SERIOUS INCIDENT

Aircraft Type and Registration:	Airbus A320-214, G-EZWE
No & Type of Engines:	2 CFM56-5B4/3 turbofan engines
Year of Manufacture:	2012 (Serial no: 5289)
Date & Time (UTC):	16 September 2019 at 1959 hrs
Location:	Lisbon Airport, Portugal
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers -167
Injuries	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	16,000 hours approximately (of which approximately 8,000 were on type) Last 90 days - approximately 130 hours Last 28 days - approximately 20 hours
Information Source:	AAIB Field Investigation

Synopsis

Under international protocols, this investigation was delegated to the AAIB by the Gabinete de Prevenção e Investigação de Acidentes com Aeronaves e de Acidentes Ferroviários (GPIAAF) in Portugal.

During pre-flight preparations, both pilots completed a takeoff performance calculation for a takeoff from Runway 21 at Lisbon Airport. In calculating the performance, the crew believed they had selected the shortest runway length available (from the intersection with Taxiway S1) but had, in fact, used the runway full length (from Taxiway S4). The aircraft was cleared for takeoff from another intersection (Taxiway U5) and used performance calculated for the full runway length. The takeoff distance available from U5, although longer than from S1, was 1,395 m less than that used for the performance calculation, and the aircraft became airborne with only 110 m of the runway remaining.

As a result of this and previous, similar incidents, the airport operator renamed part of Taxiway S to have only one intersection on Runway 21 with the letter S.

The aircraft operator moved onto a newer software version for performance calculations in December 2019 which gives a pictorial representation of the runway. They also worked with the data supplier to change the menu for intersection selections for Lisbon Airport to eliminate any confusion over which position refers to the full runway length.

History of the flight

G-EZWE arrived into Lisbon Airport at 1825 hrs having flown in from Manchester Airport. The passengers were disembarked, and the crew began the process of preparing the aircraft for its return flight to Manchester. Once the cabin preparation was complete, the passengers were released from the terminal for boarding. During pre-flight preparations both flight deck crew members were subjected to numerous interruptions. These included details of a sick passenger at the back of the aircraft, a change in fuel requirements, a mix-up over passengers released from the terminal and a late change to the loading figures. Both crew members calculated takeoff performance as required by the operator's procedures and cross-checked their results. During this process, the crew inadvertently selected what they believed to be an intersection on Runway 21 for takeoff but was in fact the full length. This error was not picked up during the initial calculation or during the pre-takeoff check of the performance.

The commander was PF for the return flight. The aircraft pushed back from its parking position at 1945 hrs and proceeded to taxi to the holding point for Runway 21 on Taxiway U5. The aircraft took off from Taxiway U5 at 1959 hrs with performance calculated for the full runway length. The commander reported that the takeoff initially seemed normal but both flight crew realised there was something wrong as they saw the red and white alternate lights of the last 900 m of the runway. Takeoff/go-around (TOGA) thrust was not selected.

The takeoff distance available from U5 was 1,395 m less than that used for the performance calculation, and the aircraft became airborne with only 110 m of the runway remaining (Figure 1). During the flight the crew realised what had happened, and they reported it to the operator after landing.

The operator had two very similar events in April and May 2019[1].

Figure 1

Image of Lisbon Airport showing the calculated and actual takeoff points
©Google Earth

Footnote

[1] Takeoff using incorrect performance data, Lisbon Airport, Portugal, 24 April 2019 https://www.gov.uk/government/news/aaib-report-airbus-a320-214-takeoff-with-insufficient-thrust-to-meet-regulatory-requirements [Accessed July 2020.]

Recorded information

Flight recorders

G-EZWE was fitted with a Cockpit Voice Recorder (CVR) but this was not removed from the aircraft. The aircraft remained in service, with power applied to the CVR, for longer than the two hours recording capability of the CVR before the AAIB were made aware of the event, and therefore any recording would have been overwritten.

