SERIOUS INCIDENT

Aircraft Type and Registration:	BAe ATP, SE-MAO
No & Type of Engines:	2 Pratt and Whitney Canada PW126 turboprop engines
Year of Manufacture:	1989 (Serial no: 2011)
Date & Time (UTC):	22 May 2020 at 1258 hrs
Location:	Birmingham Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None reported
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	4,984 hours (of which 211 were on type) Last 90 days - 56 hours Last 28 days - 30 hours
Information Source:	AAIB field investigation

Synopsis

In windy conditions the crew of SE-MAO performed a go-around from their first approach to Runway 33 at Birmingham Airport. On the second approach the aircraft departed the runway to the left after touching down. The crew had not applied or maintained into-wind aileron during the landing or landing roll and, despite the application of full rudder, could not keep the aircraft on the runway. The aircraft was off the paved surface for approximately 450 m. There was no damage to the aircraft or the airfield, and the crew were uninjured.

Following this incident, Safety Action was taken by the operator to introduce a crosswind limit for new co-pilots, and to include crosswind landing training in simulator sessions.

History of the flight

The crew of SE-MAO departed Guernsey Airport to fly to Birmingham International Airport at 1142 hrs. The weather in Birmingham for their arrival was forecast to be a strong wind from the southwest with good visibility and a high cloud base. The co-pilot was Pilot Flying (PF) for the sector. After being radar vectored for a Localiser (LLZ) DME approach to Runway 33 at Birmingham, the crew conducted a stable approach. At 1245 hrs during the flare to land the aircraft drifted to the right of the centreline with the nose about 20° left of the runway direction. A go-around was commenced, and the aircraft climbed away before being radar vectored for a further approach. At the request of the co-pilot, the commander became PF for the second approach which was again a stable LLZ DME for Runway 33. With 2 nm to go before touchdown, ATC announced the wind as from 230° at 14 kt gusting 27 kt. The aircraft touched down at 1258 hrs and, shortly afterwards, departed off the paved runway to the left. The distance from the aircraft first leaving the paved surface to when the last wheel returned to the paved surface was 450 m.

After stopping for an inspection by ground operations personnel, the crew taxied the aircraft to a stand. Subsequent engineering inspections revealed no damage to the aircraft although one main wheel tyre was replaced. There were no injuries to the crew who were the only occupants.

Recorded information

SE-MAO was equipped with an L3 FA2100 solid state cockpit voice recorder (SSCVR), which recorded 2 hours of audio, and a Plessey PV1584F1 tape flight data recorder (FDR), which recorded over 27 hours of data. A copy of the flight data was also recorded on a solid state L3 μQAR Quick Access Recorder (μQAR). The audio recordings included the commander's and co-pilot's communications, radio transmissions and audio from the cockpit area microphone. CCTV from the airport and video footage from a witness outside the airfield boundary were also reviewed to corroborate evidence and other data sources. Images from the witness's video are used in the report.

Due to the age of the aircraft and the extant flight recorder carriage requirements at the time the certificate of airworthiness was issued, the number of parameters recorded by the FDR was limited to less than thirty. As a result, parameters such as weight on wheels, rudder pedal position and power lever angle were not recorded. Also, the quality of the mandatory FDR recording was poor due to inherent issues of using magnetic tape as a recording medium. However, there were no such issues with the μQAR recording of the flight data.

First approach and go-around

Figure 1 plots the flight data for the first approach and go-around. It starts with the aircraft on the descent passing through 400 ft agl, crabbed to the left by over 20° to the runway heading, and shows that during the approach varying amount of aileron and rudder inputs were used to keep the aircraft on the extended runway centreline. Key points from the data are labelled [A] through [D] and detailed as follows:

1. The co-pilot (PF) called "go-around" just as the aircraft was about to touch down briefly on the left main gear [A] (and Figure 2). The aircraft heading was about 8° to the left of the runway heading and increasing. The rudder deflection varied around zero and just under half left aileron was being used.

2. During the next three seconds the aircraft veered away from the runway heading while the commander was heard to say "land it land it land it". The engine torques increased from idle to about 80% and then back to about 25% just as the aircraft touched down [B]. At touch down, the aircraft's heading was 15° left of the runway.

3. Shortly after touchdown, the commander called "GO-AROUND" which the co-pilot acknowledged [C] whilst advancing the power levers.

4. The aircraft remained on the ground for about eight seconds during which a small amount of right rudder and left aileron was initially used. The aircraft's heading responded to the right rudder before veering away to the left. About 75% of full right rudder was then applied [D]. The aircraft's heading was 24° left of the runway as the aircraft became airborne (Figure 3).

