SERIOUS INCIDENT

Aircraft Type and Registration:	Bombardier Global 6000, LX-NST	
No & Type of Engines:	2 Rolls Royce BR700 engines	
Year of Manufacture:	2017 (Serial no: 9814)	
Date & Time (UTC):	7 April 2022 at 1625 hrs	
Location:	London Luton Airport	
Type of Flight:	Commercial	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to right wing tip, flap fairing, leading edge slat and aileron	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	51 years	
Commander's Flying Experience:	7,200 hours (of which 1,350 were on type) Last 90 days - 34 hours Last 28 days - 0 hours	
Information Source:	AAIB Field Investigation	

Synopsis

On approach to Runway 25 at London Luton Airport in gusty conditions, the right wing of LX-NST made contact with the runway causing damage to the wingtip, flap fairing, aileron and slat. The runway contact occurred during a baulked landing in which the pitch and roll combination was sufficient for the right wing to touch the runway for approximately 18 m.

The risk of wingtip contact is well known in this aircraft type and has been the subject of numerous previous reports including by the AAIB. As a result of this known risk, the manufacturer has taken a number of actions including improving training and publishing new guidance for pilots on techniques for wingtip strike avoidance. Before this serious incident, the manufacturer applied to Transport Canada for approval to make crosswind training a Training Area of Special Emphasis (TASE) for the Global Fleet. This would ensure that all training providers have a standardised approach to crosswind techniques and training, for both initial and recurrent training programs. At the time of publication, the manufacturer was in the midst of on-going discussions with Transport Canada regarding the details of the proposed TASE.

History of the flight

The aircraft departed from Biggin Hill Airport at 1605 hrs for a positioning flight to London Luton Airport. The flight was crewed by two pilots with no other crew members and no passengers on board. The commander was a training captain, and it was the co-pilot's first flight on the aircraft type. The co-pilot was PF.

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The aircraft was radar vectored for an approach at Luton on Runway 25. The wind given on the ATIS before the start of the approach was 290/27G38 which gave a crosswind component of 23 kt including the gust. This was below the maximum demonstrated crosswind for the aircraft type. The aircraft was configured and began a stable approach on the ILS. The wind given by Luton ATC when the aircraft was cleared to land was 290/22G36 which gave a crosswind component of 22 kt. At 100 ft radio altitude (RA) the commander recalled that the aircraft began to be affected by what he considered to be turbulence generated by the nearby buildings but, although the aircraft was deviating slightly from the centre of the ILS, he considered it to be well within acceptable boundaries. At the 50 ft RA call, the autothrottle system (ATS) began to retard the throttles as designed. At some point after this the commander described how he suddenly felt the aircraft becoming unstable and beginning to drift to the left. He decided that the aircraft was no longer in a suitable stable state to land and, on taking control from the co-pilot, applied full power by pushing the throttles forward.

The aircraft rolled to the right before the right main gear momentarily touched down. During this, the right wingtip contacted the runway. The commander applied full left controls and the aircraft rolled rapidly to the left. The aircraft climbed away from the runway.

There were no control difficulties after the aircraft climbed away and the subsequent approach and landing was completed without further incident. After shutdown, the commander noticed that there was damage to the right wingtip, flap fairing, leading edge slat and aileron. There was no damage to the left wing.

Accident site

The aircraft had touched down on Runway 25 at Luton around the normal touchdown markers. There were marks visible from the right wing contacting the ground from around 390 m from the threshold of the runway for 18 m as shown in Figure 1.

Figure 1

Markings on Runway 25 with the arrow indicating the direction of landing

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The winglet damage consisted of trailing edge and outboard skin damage. The flap fairing, which was composite construction, had been partly worn away. The outboard leading edge slat outer skin was damaged down to the second inner skin layer, and the aileron trailing edge lower outboard skin had been shaved off. Three of the static discharge wicks on the right aileron also required replacement. The damage is shown in Figure 2.

Figure 2

Damage to LX-NST Clockwise from top left – slat, winglet, aileron, flap fairing

The following parts were replaced:

- Right hand slat assembly
- Right hand aileron including three static dischargers
- Access panel

Repairs were made to the flap fairing and winglet trailing edge.

Recorded information

Closed-circuit television (CCTV)

LX-NST's baulked landing was recorded on the airport's CCTV system. Figure 3 shows the moment the right wing contacted the ground.

