Air Accident Investigation Unit Ireland

SYNOPTIC REPORT

ACCIDENT

Cessna F172P Skyhawk, EI-ING
Near Craughwell Airfield, Co. Galway

4 August 2018

An Roinn Iompair
Turasóireachta agus Spóirt
Department of Transport,
Tourism and Sport

Foreword

This safety investigation is exclusively of a technical nature and the Final Report reflects the determination of the AAIU regarding the circumstances of this occurrence and its probable and contributory causes.

In accordance with the provisions of Annex 13[1] to the Convention on International Civil Aviation, Regulation (EU) No 996/2010[2] and Statutory Instrument No. 460 of 2009[3], safety investigations are in no case concerned with apportioning blame or liability. They are independent of, separate from and without prejudice to any judicial or administrative proceedings to apportion blame or liability. The sole objective of this safety investigation and Final Report is the prevention of accidents and incidents.

Accordingly, it is inappropriate that AAIU Reports should be used to assign fault or blame or determine liability, since neither the safety investigation nor the reporting process has been undertaken for that purpose.

[1] **Annex 13**: International Civil Aviation Organization (ICAO), Annex 13, Aircraft Accident and Incident Investigation.
[2] **Regulation (EU) No 996/2010** of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation.
[3] **Statutory Instrument (SI) No. 460 of 2009**: Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulations 2009.

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In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No 996/2010 and the provisions of SI No. 460 of 2009, the Chief Inspector of Air Accidents, on 4 August 2018, appointed John Owens as the Investigator-in-Charge to carry out an Investigation into this Accident and prepare a Report.

Aircraft Type and Registration:	Cessna F172P Skyhawk, EI-ING	
No. and Type of Engines:	1 x Lycoming O-320-D2J	
Aircraft Serial Number:	F17202084	
Year of Manufacture:	1981	
Date and Time (UTC)[4]:	4 August 2018 @ 11.40 hrs	
Location:	Near Craughwell Airfield, Co. Galway, Ireland	
Type of Operation:	Private	
Persons on Board:	Crew – 1	Passengers – 2
Injuries:	Crew – None	Passengers – 1 (Minor)
Nature of Damage:	Damaged beyond economic repair	
Commander's Licence:	Airline Transport Pilot Licence (ATPL) Aeroplane (A) issued by the Irish Aviation Authority (IAA)	
Commander's Age:	48 years	
Commander's Flying Experience:	8,161 hours, of which 160 were on type	
Notification Source:	Pilot	
Information Source:	AAIU Report Form submitted by the Pilot AAIU Field Investigation	

[4] **UTC**: Co-ordinated Universal Time. All timings in this report are quoted in UTC; to obtain local time, add one hour.

SYNOPSIS

The Cessna F172P aircraft, with one Pilot and two passengers on board, had just flown from Weston Airport, Co. Dublin, to Craughwell Airfield, Co. Galway, where the landing on Runway 34 was fast and long. Upon realising that there was a stone wall located just beyond the end of the runway at the airfield boundary, and that the aircraft was not going to stop in the distance remaining, the Pilot applied engine power and took-off again. The aircraft marginally cleared the boundary wall, briefly climbed and travelled over the field immediately beyond the boundary wall. It then lost altitude, drifted left, and struck a tree at the far boundary of the field, before impacting with the ground and coming to rest. The three occupants evacuated the aircraft with some difficulty and the emergency services brought them to hospital for assessment. There was no fire.

NOTIFICATION

The AAIU on-call duty Inspector was notified of the accident by the Pilot shortly after it occurred. Two Inspectors of Air Accidents deployed to the accident site and commenced an Investigation. Following a technical examination of the aircraft and a detailed site survey, permission was given to the aircraft owner to recover the aircraft.

PREAMBLE

A trip to bring two passengers from Dublin to a horse-racing event in Galway had been funded by a private company, for sale at a fundraising auction. One of the two passengers had successfully bid for the trip, part of which was to fly the two passengers to Co. Galway by fixed-wing aircraft. It was initially intended that the aircraft would fly to the main airport in Galway (EICM). However, the Pilot subsequently realised that EICM was closed for such flights, and a number of days prior to the flight, he decided to operate to Craughwell Airfield – a private grass strip, also in Co. Galway. He had not flown to that airfield before. The Pilot had arranged that following the aircraft's arrival at Craughwell, the passengers would be flown by helicopter to Ballybrit Racecourse, in Co. Galway.