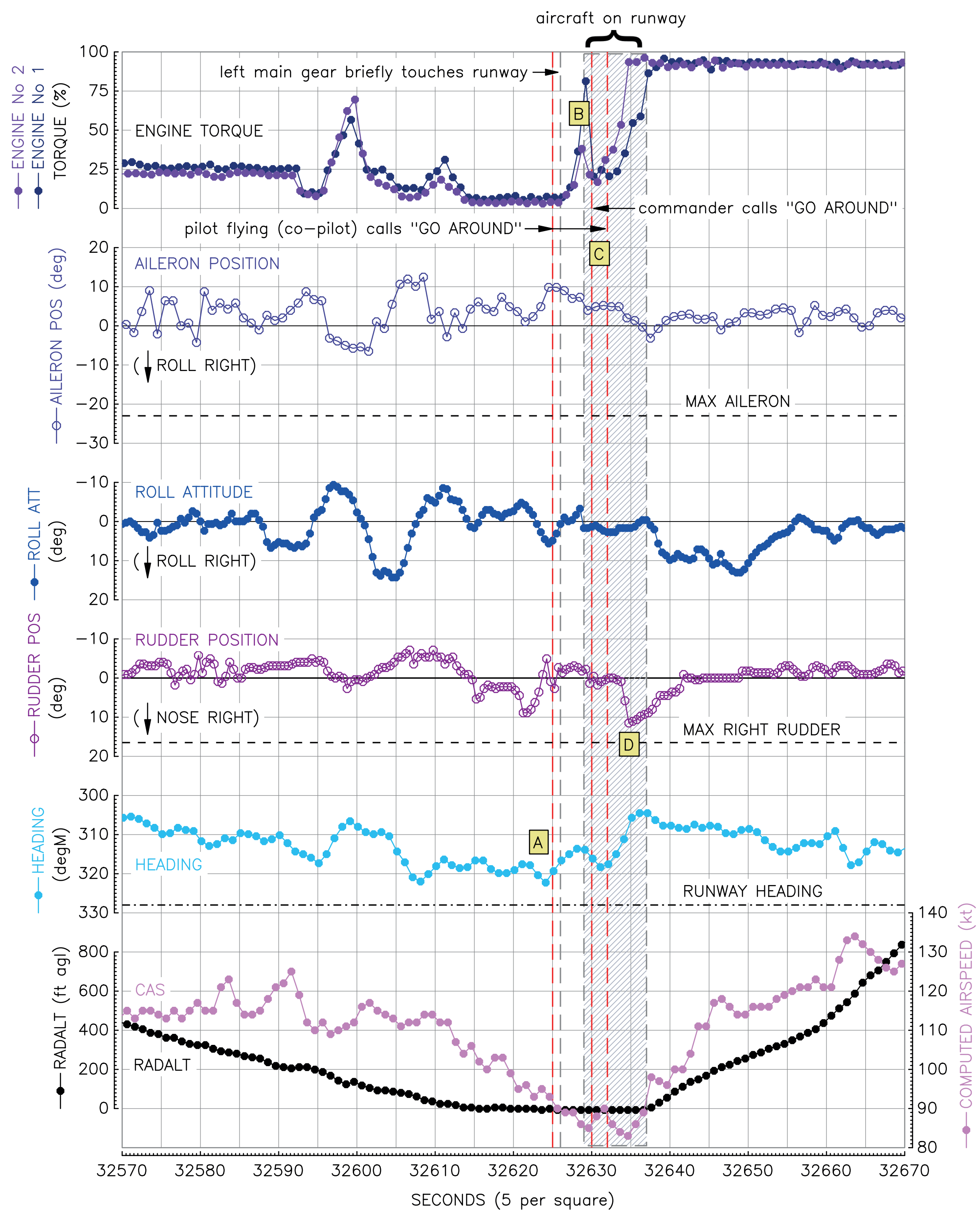

Figure 1

Flight data for the go-around

Figure 2

Image showing Point A from Figure 1 – touchdown on Runway 33

Figure 3

Image showing Point D from Figure 1 – power applied for the go-around

Second approach and landing

Figure 4 plots the flight data for the landing. It starts with the aircraft on the descent passing through 400 ft agl, crabbed to the left by about 20° to the runway heading. A small amount of left rudder was used throughout the approach, with similar roll control to that of the first approach. During the last 15 seconds of the approach, the rudder became more active and moved to the right, reducing the crab angle to about 10° left of the runway heading. Key points from the data for the landing are labelled [A] through [F] and detailed as follows:

1. At touchdown, the aircraft heading was about 10° left of, and veering away from, the runway heading [A] (and Figure 5).
2. Full right rudder was immediately applied [B] and slowed the veering to the left, which peaked at 24° nose left.

3. Full right aileron was applied [C] causing the aircraft to bank 8° left wing up [D] and lift the left main gear off the runway (Figure 6).

4. About five seconds after touching down, the aircraft left the paved surface to the left [E] (and Figure 7) but in a right turn on the nose and right main gear.

5. Seven seconds after leaving the paved surface, the aircraft turned onto the runway heading [F], but on a parallel track to the left of the runway, before veering a little to the left again then back right, re-joining the runway another seven seconds later (Figure 8).