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Figure 3
Redacted CCTV image of LX-NST's wing contacting the ground

Flight data and anemometry

The recorded data, downloaded from the solid-state FDR fitted to LX-NST, showed that the autopilot was disengaged at 450 ft RA. In the windy conditions, significant activity was recorded on the controls, especially the control wheel position, and, after the autopilot was disengaged, on the rudder pedals. This resulted in larger roll perturbations, but the aircraft's flight path was generally well controlled. At point 'A' on Figure 4, at 50 ft RA, the ATS retarded the throttles towards idle. The wind, sampled four times a second and recorded by the anemometer situated near to the touchdown point of Runway 25, was from 308° at between 17 and 19 kt and varied little over the next 10 seconds – between point 'A' and point 'C'. Three seconds after the ATS had retarded the throttles, at approximately 25 ft RA, a significant nose-left rudder pedal demand and corresponding right-wing-down wheel input was made to de-crab the aircraft and align it with the runway. At approximately 10 ft RA, during the de-crab manoeuvre, the rudder and wheel position were reversed to demand a nose-right and left-wing-down correction, but almost immediately afterwards, at point 'B', the landing was aborted and the throttles were selected to full thrust. However, the aircraft rolled to the right and, before the engines had developed a substantial increase in thrust, reached 10.5° right angle of bank with a pitch attitude of 9.5°. At this point, the right main gear briefly touched down and the wing contacted the ground. The aircraft then began to roll rapidly left to 7.5° angle of bank, which was countered by a large, swift right-wing-down wheel input. Shortly afterwards, at point 'C' – three seconds after the selection of TOGA, the engine thrust began to increase significantly and the aircraft began to climb away.

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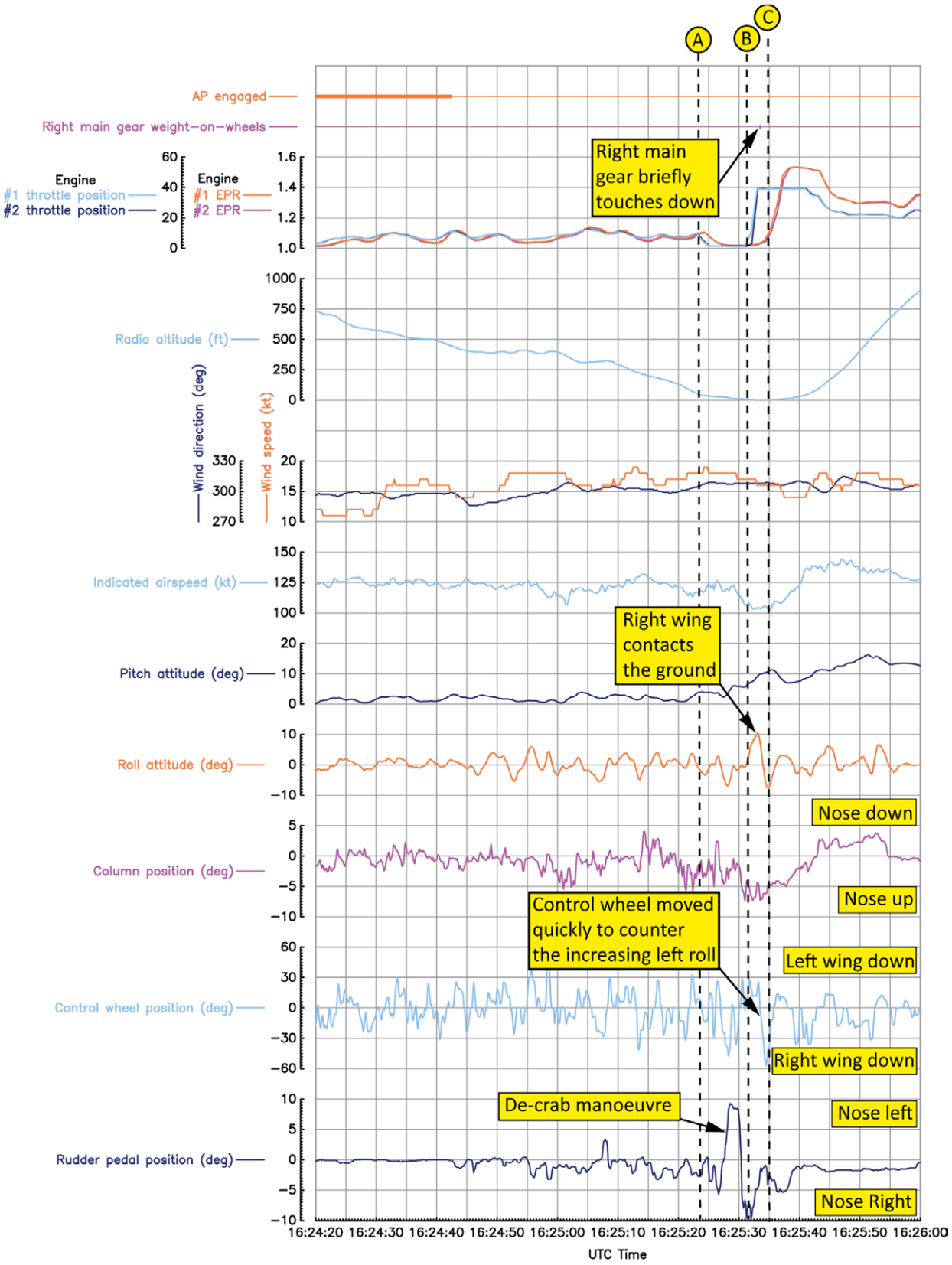