1. FACTUAL INFORMATION

1.1 History of the Flight

The Pilot informed the Investigation that he arrived at Weston Airport (EIWT) at approximately 08.30 hrs on the morning of the accident, checked the weather for the flight, and completed a weight and balance calculation. He then contacted Craughwell Airfield to obtain prior permission to land at the airfield. He was informed that a '*fly-in*[5]' was taking place at the airfield that day.

The Pilot was joined by his two passengers at approximately 10.00 hrs and he discussed the flight with them. According to the Pilot, the passengers were given a safety briefing at the aircraft. One passenger sat in the right-hand seat beside the Pilot (Passenger No. 1) and the second passenger sat in one of the rear seats (Passenger No. 2). The Pilot informed the Investigation that when both passengers were seated, he ensured that their seat belts were fastened.

[5] **Fly-in:** A pre-arranged gathering of pilots, aircraft and aviation enthusiasts, for recreational and social purposes.

The aircraft took-off from EIWT at approximately 10.30 hrs and proceeded west under Visual Flight Rules at an altitude of 1,500 ft. The Pilot indicated that the en route weather conditions were benign and that there was good visibility throughout the flight. The Pilot stated that on arriving overhead Craughwell Airfield, he proceeded to join a left-hand downwind (positioning leg) for Runway (RWY) 34. According to the Pilot, the aircraft's approach was fast and high.

The aircraft landed long and bounced before touching down again. The Pilot noticed a stone wall just beyond the end of the runway at the airfield boundary and realised that the aircraft was not going to stop safely in the distance remaining. He immediately applied full power and the aircraft took-off again, marginally clearing the 1.7 m high stone wall. The aircraft climbed briefly and travelled over the field immediately beyond the boundary wall, but then sank, drifted left, and struck a tree situated in a line of trees at the far boundary of the field. The aircraft impacted the ground in the next field, and travelled for approximately 30 m before coming to rest (**Photo No. 1**). The three occupants evacuated the aircraft with some difficulty and were brought to hospital by the emergency services, for assessment. There was no fire.

Photo No. 1: Final resting position of EI-ING (area of impact with tree circled)

1.2 Interviews and Statements

1.2.1 Pilot

The Pilot said that the trip had been planned for a '*few weeks*' and because EICM was closed, he had intended to fly to Connemara Airport (EICA), at Inverin, Co. Galway, but a number of days prior to the accident flight, he became aware of Craughwell Airfield and elected to fly to there instead.

He said that after arriving overhead the airfield, he commenced '*a left turn downwind for arrival*', eventually establishing on '*long finals for* [Runway] *three four*'. He had selected '*flaps twenty*' and the carb heat was ON. He said the airspeed was about 85 knots (kts) and he was trying to '*bleed the speed back*', but that it wasn't coming back as quickly as he had hoped. The Pilot stated that he '*opted to deploy full flap'* (30^{o}) and realised that he was high on the approach. He said he was trying to get the speed back towards 65 kts and realised it was '*going to be a bit tight*'. He contemplated aborting the approach, but then decided to continue. He said he was '*carrying about an extra ten to fifteen knots coming over the threshold*', but that the speed wasn't reducing and he wasn't getting down.

The Pilot initially thought that he touched down about '*three hundred feet into the runway*', before subsequently estimating that it was '*prior the mid-point*' of the runway, followed by a bounce and float. He said that the aircraft '*skipped across, still carrying too much speed*' and at this point he saw the boundary wall and realised that the aircraft wasn't going to stop before reaching it. The Pilot stated that he didn't recall applying the wheel brakes and that the presence of the wall resulted in '*a momentary pause and startle*[6] *effect*'. He said that he applied full throttle and the aircraft '*pitched up'*, and that he retracted the flaps to the 20^{o} position, but that the aircraft nose '*pitched up a little*' [more]. The Pilot estimated that the aircraft's speed was in the region of 50-60 kts at this stage.