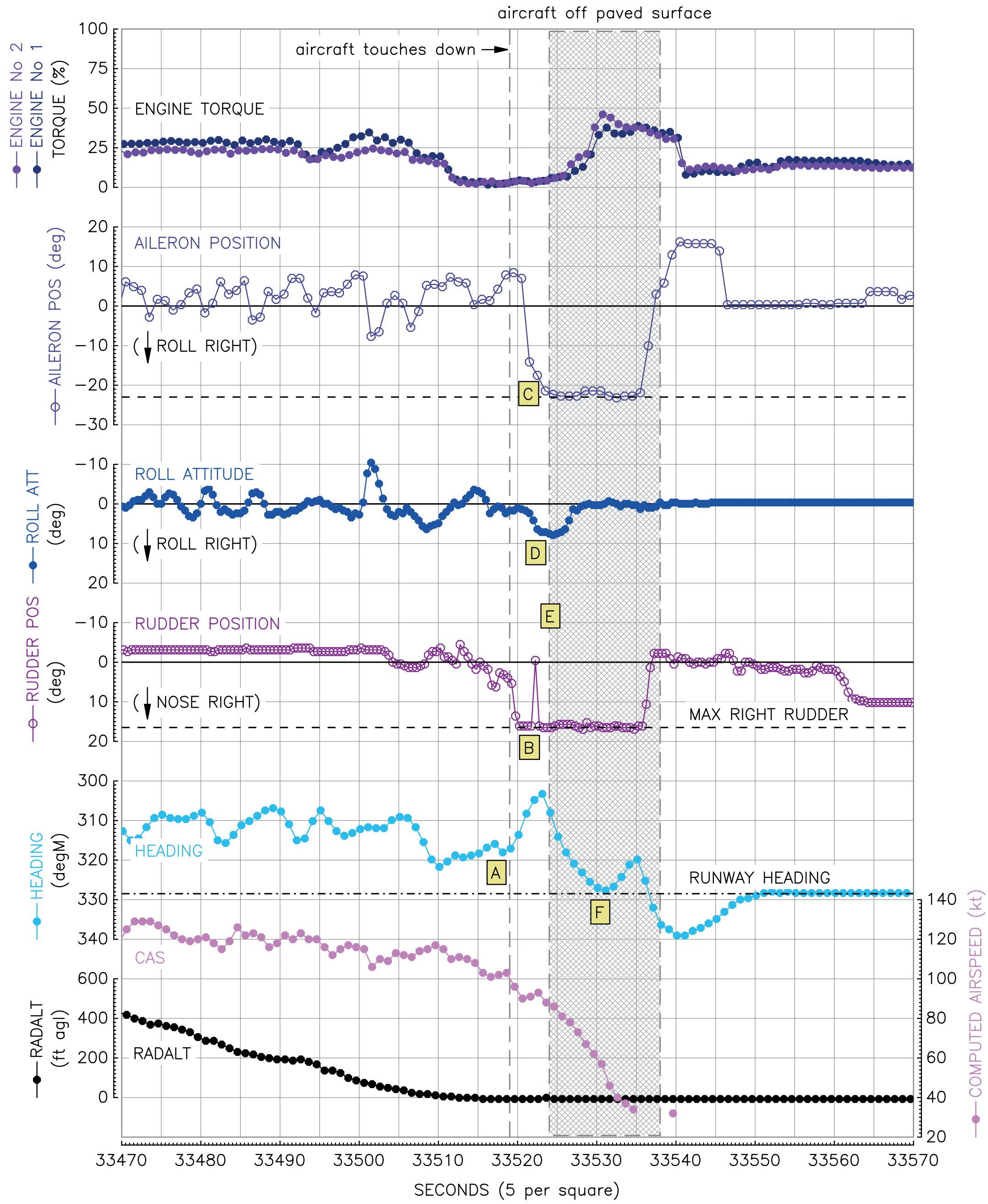

Figure 4

Flight data for the landing

Figure 5

Image showing Point A from Figure 2 – touchdown on Runway 33

Figure 6

Image showing Point C from Figure 4 – full right aileron applied

Figure 7

Image showing Point E from Figure 4 – SE-MAO leaves the paved surface

Figure 8

Image showing Point F from Figure 4 – SE-MAO returns to the paved surface

Aircraft information

The ATP is a twin turboprop aircraft with a wingspan of 30.632 m and a main landing gear span of 8.456 m. The propellers are 6-bladed with a diameter of 4.191 m and ground clearance of 0.54 m. The propeller tips are 9 m from the wing tips. The wings have a dihedral of 7°.

SE-MAO was built in 1989, entering service as a passenger aircraft the same year. The aircraft began operating in cargo configuration in 2007.

Aircraft examination

After the incident the aircraft was inspected by ground operations staff from the airport for any damage. As none was observed, the aircraft taxied under its own power to the stand. After shutdown the commander contacted the operator and engineers attended the aircraft to carry out a full inspection.

A full inspection of the wheels, tyres, brakes, propellers, and brake temperature sensors showed that there was no damage to the aircraft. One main wheel tyre was replaced as it showed some uneven wear. There were no leaks from or marks on the airframe. As a precaution the engineers also carried out a heavy landing check and found no damage.

The aircraft had a previous cosmetic defect with the nose landing gear leg, probably as a result of contact with a towbar during pushback operations. This defect had been noted in the month before the incident and a replacement scheduled. The nose gear was replaced as scheduled a few weeks after this incident. The cosmetic defect had no role in the incident.

Weight and balance

The weight of the aircraft on approach to Birmingham was around 30% less than the allowable maximum. The centre of gravity was within limits.

