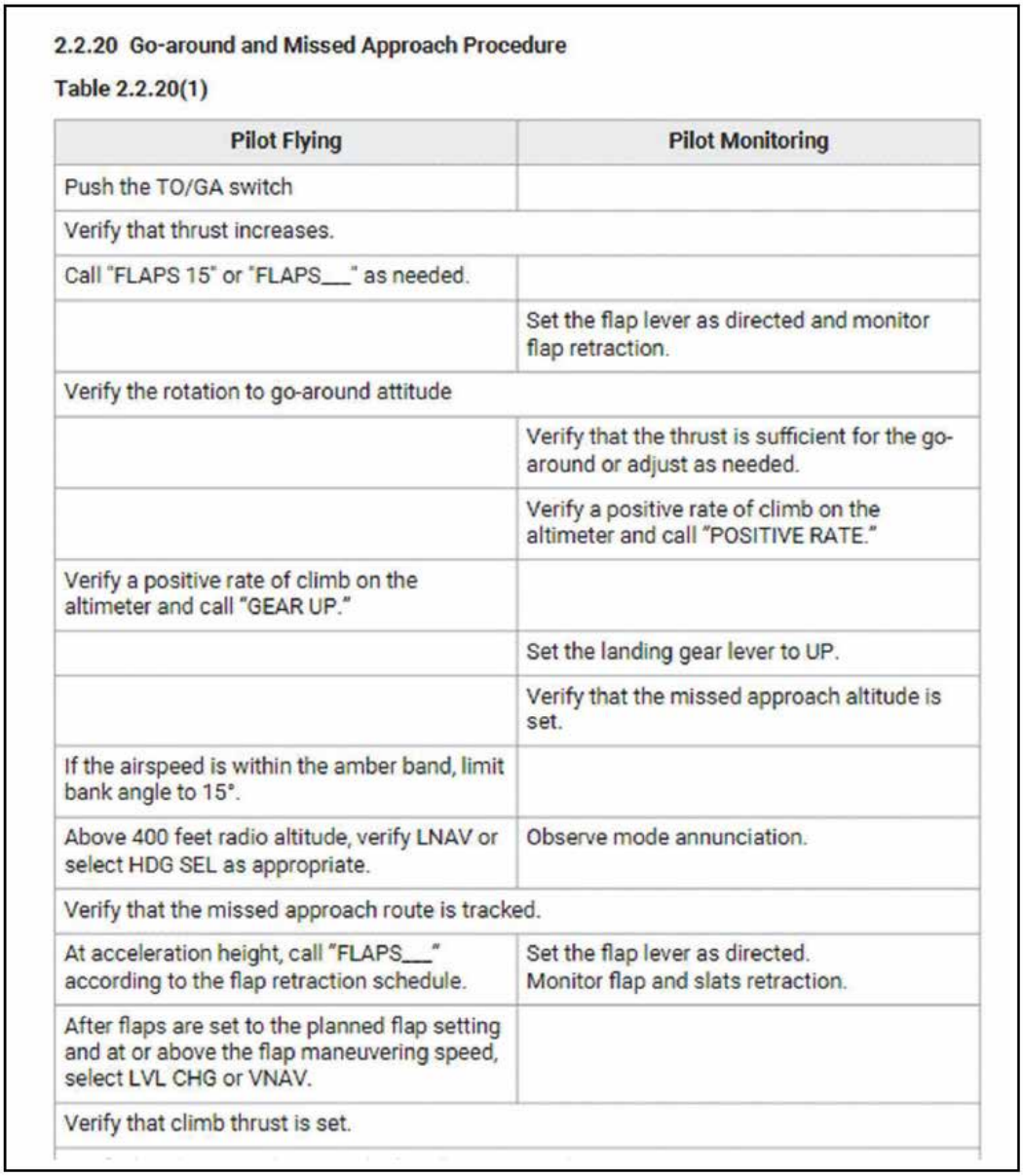
Startle is a '*brief, fast and highly physiological reaction to a sudden, intense or threatening stimulus*'[3]. A startle response occurs immediately in response to a startling stimulus and can impair pilot responses for a short period of time, usually between 0.3 and 1.5 s[4].

Footnote

[2] Windshear is a change of wind speed and/or direction over a short distance along the flight path. The windshear escape manoeuvre is published in the aircraft's Quick Reference Handbook. It is design to achieve maximum climb performance to escape from windshear conditions.

[3] Landman, A., Groen, E.L., van Passen, M.M. Bronkhorst, A. & Mulder, M. (2017) 'Dealing with unexpected events on the flight deck: A conceptual model of startle and surprise' in Human Factors, Vol 59 pp 1161-1172.

[4] Martin, W., Murray, P. & Bates, P. (2012) 'The effects of startle of pilots during critical events: a case study analysis' Proceedings of 30th EAPP Conference: Aviation Psychology & Applied Human Factors – working towards zero accidents.