The Pilot said that the aircraft cleared the wall, but that it wasn't climbing and noted that the attitude of the aircraft resulted in an erosion of airspeed. He reported that the aircraft started to sink and drift to the left and said that he '*didn't get a chance to remove carb heat*'. He didn't recall hearing the stall warning, but noted that he was '*still carrying a lot of speed*'. He said he noticed a large tree at his 12 o'clock position and '*attempted to raise the nose and try a slight turn to the right*' and recalled that at this point, he heard the stall warning. He said he clipped the tree and that reduced any forward speed he had and the aircraft started to descend, but that he tried to maintain wings level and '*make a landing*'. He said the aircraft landed quite hard, but that it wasn't a '*hugely abrupt landing*' as the aircraft still had forward velocity. He said [that when the aircraft came to rest] he checked that his occupants were ok, turned off the ignition, made sure that there was no fuel leaking, and that there was no sign of any fire. The Pilot said that his door was jammed, and the three occupants exited the aircraft through the door on the right-hand side.

1.2.2 Passenger No. 1

Passenger No. 1 said he had attended a fundraising event, where there was a charity auction, and one of the prizes to bid for was a trip to the Galway Races. He said his colleague, the other passenger (Passenger No. 2), won the bid. He originally thought the flight would be in a '*jet*' and helicopter. He said that he received a telephone call and emails from a company that seemed to be involved with the prize, and that the first time he spoke to the Pilot was on the night before the flight. He said he had never flown in an aircraft that small before and that when he met the Pilot before the flight, the Pilot was very good at reassuring him and the Pilot was '*very good throughout the journey*'.

[6] **Startle:** An uncontrollable, automatic muscle reflex, raised heart rate, blood pressure, etc., elicited by exposure to a sudden, intense event that violates a pilot's expectations (*FAA AC 120-11, 14 April 2015*).

Passenger No. 1 was seated in the front right-hand seat, beside the Pilot. The passenger said flying conditions were perfect and that there was no wind. He said that when the aircraft arrived over the airfield, the Pilot performed '*two big left-hand downward spirals to descend*' and that the aircraft landed halfway down the runway and quickly approached a stone wall. He thought that the Pilot didn't initially realise that they weren't going to stop in time before attempting to take-off again. He said that the wall was cleared by a '*few feet*' and that the aircraft '*only got back into the air by 30 to 50 feet*', before it '*seemed to stall and descend again*'.

The passenger said that the aircraft hit a tree and recalled that a branch came through the windscreen and that the aircraft hit the ground hard approximately 20 m later. He thought that '*the tree absorbed the impact and took the force out of the descent*'. He said that he had to '*kick out the door*' to evacuate the aircraft and that the other passenger struggled to get out with his assistance.

1.2.3 Passenger No. 2

Passenger No. 2 was seated in one of the rear seats of the aircraft. He reported that before landing, the aircraft seemed to spiral over the landing strip, and that after landing, the aircraft was '*running too fast and heading towards a stone wall and some trees*'. He said that the Pilot attempted to get the aircraft '*into the air again to avoid hitting the wall and the trees*' and that the aircraft started to ascend again, before hitting the ground. The passenger said that his feet were jammed and that the other passenger managed to kick the door out on the right-hand side and was able to assist him out of the aircraft.

1.3 Injuries to Persons

All three persons were brought to hospital by the emergency services for assessment following the accident. The Pilot informed the Investigation that he had no injuries. Passenger No. 1, who occupied the front right-hand seat, stated that he had received a slight crush injury to his hand, some cuts, a sore hip, and also that the seat belt had caused some bruising. Passenger No. 2 (who occupied a rear seat) did not report any injuries as a result of the impact, but stated that a pre-existing medical condition of his had worsened since the accident.