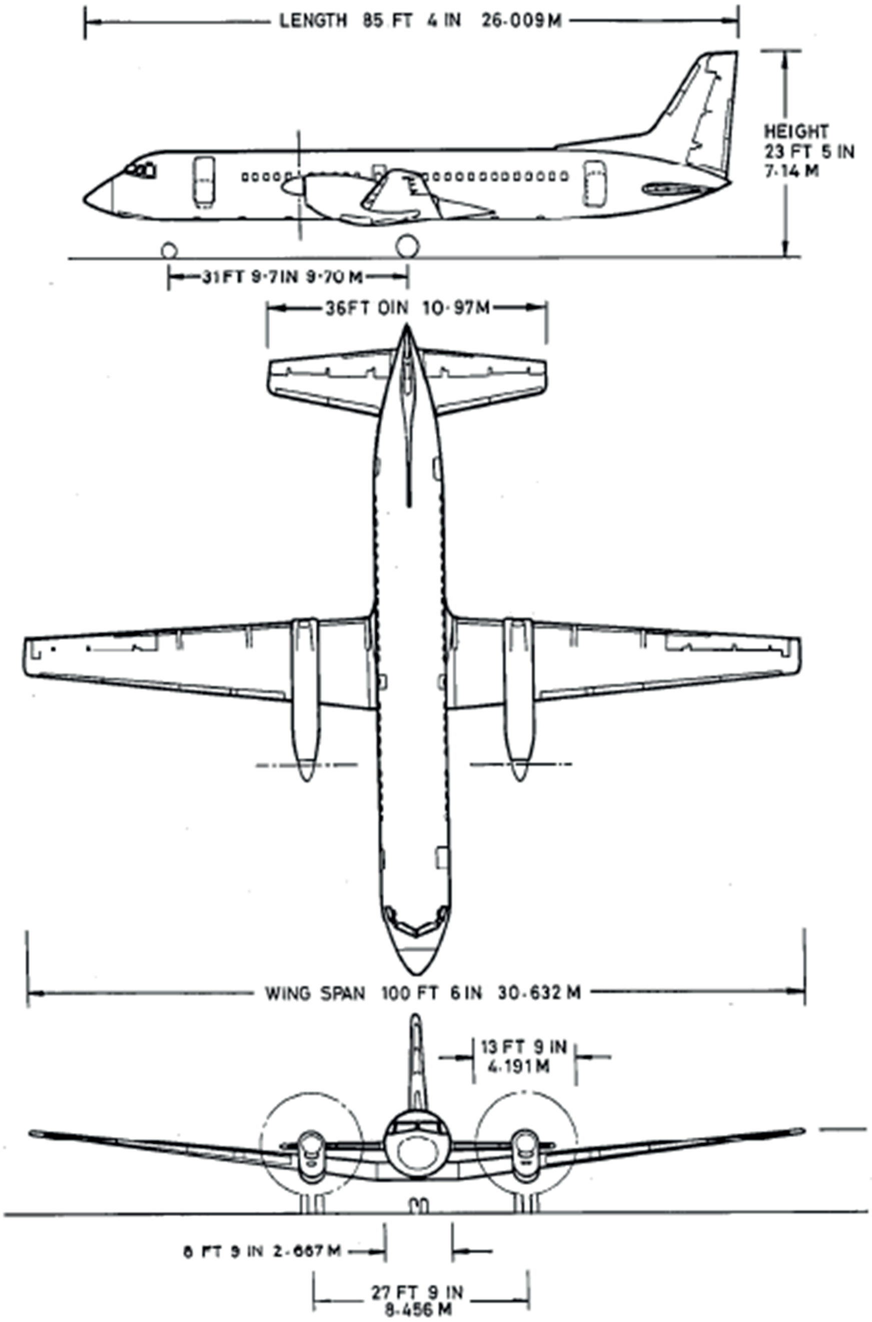

Figure 9

Dimensions of the ATP

Meteorology

The weather conditions on the day of the incident showed an area of low pressure to the west of the UK, extending a moderate to fresh, slightly unstable, south-westerly flow across the Birmingham area. This led to gusts of 25 kt in the morning, increasing to 31 kt by early afternoon, potentially giving moderate low-level turbulence. Visibility and cloud bases remained good throughout.

The latest TAF for Birmingham which was issued before the incident was at 1055 hrs. This forecast for the period of arrival for SE-MAO showed a south-westerly wind at 16 kt with gusts of 28 kt. The visibility was excellent with only scattered cloud at 4,000 ft aal. The previous TAF, which was issued at 0555 hrs, forecast very similar conditions with gusts up to 30 kt.

The observations at the airport for the times around the incident show the actual conditions were as forecast with the wind backing slightly from 250° at 1220 hrs to 230° at 1320 hrs. The wind was gusting throughout the period between 25 kt and 31 kt. The direction of the wind was varying from 190° to 280°. Both crew members reported that it was turbulent on the approach.

There had been little rain at the airport over the previous months and the ground was dry and hard.

Airfield information

Birmingham has a single runway, orientated north-west/south-east (Runway 15/33) (Figure 10). The landing distance available on Runway 33 is 2,449 m, and both ends of the runway are fitted with a Category 3 ILS DME. At the time of the incident there was an active NOTAM regarding the ILS glidepath on Runway 33. Due to ongoing work in the area of the glide path, it was not available for use.

To the west of the runway there are a number of buildings mainly clustered in the south-west corner of the airfield. This includes a large hangar which was completed in 2013. The airport terminals and passenger facilities are located to the east of the runway. There are two anemometers, one for each runway, located abeam the touchdown zones. The anemometers met all the required servicing and accuracy requirements set out by the CAA. ATC select the relevant anemometer for the runway in use for display in the tower. The wind given to the pilots is the two-minute mean for wind direction and speed.

The METAR wind is reported as the ten-minute average wind speed and wind direction. It is reported twice per hour. The METAR will also include a gust report (maximum three second gust in the ten-minute period) if the gust exceeds the mean wind speed by at least 10 kt.

The UK Aeronautical Information Publication[1] contains the following warning about Birmingham:

> *'Due to runway orientation relative to prevailing winds, pilots should anticipate crosswinds and may experience building induced turbulence and wind shear on aerodrome in strong winds.'*

In spring 2016 Birmingham fitted two temporary anemometers in addition to those already at the airport. These were located either side of the runway, near to the Runway 33 threshold.

Footnote

[1] https://www.aurora.nats.co.uk/htmlAIP/Publications/2020-07-16-AIRAC/html/index-en-GB.html [accessed November 2020].

The data from these temporary wind masts was provided to the Met Office by the AAIB who completed a study looking at the wind data against that in the METAR for the period the temporary masts were installed (7 April 2016 – 25 May 2016). The report makes the following conclusions:

- *'Analysis of the temporary mast wind data indicates a potential for the observed wind speeds in the vicinity of the Runway 33 threshold to be on the order of around 10% faster than those observed by the METAR anemometer when winds are from the west-southwest. There is evidence of potentially higher gustiness in the vicinity of the Runway 33 threshold when winds come from the west-southwest.'*