The aircraft was also fitted with a Flight Data Recorder (FDR), but the operator supplied Quick-access Recorder (QAR) data, therefore there was no need to remove the FDR from the aircraft.

The QAR data (Figure 2) showed that the aircraft commenced its takeoff roll at 1958:19 hrs having entered Runway 21 from Taxiway U5. 44 seconds later, at 1959:03 hrs, after a ground roll of 1,775 m and with approximately 570 m of runway remaining ahead of the aircraft, a V_1 of 162 kt was achieved. Five seconds later, at 1959:08 hrs, the aircraft became airborne approximately 110 m from the end of Runway 21. At the speed the aircraft was travelling over the ground this distance would have taken approximately 1.3 seconds to cover. One second later, whilst still over the paved surface of Runway 21, the aircraft achieved the regulatory screen height of 35 ft, for a dry runway, and crossed the airport boundary at 225 ft radio altitude. TOGA thrust was not selected at any point.

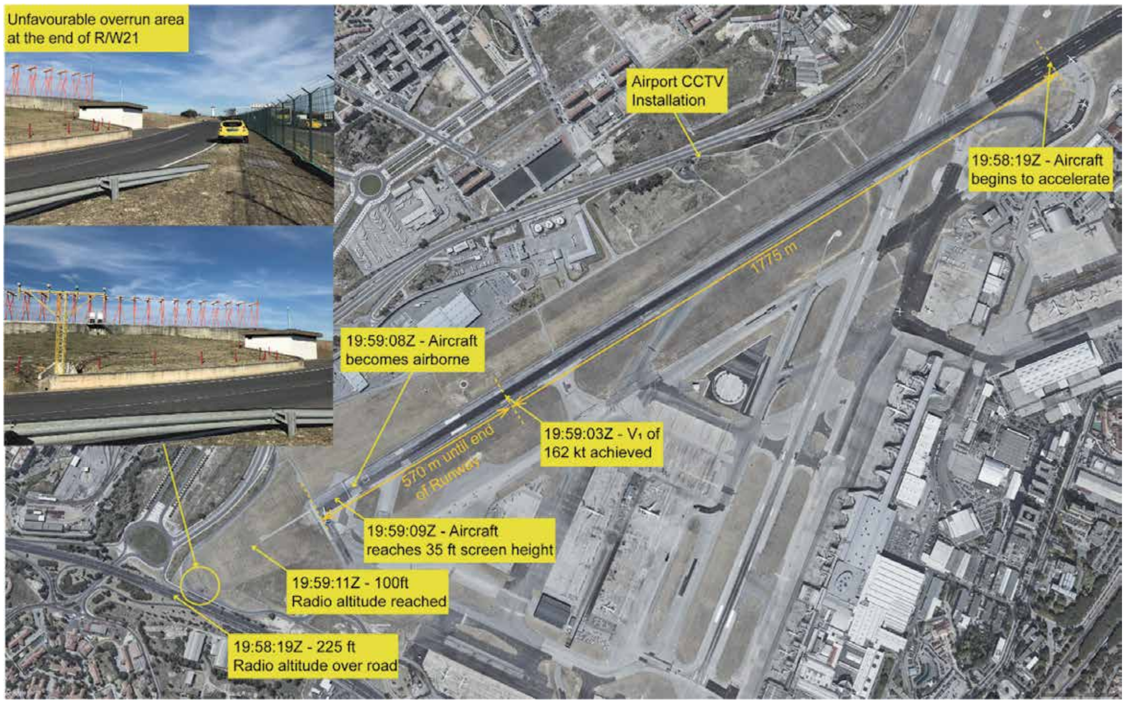

Figure 2
QAR Data showing G-EZWE's takeoff roll

Closed-circuit Television (CCTV) recordings

G-EZWE's takeoff roll was captured on several CCTV cameras around the airport. One of these cameras (situated as shown in Figure 2) covered the latter part of the aircraft's takeoff roll. The frame shown below (Figure 3), where the aircraft is highlighted by the yellow circle, was recorded just after the aircraft reached V_1, and the end of the runway is indicated by the row of red lights towards the right of the image.