1.4 Damage to Aircraft

The aircraft was damaged beyond economic repair. The aircraft wreckage remained upright, lying on its fuselage, left main wheel and right wingtip. No significant deformation of the aircraft cabin was evident. The left wing was angled downwards from the root and exhibited impact damage to its leading edge. Both propeller blades sustained bending damage, there was damage to the engine cowlings and engine mounting points, the forward windscreen was broken at its right-hand side, and the upper hinge of the access door on the right side of the fuselage was found broken away from its hinges (**Photo No. 2**). The right horizontal stabiliser sustained substantial impact damage to the inboard section of its leading edge (**Photo No. 3**).

Photo No. 2: Damage to propeller blades; engine cowling and mounting points; windscreen; and right-hand access door

Photo No. 3: Impact damage to right horizontal stabiliser

1.5 Other Damage

There was impact damage to several branches of an approximately 10 m high tree, situated in a line of trees at the far boundary of the field beyond the wall located near the end of RWY 34. The branches struck were at heights ranging from 5 m to 9 m approximately. There were also impact marks on the field surface where the aircraft came to rest.

1.6 Personnel Information

The Pilot held a Part-FCL[7] ATPL(A), which was issued by the IAA on 20 August 2004. The licence contained an SEP[8] (land) Class rating that was valid until 31 August 2018. The Pilot's Class 1 Medical Certificate (for '*single-pilot commercial air transport operation carrying passengers*') was issued on 9 March 2018 and was valid until 9 September 2018. The Pilot's flying experience is outlined in **Table No. 1**.

Total all types:	8,161 hours
Total on type:	160 hours
Total on type P1:	135 hours
Last 90 days:	35 hours
Last 90 days on type:	2 hours
Last 28 days:	28 hours
Last 28 days on type	1 hour
Last 24 hours:	20 minutes
Last 24 hours on type:	Nil

Table No. 1: Pilot's flying experience

[7] **Part-FCL** (Flight Crew Licensing): Commission Regulation (EU) No. 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council.

[8] **SEP**: Single Engine Piston.

1.7 Pilot Licensing Requirements

Commission Regulation (EU) No 1178/2011 states the following regarding recent experience:

> *'A pilot shall not operate an aircraft in commercial air transport or carrying passengers:*
>
> *(1) as PIC* [Pilot-in-Command] *or co-pilot unless he/she has carried out, in the preceding 90 days, at least 3 take-offs, approaches and landings in an aircraft of the same type or class or an FFS*[9] *representing that type or class. The 3 take-offs and landings shall be performed in either multi-pilot or single-pilot operations, depending on the privileges held by the pilot* […]'.

The Pilot reported that he had completed 14 take-offs and landings [in SEP-class aircraft] in the previous 90 days and that several of these were conducted with a Flight Instructor present.

1.8 Aircraft Information

1.8.1 General

The Cessna F172P is an 8.22 m long, all-metal, high-wing aircraft, with a wingspan of 10.97 m. It is powered by a Lycoming O-320-D2J normally-aspirated piston engine, driving a clockwise-rotating (as viewed from the cockpit) two-blade McCauley fixed-pitch, metal propeller. The aircraft's maximum permitted take-off and landing weight is 1,089 kg in the '*normal*' category. A stall warning horn is fitted that produces a steady aural warning 5-10 kts before an actual stall is reached. The aircraft/engine is equipped with a carburettor heat system to prevent carburettor icing (and subsequent unexpected engine power loss, rough running, or shut down) during certain operating conditions. To apply carburettor heat, the 'CARB HT' control located below the main instrument panel in the cockpit is pulled towards the ON position. The Aircraft Manufacturer advised that the engine rotational speed will reduce by approximately 200 revolutions per minute (rpm) when carb heat is applied. This would result in a reduction in engine power.

The subject aircraft was manufactured in 1981 under licence in France by Reims Aviation S.A. It had accommodation for a pilot and three passengers. The two side-by-side cockpit seats were fitted with three-point restraint harnesses, consisting of a lap belt and a shoulder strap. The two rear seats were fitted with two-point harnesses (lap belts). Access to the aircraft was by two doors, one on either side of the fuselage; a boarding step was fitted on each main undercarriage leg to facilitate entry and egress.