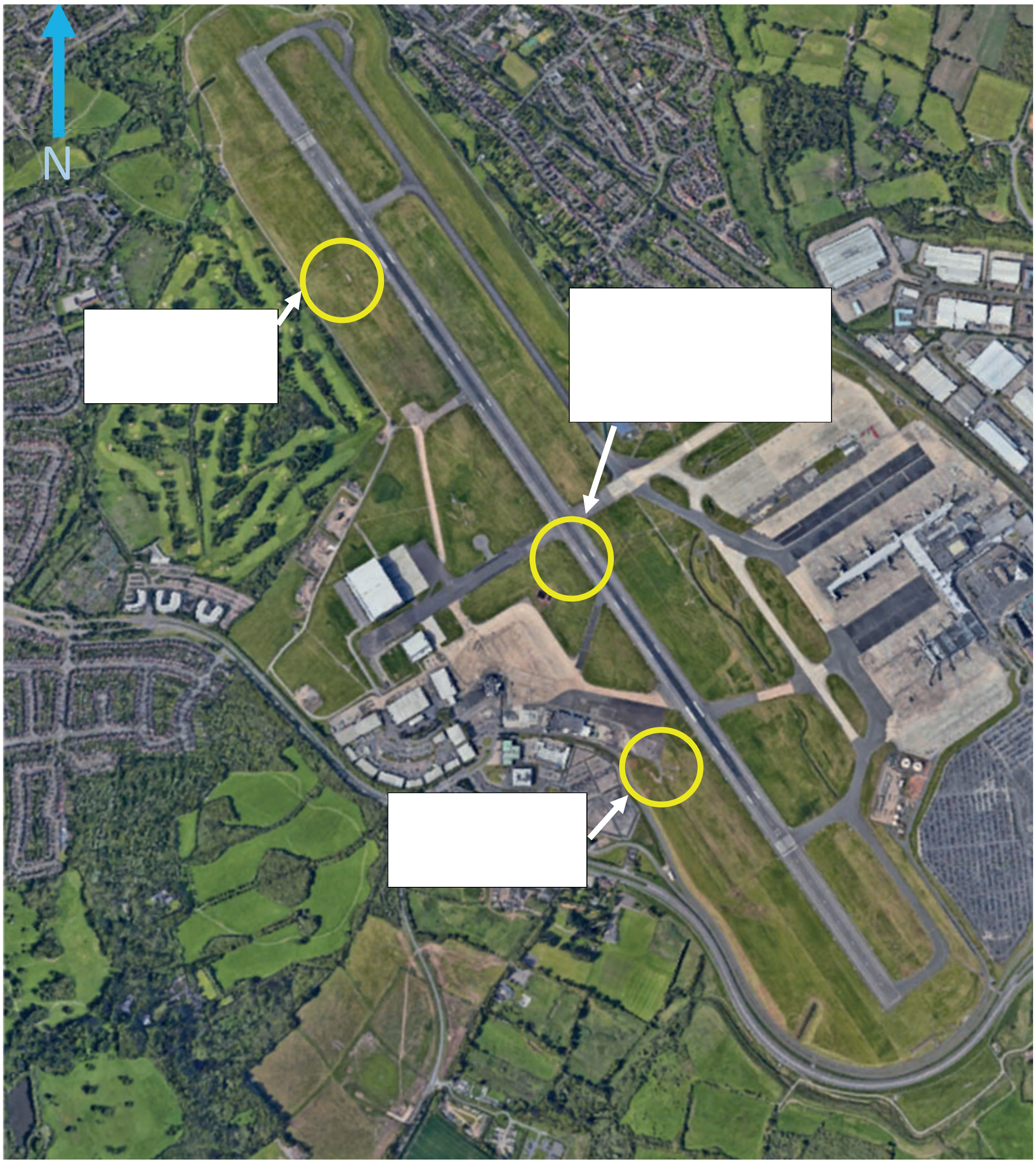

Figure 10

Image of Birmingham Airport
© 2020 Google, Image © Landsat / Copernicus

Incident site

A team was deployed to survey the incident site. The nature of the terrain over which the aircraft travelled during the runway excursion was even and firm. The aircraft tyre marks on the airfield and the tracks in the grass were very clear and allowed accurate measurement. To determine the path of the excursion from the runway, GPS markers were sited at key points on the aircraft tyre tracks and an unmanned air system (UAS) used to compile an aerial survey of the section of airfield.

Using the images taken by the UAS it was possible to measure the distance from when the aircraft first left the paved runway surface until when the last wheel returned to the runway. The total distance was 450 m. Figure 11 shows the extent of the excursion, with the wheel tracks clearly visible in the grass.