Figure 4

Flight data from LX-NST's approach and baulked landing

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All times are UTC

Aircraft description

The Bombardier Global Express is an ultra-long-range, high-speed, business/corporate turbofan powered aircraft. The aircraft has mechanically controlled, hydraulically actuated primary flying controls.

Approach speed control

The ATS is designed to manage engine thrust through automatic positioning of the throttle levers over the aircraft's complete flight regime. When the aircraft is on approach and the ATS is engaged, it will aim to maintain a speed appropriate to the configuration of the aircraft and then of the selected approach speed. The approach speed calculation for the aircraft type recommends adding half the gust to V_{REF} in gusty conditions.

The ATS has a retard mode which causes both thrust levers to automatically retard to idle at a fixed rate during the landing flare. The mode activates when the aircraft is in a landing configuration (Slats OUT / Flaps 30, Gear DOWN) and a RA of 50 ft agl is reached. The ATS remains engaged until touchdown to provide go-around thrust should a go-around be selected. If go-around is selected, then the ATS will advance the thrust leavers to the active upper engine rating.

Crosswind technique

The Flight Crew Operations Manual (FCOM) for the aircraft type specifies that pilots are to use the wings-level crab technique until the flare for landing with the aircraft pointing into wind and tracking the extended centreline. The flare is commenced at approximately 30 ft agl when downwind rudder is applied to align the aircraft with the centreline. Opposite aileron is required to maintain wings-level with the aim to touch down as soon as the aircraft is aligned with the runway. The FCOM warns against extending the flare or delaying the touchdown as this usually results in an increasing pitch attitude reducing the wingtip clearance in bank (as shown in Figure 5). For gusty conditions the FCOM recommends a '*deliberate positiv touchdown*'.

The maximum demonstrated crosswind component for takeoff and landing is 29 kt and is not considered limiting for takeoff and landing. The operator did not have an additional crosswind limit for co-pilots or inexperienced pilots beyond that of FCOM.

Go-around technique

The FCOM states that a go-around can be initiated by the pilots until thrust reversers have deployed. The technique requires the selection of maximum thrust and the simultaneous press of the go-around switch. The PF must then increase the pitch attitude smoothly to +10°. The aircraft type demonstrated minimum height for a go-around without touching the ground is 50 ft.

The FCOM also has a procedure for baulked or rejected landings which it defines as '*a missed approach initiated after the aeroplane has entered the low-energy landing regime. It may be before or after the main gear contact with the runway'*. In this low-energy state

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the engines are usually at or close to idle and they require several seconds to accelerate up to maximum thrust. The procedure requires the pilot to simultaneously select TOGA and advance the thrust levers, maintain the landing flap setting and maintain or slightly increase the pitch attitude. The pilot is warned to expect the aircraft to touch down and to keep the aircraft aligned with the runway with minimum bank angle. Only once the aircraft is safely established in the go-around and there is no further risk of touchdown is the configuration of the aircraft changed.