Figure 3

CCTV screenshot showing G-EZWE just after reaching V_1

Aircraft information

The aircraft manufacturer has developed a system to provide crews with a warning when the thrust levers are set for takeoff if there is insufficient runway ahead to lift-off. This system compares the runway distance ahead of the aircraft at the point the thrust levers are set for takeoff with a lift-off distance for the takeoff, drawn from an internal dataset. The system is not designed to take account of the case of an aircraft stopping, or the climb-out performance. G-EZWE was not fitted with this system, but calculations by the aircraft manufacturer showed that in this case the system may have warned the crew, although the event was at the edge of the detectable envelope.

Aircraft performance

The purpose of the takeoff performance application in the Electronic Flight Bag (EFB) is to calculate the maximum takeoff weight or the maximum takeoff thrust reduction (known as FLEX on this type) for that particular aircraft, for a given runway and intersection taking into account all the regulatory requirements and the ambient conditions.

When the runway length is not limiting, there may be a range of valid V_1 speeds available. In this case, the program will select a V_1 which provides performance margins on both the accelerate-stop and the accelerate-go cases. In the case of the performance calculation for the full length of Runway 21, this generated a V_1 which was a balance from those that were valid for the Takeoff Run Available (TORA), Takeoff Distance Available (TODA) and Accelerate-Stop Distance Available (ASDA). This V_1 was higher than that which would have been generated if the performance had been calculated from U5 (the actual takeoff point), from where the runway distances were 1,395 m less. The V_1 generated for G-EZWE was 162 kt from the full length but would have been 142 kt for a calculation from U5. As the takeoff was from U5, the takeoff data used for G-EZWE's takeoff was invalid.

As part of the EFB calculations, an accelerate-stop distance (ASD) is calculated. This is the distance required to accelerate the aircraft to V_1 and, on experiencing an engine failure or emergency at that point, discontinue the takeoff and stop the aircraft. The ASD for G-EZWE from U5 was calculated as 2,995 m whereas the ASD available from U5 is 2,410 m. These figures suggest that, had the aircraft been required to stop from near V_1, a significant overrun of up to 585 m could have occurred. The calculated ASD includes a number of performance assumptions and factorisations, such as: no credit being taken for the use of reverse thrust; a delay being assumed before stopping action is taken by the pilot; and an increase in the two-engine distance to V_1 to account for other variables. The calculated ASD is therefore conservative.

A calculation was then made using the point at which the aircraft reached V_1 (162 kt). This calculation used none of the assumptions or factorisations used in the ASD case above and instead used a figure for the maximum rate of deceleration possible in the aircraft type (10 m/s^2). This calculation indicated that it would have required a minimum of around 580 m to stop from the V_1 speed of 162 kt. G-EZWE reached V_1 with approximately 570 m of Runway 21 remaining. Even using this idealised calculation, the aircraft could have overrun the available tarmac.

As shown in Figure 2, there are several obstructions beyond the runway that could have caused significant damage to the aircraft and its occupants should an overrun have occurred.

Previous incidents

The operator had two similar incidents at Lisbon which occurred within 14 days of each other earlier in 2019. As a result of these incidents the aircraft operator took action to try and prevent a further occurrence, including issuing a notice to crews, as part of the NOTAMs for Lisbon, to clarify the available takeoff points on Runway 21. They issued a full description of the events to all crew to raise awareness of the risks of using the wrong intersection and distance for takeoff. They also began work with the EFB data supplier to change the nomenclature of the takeoff points for Runway 21 in the performance software.

Airfield information

At the time of the incident Lisbon Airport had two runways which were orientated 03/21 and 17/35 (Figure 4). Runway 03/21 is the preferential runway for both takeoff and landing, and the prevailing winds mean that Runway 03 is more commonly used. Runway 17/35 is currently closed for use as a runway due to building work and is being used as a taxiway instead.