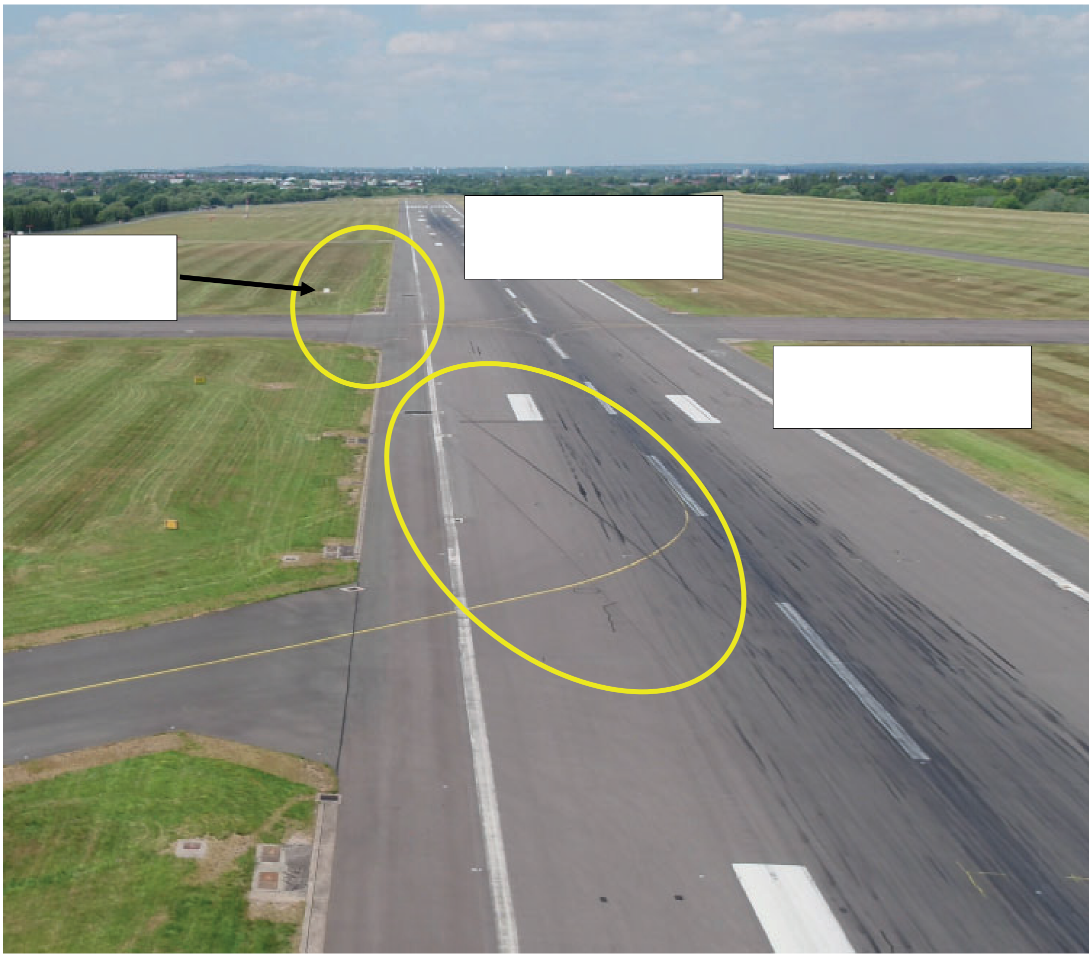

Figure 11

UAS image of the runway and grass markings

The airfield taxiway sign that passed under the left wing during the excursion was calculated to be just over 1 m below the lower surface of the wing. The sign was outside the diameter of the propeller, but it was above the lowest point of the rotational arc. Figure 12 shows the aircraft wing passing over the sign and Figure 13 shows an image of how close the sign was to the wing. Whilst all signs on the airport are designed to be frangible, it is likely that had the propeller hit the sign some damage would have occurred to the aircraft.

Figure 12

Image of the aircraft wing passing over the taxiway sign

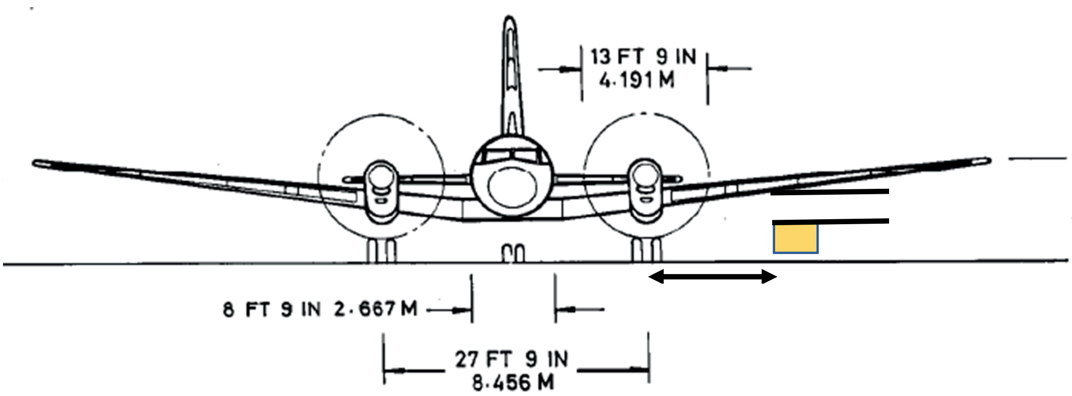

Figure 13

Distance of SE-MAO from taxiway sign represented by the yellow box

Flight crew

Both crew members were relatively new to the ATP. The commander had completed his type rating course in September 2019, completed line training in October 2019 and had approximately 211 hours on type at the time of the incident. The co-pilot had completed his type rating in May 2019, completed line training in August 2019 and had approximately 250 hours on type at the time of the incident. This was the co-pilot's first commercial air transport employment and he had approximately 730 hours total flying time at the time of the incident.

Both pilots completed an EASA type rating at a third-party organisation which was contracted by the operator. At the time that both completed their type rating there was no requirement to record crosswind landings as a discrete item in the training programme[2], although crosswinds did form a required element of the type rating. Both crew members were signed off for crosswind landings on the skills test form. Although both crew members recall completing one crosswind landing during the simulator phase of their type rating, neither recalls receiving any specific training in relevant handling techniques and the wind used was not at or near the aircraft limit.

After completing their type rating courses, both pilots proceeded to line training with the operator. Line training is a series of flights conducted with a training captain occupying the other seat. The line training syllabus included crosswind landings, but this requirement could be completed as a discussion item rather than as a practical exercise. Both pilots were signed off for crosswind landings as a discussion item. Having completed their training and a line check conducted by a senior training captain both pilots were released to fly the line as normal crew members.

In the winter of 2019/20 both pilots completed a recurrent simulator session. This session included a crosswind landing as part of the tri-annual recurrent rotation of events to be covered in the simulator.

Both pilots had flown some crosswind landings on the line before this incident, but neither could remember any landing where the crosswind exceeded 20 - 25 kt. They were in recent flying practice and had been flying throughout the previous three-month period.

Organisational information

The operator has no restrictions on the crosswind limit for either newly qualified flight crew members or inexperienced co-pilots. All pilots were restricted only by the flight manual maximum demonstrated limit of 34 kt (not including gusts).