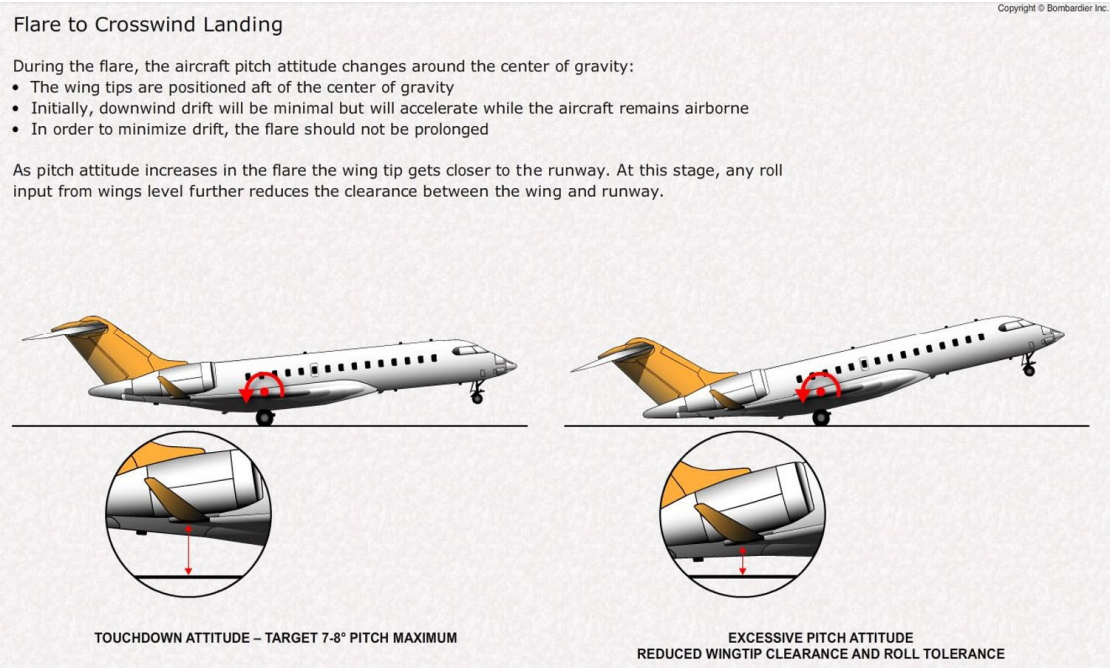

Figure 5

Flare to crosswind landing

Landing attitude and roll control

The aircraft manufacturer provided the following information on the pitch attitude and angle of bank combinations in which the wingtip will contact the runway (Table 1). The JIG figures are for when the wing is under no aerodynamic load (as if in the manufacturing jig) and the FLIGHT figures for a fully loaded wing with the aerodynamics bending the wing upwards. The true figure will lie somewhere between the two depending on many variations such as the aircraft weight, flap position, airspeed, and spoiler activity. The figures are intended to provide the pilots with a good idea of how much they can bank the aircraft with a given pitch angle close to the ground.

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PITCH°	Bank Angle JIG° (Wing under no aerodynamic load)	Bank Angle FLIGHT° (Wing under aerodynamic load)
0	10.6	13.5
3	9.6	12.3
6	8.5	11.2
9	7.4	10.1

Table 1

Nose-up pitch attitude and angle of bank at wingtip contact

Previous incidents

The AAIB has conducted several investigations into very similar incidents with this aircraft type, most recently to CS-GLD[1]. This aircraft was operating into Biggin Hill with a crosswind from the right when the right wing contacted the runway. The damage to CS-GLD was almost identical to that on LX-NST. Worldwide, there have been a significant number of similar events; it is a known risk with this aircraft type as it has a relatively low undercarriage height and a long, swept-back wing.

The manufacturer has taken a number of steps to better understand, reduce and/or mitigate the risk of wingtip strikes in the aircraft type. These include completing internal safety studies, providing free online training modules as well as issuing further guidance to pilots setting out the correct technique to be used in a crosswind and its importance in terms of aircraft geometry. The manufacturer also introduced a new section into the FCOM called Recommended Operational Procedures and Techniques (ROPAT). The aim of the ROPAT was to provide a single document for pilots, operators, and training organisations to refer to. The ROPAT includes expanded guidance on the crosswind technique and wingtip strike avoidance.