2.2.20 Go-around and Missed Approach Procedure

Table 2.2.20(1)

Pilot Flying	Pilot Monitoring
Push the TO/GA switch	
Verify that thrust increases.	
Call "FLAPS 15" or "FLAPS___" as needed.	
	Set the flap lever as directed and monitor flap retraction.
Verify the rotation to go-around attitude	
	Verify that the thrust is sufficient for the go-around or adjust as needed.
	Verify a positive rate of climb on the altimeter and call "POSITIVE RATE."
Verify a positive rate of climb on the altimeter and call "GEAR UP."	
	Set the landing gear lever to UP.
	Verify that the missed approach altitude is set.
If the airspeed is within the amber band, limit bank angle to 15°.	
Above 400 feet radio altitude, verify LNAV or select HDG SEL as appropriate.	Observe mode annunciation.
Verify that the missed approach route is tracked.	
At acceleration height, call "FLAPS___" according to the flap retraction schedule.	Set the flap lever as directed. Monitor flap and slats retraction.
After flaps are set to the planned flap setting and at or above the flap maneuvering speed, select LVL CHG or VNAV.	
Verify that climb thrust is set.	

Figure 1

Extract from the Operator's OM-B showing the go-around procedure

Surprise is: '*an emotional and cognitive response to unexpected events that are (momentarily) difficult to explain, forcing a person to change his or her understanding of the problem.*' Surprise often follows a startle response if the cause of the stimulus that triggered the startle is not understood. Experimental studies looking at the effects of surprise on the flight deck have shown for example, delayed initiation of responses[5] and incorrect or incomplete application of procedures[6].

Footnote

[5] Martin, W.L., Murray, P.S., Bates, P.R., & Lee, P.S. (2016) 'A flight simulator study of the impairment effects of startle on pilots during unexpected critical events.' Aviation Psychology and Applied Human Factors, Vol 6, pp 24-32.

[6] Casner, S.M., Geven, R.W. & Williams, K.T. (2013) 'the effectiveness of airline pilot training for abnormal events.' Human Factors, Vol 55, pp 477-485.

Analysis

As the pilots made the approach to Runway 05R there was a thunderstorm moving towards the airfield, but they maintained visual contact with the runway until decision height. The company's OM recommends that an approach should not be attempted in these conditions. However, as the pilots could clearly see the runway they considered it safe to continue.

After passing 1,000 ft the wind shifted from a tailwind to a headwind and a right crosswind, the airspeed was variable, the aircraft descended to almost 1 dot low on the glideslope and there were large changes in thrust. These changes did not exceed the parameters specified in the aircraft's QRH but may have provided a clue to the presence of windshear. However, there was no automatic windshear alert at any point.

When the pilots lost visual reference, they initiated a manual thrust go-around, setting approximately 86% N_1 During the initial go-around actions the wind shifted 40° in direction which resulted in an 18 kt loss of headwind, causing a loss of airspeed. The commander reacted to the loss of airspeed and negative airspeed trend by reducing the pitch attitude. The reduction in pitch attitude with less than full go-around thrust caused the aircraft to descend, triggering the EGPWS '*DON'T SINK*' caution. He reacted appropriately to the caution and the aircraft climbed away. The go-around procedure requires the pilot monitoring to '*verify the thrust is sufficient for the go-around or adjust as needed'*. During this go-around additional thrust was required. Both pilots reported being startled by the sudden loss of visual reference on the approach. The commander reported that he was surprised that the aircraft was not performing as he expected on a go-around and he became focused on the airspeed loss; it took him a few moments to understand what was happening. The co-pilot reported his ability to monitor was reduced and this limited his ability to assist the commander during the first few moments of the go-around.

The aircraft manufacturer considered that the correct response to the situation was to use maximum available thrust or to fly the windshear escape manoeuvre (WEM). To address these issues the operator has proposed to:

- Raise awareness amongst their flight crew that thunderstorms in the UK can pose a similar threat to other well-known thunderstorm areas elsewhere on their network.
- Emphasise the possibility of unalerted windshear and signpost the guidance contained within the company manuals.
- Use the details of this event to encourage flight crew to build operational resilience via relevant threat-based briefings, to increase situational awareness and mitigate against the effects of 'surprise'.
- Review the guidance regarding manual thrust go-arounds and how flight crew determine if 'sufficient thrust' is set.

Conclusion

The slight descent and EGPWS caution during the go-around were caused by the commander reducing the pitch attitude in response to a loss of airspeed. The loss of airspeed was due to a change in wind direction caused by the approaching thunderstorm with insufficient thrust applied. The go-around procedure requires the flight crew to verify sufficient thrust is set to achieve the climb performance during a go-around. The aircraft manufacturer considers a windshear escape manoeuvre to be an appropriate response in these circumstances.