Operational procedures

Crosswind landing technique

The manufacturer's aircraft operating manual provides the following guidance for a crosswind landing:

> *'The aircraft may be flown in crosswind conditions using the "Wing Down" technique, the "Kick-Off Drift" technique or a combination of the two. The approach should be made with the aircraft lined up with the extended centreline, using normal speeds plus any allowance for turbulence. Towards the end of the flare, with Power Levers at FLIGHT IDLE, apply the required aileron to prevent a wing lifting as the aircraft touches down. After the main wheels have touched the runway, lower the nosewheel to the ground as soon as possible and as*

Footnote

2 Since the crew of SE-MAO completed their training the EASA have updated their requirements to ensure that crosswind training is now a discrete item within the type rating training.

the speed decreases gradually centralise the ailerons, maintaining directional control and braking as for a normal landing.'

Nosewheel steering

The ATP is fitted with nosewheel steering which is controlled from a tiller on the left side of the flight deck. There is no tiller fitted for the right seat pilot. The nosewheel steering can be used when the aircraft is on the ground at any speed.

Landing technique and post-landing actions

Ideally the pilots should achieve a gentle round out, with the power levers at FLIGHT IDLE at the end of the flare. The aircraft should then be allowed to settle onto the runway, mainwheels first, before the nosewheel is gently lowered to the ground. When the aircraft is on the ground, GROUND IDLE should be selected, with REVERSE used as necessary. Directional control is with rudder initially, then with nosewheel steering as the speed decreases. As the aircraft slows below 60 kt, with GROUND IDLE selected, the control locks should be engaged.

As the aircraft has no right seat nosewheel steering tiller, the manual offers further guidance when the right seat pilot is flying:

"When the aircraft is firmly on the ground with the power levers in the GROUND IDLE position, the Left Hand Seat Pilot should take control of the aircraft whilst the rudder is still effective. As he does this, he should call "I Have Control", to which the other pilot will respond "You Have Control". In crosswind conditions it may be necessary for the Right Hand Seat Pilot to continue to apply some ailerons into wind after the change-over of control."

The operator also published Standard Operating Procedures (SOPs) in the operations manual for landings. These SOPs stipulated that if the right seat pilot was landing, the left seat pilot would take control of the aircraft at 80 kt, although the right seat pilot would continue to hold the control column "*slightly forward and ailerons into the wind throughout the roll out".* If the left seat pilot was landing, then "*he/she will hand over the control column no later than eighty knots".*

Crew brief and actions

The crew did not discuss if, how or when hand over of the control column would occur for the second approach flown by the left seat pilot. They also did not discuss what inputs might need to be made on the control column given the strength of the crosswind for either approach.

Human factors

Human information processing

The concept of human information processing tries to explain how we make sense of the world around us. We are all subject to a continuous flow of stimuli from our surroundings which our brain must sift through and decide which should be processed before any possible response is generated. Figure 14 shows a simplified representation of the human information processing system taken from the CAA Flight crew human factors handbook[3].

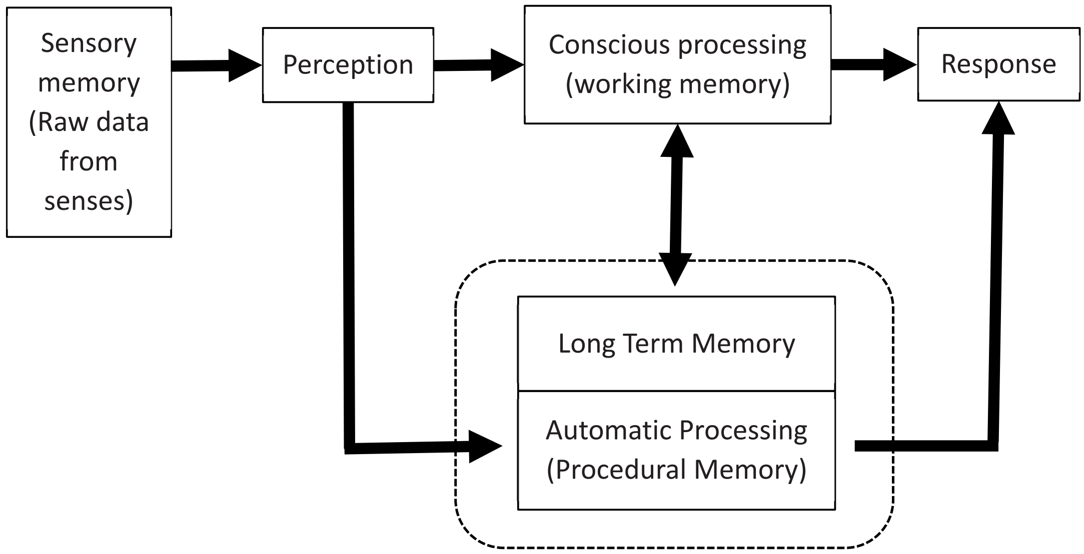

Figure 14

Simplified generic diagram of Information Processing

Figure 14 works from left to right. Using our senses, we detect data from our surroundings. This data cannot all be perceived and processed as we have limited cognitive resources to do so. There must be some filtering of the data so that we can focus on what is important at that moment. We have some very short-term capacity to store some of this data, although most of what we collect from our senses is lost as it is refreshed constantly. Sensory memory remembers stimuli just long enough to allow perception. Perception allows us to sort the sensory data into what needs our attention, and therefore needs further cognitive processing. Further processing takes place in the working memory.

We use our long term memory to store previous experiences which then provide a template for responding to data coming from the senses. Part of our long term memory also contains automatic processing, such as speech or motor programmes, which require little or no conscious cognitive effort. An example of such programmes could be changing gear in a manual car. These may be complex motor skills learned and practised over a period. Whilst automatic processes are very effective and efficient, there can be a risk that the wrong automatic process is triggered which can result in an incorrect response, especially when there are limited cognitive resources available.