The manufacturer also worked with a training provider to improve existing initial and recurrent training, ensuring it reflected the FCOM and ROPAT technique. In 2021 they also applied to Transport Canada for approval to make crosswind training a TASE for the Global Fleet. This would ensure that all training providers, both initial and recurrent have a standardised approach to crosswind techniques and training. At the time of publication, the manufacturer was waiting for Transport Canada's assessment of the proposed TASE.

Aircraft performance

When calculating the approach speed required for the aircraft type, pilots must first establish the reference approach speed for the aircraft weight (V_{REF}). This speed at the aircraft weight was 111 kt. They must then make a correction for half of the wind gusts, which in the case of LX-NST added an extra 7 kt, leading to an approach speed (V_{APP}) of 118 kt.

Footnote

[1] https://www.gov.uk/aaib-reports/aaib-investigation-to-bombardier-bd700-1a10-cs-gld [accessed December 2022]

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The operator's Operating Manual Part B states that for landings on runways over 4,500 ft (1,372 m) the minimum approach speed is to be V_{REF}+5 kt. The manual does not make clear whether this is additional to any wind correction or is intended to make sure on longer runways the V_{APP} is always equal or greater than V_{REF} + 5 kt regardless of the wind. The commander understood that the 5 kt was in addition to the wind correction figure. During the approach the speed set was 123 kt which was 5 kt over the calculated VAPP.

The manual also states:

> *'Increased airspeeds above VREF may be required upon encountering turbulence, strong crosswinds or gusts. The increased approach speed shall be cross-checked to be compatible with the landing distance requirements. In any cases, during flare, crew shall make sure that the aircraft is not floating to such a point where the speed reduces significantly below VREF'.*

As designed, the ATS entered retard mode at 50 ft agl and the aircraft speed had dropped to 107 kt by 8 ft RA, which was 11 kt below the required, adjusted V_{REF} and 16 kt below the selected airspeed.

Previous incidents in this aircraft type resulted in further research into the control effectiveness at slower speeds. This research showed that roll control was effective down to much lower speeds than LX-NST reached in this approach and therefore full control was available at all times during the flight, touchdown and go-around.

Meteorology

Analysis of the weather show an occlusion holding to the north of the south-east region of the UK with a tight surface pressure gradient across the area. This would suggest that strong winds would be likely across the region. Radar images showed some showers in the area, some heavy. The cloud base at Luton never reduced below 4,300 ft aal during the period that LX-NST was in flight to the airport. It was daylight during the period of both approaches.

The TAF issues at 1103 hrs showed a strong westerly wind with gusts up to 44 kt with the wind becoming more west-north-westerly from 1600 hrs but reducing in strength. The airfield METARs show that the wind did move to a more north-westerly direction but that the reported gusts remained strong. The METARs for 1620 hrs and 1650 hrs are shown below:

METAR EGGW 071620Z 29026G36KT 9999 -SHRA BKN043 10/00 Q0991=

METAR EGGW 071650Z AUTO 30025G43KT 9999 FEW044 09/01 Q0992=

The Luton Airport wind reporting system recorded the wind speed and direction every four seconds. This wind was recorded by the anemometer close to the touchdown zone for Runway 25, south of the runway as shown in Figure 6. The figures from this recording at the time that LX-NST was approaching the runway are shown in Figure 4.

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Airfield information

Luton Airport has a single runway orientated 07/25. The airfield sits on a hill at 526 ft amsl. The terminal and associated buildings are to the north of the runway and include a multistorey carpark which is 325 m from the centreline. Figure 6 shows these buildings in relation to the wind from the METAR and area in which the aircraft wing made contact with the runway.