Lisbon Airport is unusual in that it uses named Positions to describe the available takeoff points on the runways. The reason for this has been described as “historic”, and it would be more commonplace for an airport to use taxiway nomenclature to describe takeoff points. The use of Positions is limited to the airport’s description within the Aeronautical Information Publication (AIP), but it is this information that commercial chart companies use in generating their publications. The information is also used by companies to generate the performance data for airlines. Positions are not generally referred to by ATC at Lisbon.

When Runway 21 is in use, the preferred departure point for all aircraft, except heavy jets, is ‘Position U’, which is the intersection of the runway with Taxiway U5. Pilots must advise air traffic control on start-up if they require the full length of the runway for departure. Full length departures are from holding point S4 which is known as ‘Position S’. At the time of the incident, Taxiway S began abeam Runway 17, before crossing Runway 21 at Taxiway S1, and then turning north-east to run parallel to Runway 21. This is marked on Figure 4 in blue. The taxiway ends at the threshold of Runway 21. There were therefore two points on Runway 21 where Taxiway S intersected the runway.

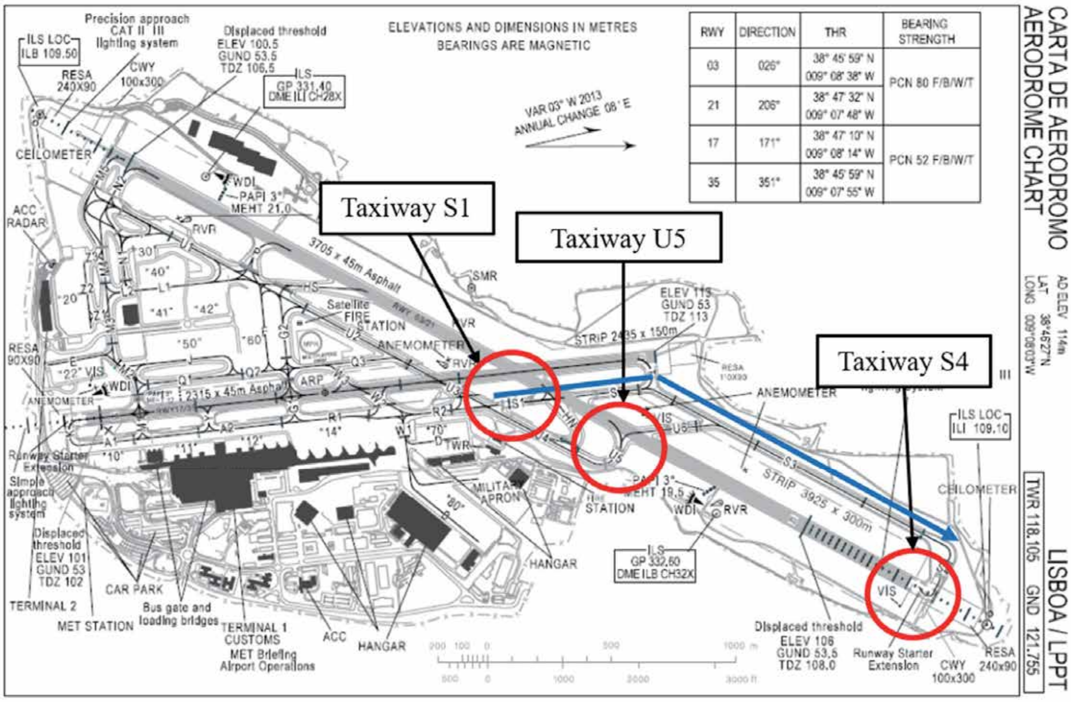

Figure 4

Plan of Lisbon Airport showing Taxiways S1, U5 and S4

Note: north is to the right of the image

As a result of the two previously reported incidents, but after this occurrence, the airport operator re-designated the taxiways on 5 December 2019 to eliminate this issue. The new taxiway designations are shown in Table 1.