When driving a car, to steer to the right requires the steering wheel to be turned to the right. This is an automatic response in most drivers once they have learnt the basics of driving. It is a re-enforced motor programme in anyone who drives regularly. When landing an

Footnote

[3] CAA CAP 737 *Flight crew human factors handbook* Page 19 https://publicapps.caa.co.uk/docs/33/CAP%20737%20DEC16.pdf [accessed November 2020]

aircraft, steering the nose of the aircraft to the right requires a right rudder input and, in a strong crosswind from the left, requires the use of full into-wind (left) aileron at the same time. This is not likely to be practised as often as most pilots drive a car and may occur only rarely for pilots operating in most areas. As a result, the 'steering the car' reaction may well be dominant in times of high cognitive workload when aligning the aircraft with the runway heading.

Analysis

Conditions at Birmingham

The weather conditions at Birmingham were a strong wind from the south-west with good visibility and little cloud. The strong wind gave a significant crosswind on the runway. The wind was also generating some turbulence on the approach. The ATP has a certified crosswind limit of 34 kt (not including gusts), and both the forecast and actual wind conditions were less than this maximum certified limit. The operator of SE-MAO had no limitations on the co-pilot flying the aircraft when there was a strong crosswind, and there was no additional limitation on the co-pilot below the certified limit of the aircraft type.

Whilst the Met Office study showed that it is possible the wind could have been stronger than that given on the METAR, the wind given to the pilots would have been from the threshold anemometer. This anemometer has been calibrated in accordance with the relevant CAA procedures. The AIP warns that in strong winds the crews may encounter building induced turbulence and windshear.

Crew training and experience

Both crew members were reasonably inexperienced on the aircraft type. Although crosswind landings were an element of their type rating courses, neither could remember having flown in conditions at or near the aircraft limit. Neither pilot used the full crosswind technique as outlined in the manufacturer's or operator's manuals.

First approach and go-around

The co-pilot flared the aircraft and it briefly touched down although insufficient rudder had been applied to line the aircraft up with the runway. As a result of not pointing down the runway, the co-pilot decided to perform a go-around and called "GO-AROUND". The commander either did not hear him or did not hear him correctly and instead called for the co-pilot to land the aircraft. As a result, the co-pilot closed the thrust levers that he had begun to open, and the aircraft again touched down about 20° nose left of the runway direction. The co-pilot did not have full right rudder applied and as a result the aircraft diverged from the centre of the runway in the strong crosswind. The commander called for a go-around which the co-pilot acknowledged. Go-around power was selected, and the go-around performed as per the SOPs.

Reversing a decision having started a go-around places an aircraft at significant risk. Applying power during the landing roll invalidates any landing performance calculation, and a breakdown of crew co-ordination can create significant confusion on the flight deck.

Whatever the reason for a go-around decision, once that decision is taken and the actions begun, it should be carried out with both crew members performing the tasks required. Should the other crew member have not heard the call or have misheard the call then it is necessary to restate the intentions immediately so that the crew have a joint and shared understanding of the actions underway.

Second approach

The second approach was flown by the commander at the request of the co-pilot. The aircraft was flared without being lined up with the runway and, after two short bounces, the aircraft touched down about 20° nose left of the runway heading. As the aircraft settled onto its landing gear and friction at the tyres increased, the aircraft began to head in the direction the wheels were pointing, which was to the left edge of the runway. This swing to the left was probably made worse by the weathercock effect of the crosswind, with insufficient right rudder applied at touchdown. The commander did not apply into-wind aileron although, as the aircraft swung left, he did apply full right rudder to steer the aircraft to the right. As the aircraft headed for the edge of the runway, the left main wheels lifted off the tarmac due to the application of full right aileron causing the aircraft to roll about the axis between nose and main tyres, and the commander could not stop the aircraft leaving the paved surface.

The application of full right aileron was almost certainly the result of an inappropriate automatic process (motor programme). Moving the steering wheel right when wanting to steer a car right and moving the control wheel to place the right aileron to full deflection are the same movements. It is likely therefore that as the commander reached his maximum ability to consciously process the inputs coming in from his senses, he subconsciously reverted to a more familiar automatic process and attempted to 'steer the car'.

The SOPs required the handover of the control column to the co-pilot at 80 kt but the aircraft had already left the paved surface by that stage.

Conclusion

Despite the challenging conditions, the crew did not discuss the conditions in any detail. They did not brief who would be holding the control column during either landing roll, or what actions they would take if they were required to abandon the approach or landing. The first approach resulted in confusion between the crew over going around which could have itself resulted in an incident or accident. The confusion was eventually overcome by the commander calling for a go-around.

The second approach resulted in a significant runway excursion due to the use of incorrect crosswind technique and the application of full right aileron. It is likely that the crew's inexperience of landing in strong crosswinds contributed to the misalignment at touchdown. It is likely this application of right aileron was as a result of an inappropriate motor programme to steer the aircraft right.

Neither attempt at landing used the crosswind technique as laid down in the manufacturer's and operator's manuals.

It was fortunate that the ground was hard due to a lack of recent rain. Except for the taxiway sign there were no other obstacles in the way of SE-MAO such as other aircraft or vehicles. As a result, despite a 450 m excursion off the runway, there was no damage to the aircraft or the airport facilities, and no injuries to the crew who were the only people on board.

Safety Action

As a result of this incident, the operator took the following safety action:

> Recurrent simulator sessions across all the operator's fleet were amended to include crosswind training.
>
> A crosswind limit would be introduced for new co-pilots during their first year of operation on type. This limit would be removed once the co-pilot had completed their first year of operations and successfully demonstrated the correct technique in their recurrent simulator.

Published: 4 March 2021.