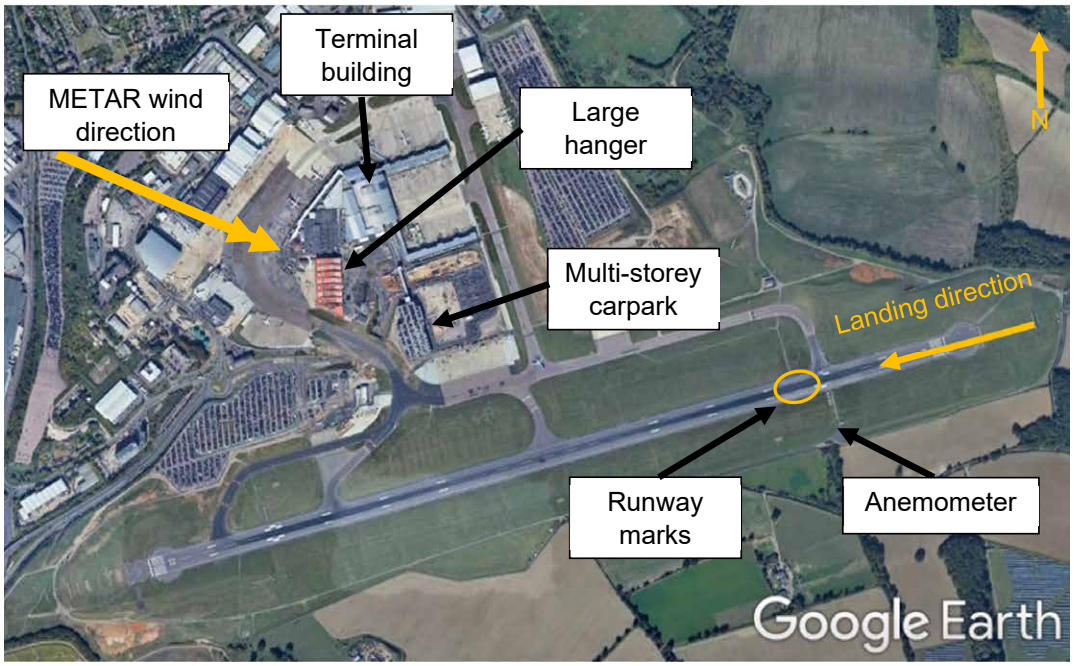

Figure 6
Luton Airport layout

Personnel experience

The co-pilot was on his first flight on type after completing his type rating. The type rating included base training, so the co-pilot had performed a minimum of six landings prior to the flight from Biggin Hill to Luton. He had also spent a considerable amount of time in the simulator supporting the training organisation's recurrent program waiting to begin his training on the aircraft itself. The commander considered that as the flight was so short it would be better for the co-pilot to operate as PF as the duties of the PM would make him extremely busy. The commander was aware that the co-pilot had significant experience of the aircraft type in the simulator and felt that he would benefit from being PF rather than PM for the sector. The commander did intend to remain as PM for the approach and landing at Luton but took control from the co-pilot below 50 ft RA with the ATS engaged in retard mode. The co-pilot stated that he made no further inputs onto the controls.

The commander had been a training captain at a previous employer, completing a Type Rating Instructors course in 2016. He had completed the operator's required training to be a line trainer. The training did not include any practise of taking control close to the ground nor any training in conducting go-arounds from low altitude close to the runway, although he

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had received training in baulked landings below the approach minima but above 100 ft agl. Although the commander had not flown the aircraft in the previous 28 days, he did not consider this to be unusual in the work pattern of the operator.

Decision making

The commander decided that the co-pilot would be PF for the sector on the basis of his previous experience doing such flights, which are very short and involve a significant amount of ATC frequency changes and mean the PM is working very hard to complete the required tasks during the flight. He felt that the weather was suitable for the co-pilot to operate as PF for the flight although he would review who would fly the final approach and landing at Luton once he had up to date wind information from Luton ATC. Having listened to the ATIS he considered that the crosswind was well below the aircraft limits and that the co-pilot was sufficiently experienced from the simulator that he could continue to act as PF for the approach and landing.

Once on the approach the commander continued to monitor the co-pilot whom he felt was dealing well with the conditions. From the point at 100 ft RA when the commander first sensed the changing wind to when he applied full thrust was approximately 10 seconds. He did not press the go-around switch as he was unsure as to whether it would work with the ATS in retard mode.

Analysis

Decision making

In allocating the roles for the flight the commander had considered his previous experience of the route, the weather forecast for Luton and what he considered would provide the greatest benefit for the co-pilot. The commander considered that the role of PM was more demanding on this route and therefore decided that it was best for the co-pilot to act as PF for the sector. The commander had also considered the weather at Luton, particularly the wind forecast and had decided that he would reassess the situation prior to allowing the co-pilot to fly the approach. There was no reduced crosswind limit for trainees or inexperienced pilots and the wind was within what he considered to be appropriate values for the co-pilot's experience level.