Previous Designation	New Designation
A2 (BTN Y and G1)	A3
R1	A4
R2	A5
S1	A6
S2	A7
T	S1
S3 (BTN A7 and U6)	S2

Table 1
Taxiway re-designation

Also as a result of previous incidents in Lisbon, the AAIB issued a Safety Recommendation to the airport operator in January 2020:

> **Safety Recommendation 2020-003:**
>
> It is recommended that ANA Aeroportos de Portugal discontinue the use of takeoff Positions at Lisbon Airport to minimise confusion concerning takeoff points.

Electronic Flight Bag

The operator uses an EFB to calculate the weight and balance of the aircraft as well as takeoff performance. Both pilots have a tablet computer on which they do the required calculations. The tablet computers also provide the crew with aeronautical and aerodrome charts.

Power and stowage of the tablets

The tablets are provided with power from the aircraft, but they also have an integral battery should the power supply be disconnected or unavailable. Both sides of the flight deck have a cradle in which to mount the EFB. On the day of the incident, the commander's EFB cradle had been removed as it was broken. This meant that the commander would need to hold the EFB or use the tray table to use it. It became apparent to the commander during the pre-flight preparation in Manchester that it was difficult to use the EFB when it was connected to the aircraft power supply without the usual cradle, but that disconnecting from the power supply meant only a very short time of operation as the battery was unable to power it for any length of time. The very limited battery power available and the need to hold the EFB without the cradle also meant that using the EFB (including checking the aerodrome plates) was challenging.

The United Kingdom's Civil Aviation Authority (UK CAA) approves the use of EFBs used by the Air Operator Certificate (AOC) holders that they oversee. An operator applying to use EFBs must complete the UK CAA's form SRG1849, which was first published in July 2019 and is in the form of a compliance checklist. This checklist would normally be completed on initial application for use of an EFB and for subsequent significant changes, such as a change of operating system, a change of EFB hardware or the introduction of certain types of new applications. None of these criteria applied to G-EZWE's operator, which already had approval to use EFBs, but it completed the checklist retrospectively as part of a Special Objective Check[2] by the UK CAA in late 2019. The checklist includes several questions on the maintenance of EFBs, together with references to the relevant EASA regulations, and details the need for:

- a programme to replace EFB batteries.
- procedures to ensure the serviceability of the EFB before flight.
- procedures detailing how EFB failures are reported and crews notified of any unserviceability.
- general maintenance procedures and dispatch guidance for unserviceable elements of the EFB.

EASA publishes further guidance material to assist in the interpretation of the regulations and this states that:

> *'As part of the EFB system's maintenance, the operator should ensure that the EFB system batteries are periodically checked and replaced as required.'*

A section of the guidance material covering the dispatch of aircraft carrying EFBs details mitigations that should be considered by operators and includes the following statement:

> *'Mitigation should be in the form of maintenance and/or operational procedures for items such as:*
>
> *(1) replacement of batteries at defined intervals as required;'*

Electronic flight bag nomenclature

Data for the EFB performance software is supplied to the operator by a third party. Within the software the crew must initially select the runway for departure and then a point on that runway from where the takeoff will begin. Some runways may have multiple intersections

Footnote

2 A Special Objective Check (SOC) is a UK CAA process used to audit areas of risk or non-compliance across either the whole industry or segments of it. The need for a SOC is identified by the UK CAA's Safety Risk Panel and managed centrally by the relevant Flight Operations Manager who appoints a SOC lead.

available for departure and, in the case of Lisbon Runway 21, two positions are available, Position U and Position S. These are named in the software as PSNU and PSNS. At the time of the incident, there was a NOTAM affecting the takeoff performance calculation (referring to an obstacle in the climb-out zone). This meant that the data supplier had inserted two further temporary selections for the two takeoff positions for Runway 21, which were labelled PSNUTMP and PSNSTMP as shown in Figure 5.

