SERIOUS INCIDENT

Aircraft Type and Registration:	Bombardier Challenger CL-600-2B16 (601-3A), 2-PAPA	
No & Type of Engines:	2 General Electric Aviation CF34 turbofan engines	
Year of Manufacture:	1993 (Serial no: 5125)	
Date & Time (UTC):	29 March 2022 at 1638 hrs	
Location:	On approach to Oxford Airport	
Type of Flight:	Private	
Persons on Board:	Crew - 3	Passengers - 2
Injuries:	Crew - None	Passengers - None
Nature of Damage:	None	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	50 years	
Commander's Flying Experience:	8,550 hours (of which 2,000 were on type) Last 90 days - 59 hours Last 28 days - 36 hours	
Information Source:	Aircraft Accident Report Form submitted by the commander and further enquiries by the AAIB	

Synopsis

The flight crew were flying a non-precision approach to Oxford Airport. As the aircraft passed the Final Approach Fix, in IMC, a high rate of descent was established leading to a GPWS terrain warning. As the aircraft emerged from cloud the commander reduced the rate of descent and elected to continue the approach. The aircraft landed normally.

There was insufficient data to determine with certainty why the high rate of descent occurred but it was likely to be due to the way the Flight Management System (FMS) was used to fly the approach. The operator's procedures required the crew to initiate a maximum gradient climb following a GPWS warning in IMC and a go-around following an unstable approach or high rate of descent on approach, but neither occurred. Fatigue and miscommunication may have been contributory factors.

History of the flight

2-PAPA was being flown from Guernsey to Oxford Airport. This was the second flight of the day and was preceded by a four hour wait on the ground in Guernsey. The previous day the crew had flown the aircraft from Nassau in the Bahamas to Bristol Airport via St John's Airport in Newfoundland.

The aircraft took off from Guernsey Airport at 1515 hrs and proceeded towards Oxford. The crew were expecting to fly the NDB/DME approach to Runway 01 at Oxford. The weather conditions at the airport were a surface wind from 050° at 8 kt, visibility 8 km, and cloud broken at 700 ft aal and overcast at 800 ft aal. Approaching the airport the crew were given a shortened routing taking them direct to the Compton VOR then direct to the Oxford NDB. When they contacted Oxford Approach, they were given a radar vector toward the Final Approach Fix (FAF).

The crew descended and slowed the aircraft, levelling at 1,800 ft amsl just prior to the FAF, with the gear up and flap 20 set. At this stage the autopilot was engaged and the aircraft was in IMC. As the aircraft approached the FAF the co-pilot reported that the commander changed the selected altitude to zero, pressed VNAV[1] on the flight guidance panel and asked him to select the gear down and flap 30. As the aircraft passed the FAF, the commander reported that he asked the co-pilot to select a 'vertical direct to the runway' in the FMS. The aircraft then started to descend rapidly. The co-pilot remembered seeing a rate of descent of 2,200 fpm to 2,500 fpm but recalled the FMAs[2] were correctly reading 'LNV' and 'VPTH'. He reported that he called "vertical speed" but the commander did not remember hearing this call. Both pilots then heard a GPWS warning, the commander recalled hearing 'TERRAIN TERRAIN' whereas the co-pilot recalled hearing 'TERRAIN TERRAIN, PULL UP PULL UP'. The commander was confident he did not hear 'PULL UP'.

The pilots' recollection of the next few moments differed. The commander recalled that following the GPWS warning he disconnected the autopilot and started to reduce the rate of descent. He thought that they broke out of cloud at between 1,000 ft and 900 ft amsl. He remembered seeing the runway, seeing four red PAPI's and being approximately 300 ft below the correct vertical profile. He decided to continue the approach. He recalled the co-pilot calling "altitude" and ATC warning them that the aircraft was low. He recalled levelling the aircraft to regain the profile and continuing the approach for a normal landing.

The co-pilot recalled that immediately following the GPWS alert he called "go-around flaps". He did not get a reply from the commander so called 'go-around' again. He stated that the commander did not physically or verbally acknowledge these calls. He recalled that the aircraft broke out of cloud passing approximately 700 ft amsl and the commander then disconnected the autopilot and started to reduce the rate of descent. The co-pilot recalled stating 'go-around' again. He remembered the commander saying "why would I go-around when I am visual with the runway?". He replied "we are below the profile and very low". The co-pilot recalled ATC stated the aircraft was low and asked if they were happy to continue and commander replied he was happy to continue. The co-pilot remembered stating "we are 200 ft above the ground with four reds" but the commander continued the approach.

The aircraft landed on Runway 01 at 1638 hrs. There was no damage to the aircraft.

Footnote

[1] VNAV – Vertical Navigation.
[2] FMA – Flight Mode Annunciator.