Whilst there was nothing in the operator's procedures to prevent the commander allowing the co-pilot to fly the approach into Luton, subsequent events left him taking control in a position of low-energy, close to the ground. The commander made a prompt and suitable decision to take control when he sensed the aircraft was no longer in a stable position to land, but he was left with little time in a very dynamic situation to decide what to do and action it whilst ensuring that the bank/pitch combination did not reach the critical point where the wingtip would make contact with the runway.

Although the commander had completed some training in initiating go-arounds below procedural minima, these had all been above the height at which he took control in LX-NST. He had received no specific training in taking control and completing a baulked landing despite conducting training in the aircraft with inexperienced pilots.

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Wind conditions

The approach was stable with a crosswind from the right which varied in speed and direction. With the aircraft below 100 ft RA the commander suddenly sensed that the aircraft was drifting sideways and took control. He selected full thrust and began a go-around. The crosswind component from 50 ft RA to 20 ft RA was less than 10 kt but as the commander began the go-around he felt that the wind shifted in both direction and strength. With the aircraft in a low-energy state, and an increasing pitch angle, the aircraft touched down momentarily on its right main wheel and the wing tip contacted the runway. The crosswind component did not exceed the maximum demonstrated value during the approach, baulked landing or go-around although the variations in strength and direction made controlling the aircraft close to the ground more challenging than a steady wind.

The layout of Luton Airport has a large multistorey car park, hangars and the terminal building to the northwest of the touchdown zone. This can mean that with a strong north-westerly wind, there can be turbulence and variations in the wind as aircraft land on Runway 25. Although the wind data from Luton does not show a large shift in wind direction or strength during the baulked landing, it is possible that the aircraft was affected by low-level turbulence or wind changes that did not reach the airport anemometer position and therefore are not recorded.

Aircraft operation

The speed the pilots flew on the approach was above that calculated by the manufacturer taking into account the aircraft weight and the wind correction. The pilots added an additional 5 kt above that required by the operating manual. Despite this additional 5 kt, once the ATS entered retard mode at 50 ft RA and the thrust levers moved back to the idle position, the aircraft speed dropped to 16 kt below that selected (V_{REF} -11 kt) by the time the aircraft reached 8 ft RA. Previous research carried on the controllability of this aircraft type at slow speeds showed that full controllability in all axes was available to much lower speeds than LX-NST reached on this approach.

The go-around and subsequent approach were performed without incident, and the pilots were unaware until after they had shutdown that the right wing had contacted the runway.

Aircraft manufacturer

There have been a number of previous incidents on this type, including those previously investigated by the AAIB. The manufacturer took action to ensure that pilots are fully aware of the risks and have received suitable specialist training in handling the aircraft in strong crosswinds. At the time of publication, the manufacturer was working with Transport Canada to approve the TASE for the Global Fleet, which should ensure that the correct and consistent technique is taught in both initial and recurrent training.

Conclusion

The pilots of LX-NST made an approach to Runway 25 at Luton with a strong and gusty crosswind. The co-pilot was flying the approach until the commander sensed the aircraft

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begin to drift sideways around 100 ft RA. The commander took control and began a go-around during which the pitch of the aircraft increased whilst the aircraft rolled to the right. The combination of the pitch and roll led to the right wingtip making contact with the runway. Wingtip strikes, particularly during crosswind conditions, are a known risk on the aircraft type that the manufacturer continues to address through publications and training.

Whilst the wind data from the airport did not show any large changes in wind speed or direction, it is possible that the aircraft was caught by some low-level turbulence or wind changes that did not reach the anemometer.

The commander was conducting line training for the co-pilot who was new to the aircraft type. Although the operator had no crosswind limitations for inexperienced pilots, and therefore there was nothing to prevent the co-pilot flying the approach, the commander subsequently faced taking control of the aircraft in a low-energy state close to the ground.

Safety actions

The operator completed their own investigation into the incident and took the following safety actions:

- Simulator training to include new scenarios of crosswind landings and low-energy go-arounds
- This event was shared amongst all crews.

A number of other recommendations made in the operator's report are under consideration, including the introduction of a specific threat and error matrix for line training captains to assess the risk level of sectors, and a reduced crosswind limit for trainee pilots until they reach a certain level of experience.

The manufacturer continued to engage with pilots and operators of the aircraft type regarding the correct crosswind technique and the risk of wingtip strikes. They also developed a TASE proposal to further mitigate the risk, which was being assessed by Transport Canada at the time of publication.

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