Figure 5

EFB drop-down menu showing the all the intersections available
(not the actual incident data)

The crew discussed the likely takeoff point and decided that they could use the S1 intersection if necessary, from which there was a lower TORA than from U5. They then performed the calculation in the EFB, using PSNSTMP as the selection for the S1 intersection. S1 is not an approved intersection for departure on Runway 21.

Operator developments

As a result of this incident and the two previous cases, the operator changed the nomenclature in the EFB for Runway 21. This change eliminated the use of Position S, instead using merely '21' to indicate that this point is the full length of the runway. The new drop-down selection is shown at Figure 6.

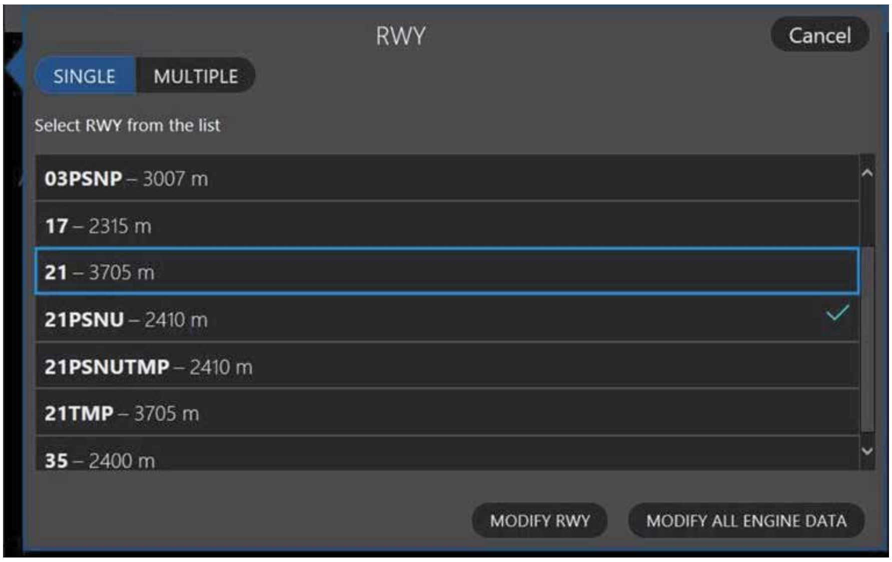

Figure 6

New nomenclature in EFB drop-down menu

In December 2019, the operator also moved onto a newer version of the performance software, Flysmart L6, which offers a pictorial representation of where the performance calculation was referenced to. Figures 7 and 8 show how the new software would have shown a calculation from Position S and Position U on Runway 21 (not using incident data).

Figure 7

New software calculation display for Runway 21 Position S

Figure 8

New software calculation display for Runway 21 Position U

Human factors

Distraction during the process of calculation

Both crew members reported that they were interrupted numerous times during the pre-flight preparation. This included during the period in which they were entering the data for the performance calculation. The operator has recognised that distraction can be detrimental to weight and balance as well as performance calculations. The Standard Operating Procedures (SOP) were designed to try to minimise this with steps such as an EFB validation check, where both pilots check their calculations against the other before the data is entered into the Flight Management Guidance Computer, and a takeoff data cross-check before completion of the Before Takeoff checklist. These are designed to focus the pilots' attention on the task at hand and avoid distraction. The performance figures are also first calculated based on the initial load figures, which tend to be given to the crew early in the turnaround which is normally a stage of low interruption. These are then not altered for any last minute changes, unless they are significant, as last minute changes typically occur at a higher workload phase.