Recorded information

The aircraft was fitted with a FDR but no data was recovered from it. Data broadcast by the aircraft was used to create Figure 1. The profile flown by 2-PAPA is shown in blue and the published NDB/DME approach profile is shown in orange. The terrain under the approach path is shown in green.

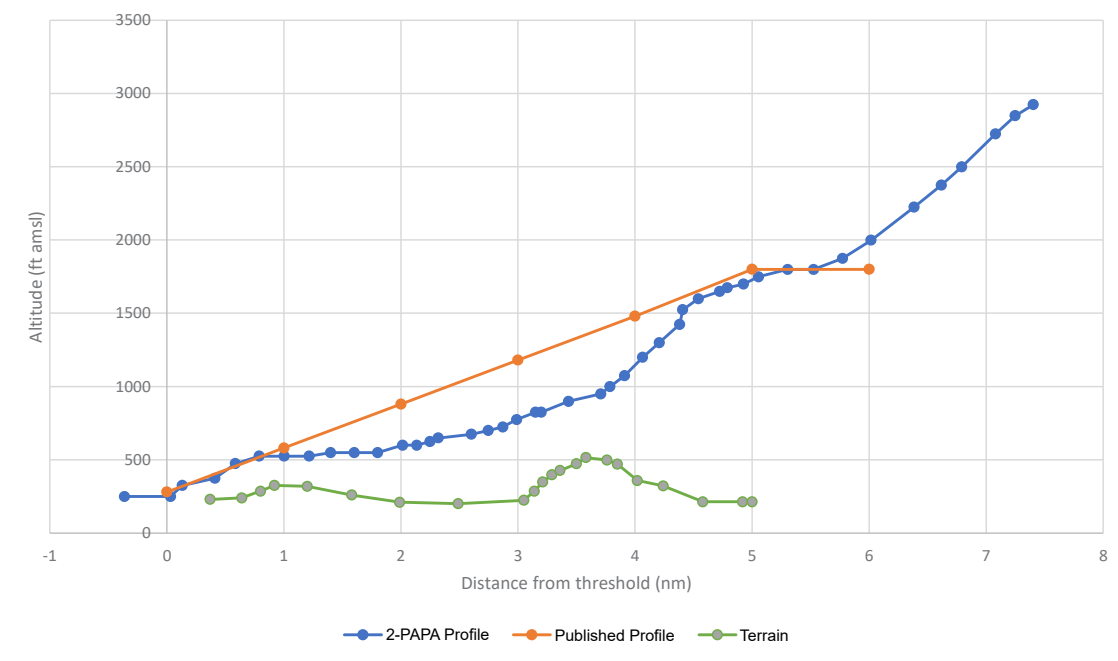

Figure 1

Profile flown by 2-PAPA compared to the published profile and terrain

Aircraft information

The NDB/DME approach to Runway 01 at Oxford was available in the aircraft's FMS database. The first waypoint in the database approach was coincident with the FAF and required the aircraft to be at 1,800 ft or above. The approach then prescribed a 3.0° descent profile to the runway threshold.

The approach could be flown by the autopilot by selecting NAV and VNAV prior to reaching the FAF. The altitude selector must be selected to an altitude below 1,800 ft to allow the aircraft to descend. The pilots were trained to reduce the selected altitude to zero or to the approach decision height to prevent the autopilot levelling prior to the runway.

It is not necessary to select 'vertical direct to' for the autopilot to fly the approach. Selecting vertical direct to a waypoint instructs the FMS to calculate a new vertical profile from the current altitude to the altitude specified at the waypoint selected and removes any existing profile.

In October 2020 the FMS manufacturer published a Service Information Letter (SIL) (revised in June 2021) advising operators of an anomaly that may result in an unexpected steeper

descent while in FMS VNAV mode[3]. The SIL explains that after passing a waypoint the FMS updates its calculation to ensure it will meet the next constraint. If the next constraint is an 'at' or 'at or above' the FMS will include an adjustment to allow the aircraft to level off prior to the constraint. This adjustment can cause a temporary increase in the rate of descent.

It is possible that when the crew selected 'vertical direct to', triggering the FMS to recalculate the profile and removing the existing approach profile, that the anomaly described in the SIL caused the aircraft to start a steeper descent.

The approach can also be flown using the autopilot's heading and vertical speed modes.

Pilot information

Both pilots were qualified to fly the Challenger 601. The commander was a freelance pilot and had completed an operator proficiency check in March 2022. The co-pilot was employed by the operator and had completed proficiency checks and line training with the operator. They had both completed the operator's initial crew resource management training.

The commander's background was primarily in corporate aviation whereas the co-pilot's background was mostly in airline operations.