Recognition of the invalid takeoff performance

The AAIB has investigated numerous serious incidents where aircraft have taken off using performance information calculated from a different start point. Worldwide, similar events present a significant hazard to civil aviation despite SOPs containing measures designed to prevent them, such as cross-checks and independent calculations. Pilots performing cross-checks often fail to notice errors or differences when the figures are unexpected, and incorrect calculations can lead to insufficient thrust, and therefore acceleration, during takeoff. Humans are poorly adapted physiologically to discriminate between slightly different acceleration rates, and many years of training have made pilots reluctant to move the throttles once takeoff power is set[3]. In recognition of this, the AAIB has previously made safety recommendations that a technical barrier should be developed which would recognise events where the takeoff acceleration is lower than expected.

Analysis

During pre-flight preparation, both flight crew of G-EZWE selected PSNSTMP in the EFB believing it to be where Taxiway S1 crossed Runway 21, but the position was actually for the full length of the runway. The operator's SOPs required the crew to cross-check the distance shown in the EFB against that shown in the aerodrome ground chart for the takeoff position, but this cross-check did not capture the error. As a result, a lower power setting was used for takeoff than was required for the actual takeoff from Taxiway U5 intersection (Taxiway S1 intersection was more limiting). G-EZWE lifted off 110 m or, at the speed at which the aircraft was travelling, approximately 1.3 seconds before reaching the end of the runway. This was the third aircraft from the same operator, although one was operating under a different AOC, which had experienced similar incidents in the previous six months.

In all three cases the pilots were confused by the EFB intersection selections as they did not use the actual taxiway names. Also, there were two points on the runway which intersect Taxiway S (1 and 4) both of which might have been thought by the crew to be in the EFB as PSNSTMP as the taxiway numbers are not used in the nomenclature.

During the completion of the initial calculation the crew were interrupted numerous times despite the SOP mitigations that the operator had in place. The commander also had no access to the EFB once the aircraft taxied due to an inoperative cradle. He was not, therefore, in a position to see the taxi plate or the performance calculation, although he was not required to be by the company SOPs. The EFB battery condition had substantially deteriorated over time and the EFB was not useable for long without being charged by the cradle. The UK CAA decided to revise the EFB compliance checklist, SRG form 1849, to ensure that the requirement for a periodic battery replacement programme is emphasised. The crew did not recognise the takeoff performance was incorrect until a late stage of the takeoff run. This would match with previous investigations completed by the AAIB which have shown that humans are not physiologically adapted to identify different acceleration rates, and often do not realise something is wrong until the end of the runway comes into view. As in previous incidents, TOGA thrust was not selected despite the compromised takeoff performance.

The magnitude of the error meant that had the aircraft stopped from a speed close to or at V_1, a significant overrun could have occurred. This could have caused significant damage to the aircraft and its occupants.

Footnote

3 AAIB report into a serious incident in Belfast Aldergrove Airport. Boeing 737, C-FWGH, took off with insufficient thrust for the environmental conditions and struck an obstacle after lift-off. https://www.gov.uk/aaib-reports/aircraft-accident-report-aar-2-2018-c-fwgh-21july-2017 [Accessed July 2020]

Conclusion

The aircraft took off using incorrect performance data for the intersection used. A selection error was made in the EFB calculation which led the crew to believe that they had calculated performance information for a departure from S1 when in fact they had selected the full length of the runway. In this case, as in the two previous identical incidents, the final barrier of checking the runway distance in the performance calculation against the aerodrome ground chart failed to prevent to error. Human performance limitations mean it is difficult for pilots to recognise and react to the performance error once the takeoff has begun, so robust adherence to procedures is a key defence against such incidents occurring.

Safety action

Following the previous incidents, the AAIB reported that the Lisbon Airport operator intended to rename taxiways to remove the risk of confusion between the two points where Taxiway S crossed Runway 21. The taxiways would be renamed so that Taxiway S intersected the runway at only one point; S4 (full length). This safety action was completed, albeit after the incident to G-EZWE, and is reported here.

The operator has moved onto Flysmart L6 performance software which now shows the crew a pictorial image of the takeoff point used for the calculation. The takeoff point selection menu was also amended to eliminated Position S making it clear to the crews that this was full length for Runway 21.

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Published: 6 August 2020.