Both pilots reported feeling well rested prior to the flight but after the incident considered that fatigue may have been a factor. The day prior to the incident they had flown the aircraft from the Bahamas to Bristol. They both reported having slept well that evening. The next morning they flew the aircraft from Bristol to Guernsey but then had a four hour wait before flying to Oxford.

They both reported that they had not effectively briefed for the approach to Oxford. The co-pilot remembered some discussion about the approach prior to departure from Guernsey. The commander reported that the shortened routing meant he did not have time to brief the approach. The pilots had not agreed how they intended to fly the approach.

Operator information

The operator's Operations Manual (OM) contains several statements relevant to the approach.

GPWS

The crew response to a GPWS alert or warning was specified in OM A 8.3.5.3:

> *'The immediate action on receiving an alert will vary according to the stage of flight and aeroplane configuration, but must involve correcting the condition for which the alert was valid. No attempts should be made to recover the original flight path until the cause of the alert have been positively established and eliminated.*

Footnote

[3] Honeywell Service Information Letter – D202010001347.

> *Whenever a warning is received, however, the immediate response must be to level the wings and initiate a maximum gradient climb to the MSA* [4] *for the sector being flown, except as in para 8.3.5.4.'*

Paragraph 8.3.5.4 specified that a warning may be treated as an alert when in day VMC conditions and it is immediately obvious to the commander that the aircraft is in no danger.

Stable approach criteria

OM B 2.13.1.1 specified the operator's stable approach criteria. It stated:

> *'An approach is considered to be stable when all the following are met:*
>
> - All briefings and checklists have been actioned.
> - The aircraft is on the correct flight path.
> - The aircraft is in the planned landing configuration.
> - Power setting appropriate for aircraft configuration.
> - The IAS is not more than final approach speed +10 kt and not less than V_{REF}.'

The manual stated that these criteria should be met when the aircraft is 1,000 ft above the approach decision height. The operator's minimum decision height for the NDB/DME approach was 740 ft so these criteria should have been achieved by 1,740 ft amsl. However, the manual stated that the approach could be continued if the commander was sure the criteria would be met by 500 ft above the approach decision height (1,240 ft amsl for this approach). The manual stated that a go-around must be flown if this was not achieved.

The section also stated that:

> *'Throughout the approach phase, descent rates should be no more than 1000 ft/min and vary by no more than +/- 300 ft/min.* […] *If these conditions are not met, an immediate go-around must be flown.'*

Analysis

There was insufficient data for the investigation to determine with certainty why the aircraft entered a high rate of descent during the approach. A possible explanation is that, when the crew selected a vertical direct to the runway, the FMS deleted the existing vertical profile and calculated a new profile. By the time the FMS had calculated the new profile the aircraft was above the new profile so the autopilot commanded a descent to intercept the profile. It is also possible that an anomaly in the FMS (described in a SIL published by the FMS manufacturer) may have caused the high rate of descent when the FMS recalculated the profile.

Footnote

[4] MSA – Minimum Safe Altitude.

Both pilots reported that they had not effectively briefed for the approach to Oxford, and that they had not agreed how they intended to fly it. It may have been possible to avoid the high rate of descent if the crew had discussed how they intended to fly the approach and had a shared mental model. The section of CAA CAP 737[5] on sharing information and mental models states:

> *'In multi-crew aircraft, sharing of information is vital, particularly for the effectiveness of the monitoring task. The same situation can look quite different to two people, depending upon their intentions and awareness of what the other knows. Monitoring pilots are handicapped if they do not have a full picture of what the flying pilot is intending to do.'*

According to the operator's OM the GPWS warning in IMC conditions required an immediate maximum gradient climb to MSA. The unstable approach and the rate of descent above 1,000 fpm required a go-around.

The co-pilot reported that he tried several times to tell the commander to go around but the commander decided to continue the approach. The commander did not recall the co-pilot telling him to go around. It is possible that an element of fatigue contributed to the communication difficulties. The section of CAP 737 regarding intervention and assertiveness states:

> *'Occasionally, even with direct and assertive comment* […], *the verbal intervention may fail. This can be for a number of reasons, but the most likely ones are that the other pilot's workload is high or situational awareness is poor, or a very poor crew relationship exists. These situations would be particularly difficult if the intervention was from the first officer to the captain.'*

Conclusion

A high rate of descent was established on final approach leading to a GPWS warning. The commander elected to continue the approach and landing despite several instructions in the operator's OM requiring a maximum gradient climb or go-around in these circumstances. The pilots' recollections differ on the verbal intervention offered by the co-pilot. It is possible that fatigue and miscommunication were contributory factors.

Footnote

[5] CAA CAP 737 '*Flight-crew human factors handbook*', available at https://publicapps.caa.co.uk/docs/33/CAP%20737%20DEC16.pdf [accessed June 2022].