The aircraft was first registered in Ireland on 18 August 2005. The aircraft's most-recent Certificate of Airworthiness was issued by the IAA on 28 August 2009. The associated Airworthiness Review Certificate was issued on 30 April 2018 by a UK Civil Aviation Authority (CAA)-approved maintenance organisation and was valid until 20 September 2018. The aircraft had operated for a total of 6,152 hours since new.

[9] **FFS:** Full Flight Simulator.

The aircraft was last weighed on 12 May 2017. Its empty weight was certified as 706 kg. The Pilot advised that the aircraft took off from EIWT with 110 litres of fuel (Avgas) on board. This equates to approximately 77 kg (using a specific gravity of 0.7). The Pilot estimated that the total weight of all three occupants was 255 kg and that there was approximately 15 kg of luggage/equipment on board. The aircraft's take-off weight was therefore estimated to be approximately 1,053 kg. Using the 75 % power cruise performance fuel consumption figure from the Aircraft Flight Manual of 25 km per US gallon (6.6 km per litre), and an approximate distance of 180 km between EIWT and Craughwell Airfield, the Investigation estimated that the aircraft would have consumed approximately 27 litres (18.9 kg) of fuel on the journey. Therefore, the aircraft's landing weight was estimated to be approximately 1,030 kg, which includes an allowance for fuel consumed during take-off and climb.

The aircraft was operated by a flying group, of which the Pilot on the accident flight was a member. The Pilot informed the Investigation that the flying group's Operations Manual categorised Craughwell as an airfield requiring authorisation from the Chief Flying Instructor to land there and that this was obtained prior to the flight.

1.8.2 Aircraft Operating Information

The Manufacturer's Aircraft Flight Manual, carried on board the aircraft contains details of the aircraft, its limitations, and its operating procedures.

1.8.2.1 Wing Flap Settings

The aircraft type is fitted with electrically operated wing flaps, which may be set between 0^o (full up), 10^o, 20^o and 30^o (full down), as required. Section 4 ('*NORMAL PROCEDURES*') of the Aircraft Flight Manual provides the following information regarding the flap settings. The '*NORMAL LANDING*' section states, *inter-alia*, that:

> *'Normal landing approaches can be made with power-on or power-off with any flap setting desired.* [..]

The following information is provided regarding a '*BALKED LANDING*[10]*'*:

> *'In a balked landing (go-around) climb, the wing flap setting should be reduced to 20^o immediately after full power is applied. Upon reaching a safe airspeed, the flaps should be retracted to the full up position. If obstacles must be cleared during the go-around climb, reduce the wing flap setting to 10^o and maintain a safe airspeed until the obstacles are cleared.'* […]

1.8.2.2 Take-Off Speeds

The Aircraft Flight Manual gives a '*Lift Off*' speed of 51 kts when the aircraft is operating at its maximum weight of 1,089 kg, 49 kts when operating at 998 kg, and 46 kts when operating at 907 kg.

[10] **Balked/Baulked Landing:** An aborted landing of an aircraft that is on final stages of the approach, prior to touchdown.

1.8.2.3 Landing Checklists

The '*BEFORE LANDING*' checklist as contained in the Aircraft Flight Manual requires the carburettor heat to be ON and specifies that full heat is applied before reducing engine power.

The '*BALKED LANDING*' checklist is as follows:

1. *Throttle - FULL OPEN.*
2. *Carburetor Heat - COLD.*
3. *Wing Flaps - 20^{o} immediately.*
4. *Climb Indicated Airspeed - 102 km/h - 55 kts.*

1.8.2.4 Aircraft Performance

The Aircraft Flight Manual provides the following information to assist in calculating the landing distance required and the ground roll for the expected conditions at the destination airfield, when planning a flight. The landing distance figure is based on the total distance required to clear a 15 m obstacle at the runway threshold while landing. The landing distance and ground roll figures are predicated on a pilot using a '*short-field technique*'.

Section 4 ('*NORMAL PROCEDURES*') includes the following information:

> *'SHORT FIELD LANDING*
>
> *For a short field landing in smooth air conditions, make an approach at 113 km/h – 61 kts – IAS with 30° flaps using enough power to control the glide path. (Slightly higher approach speeds should be used under turbulent air conditions.) After all approach obstacles are cleared, progressively reduce power and maintain the approach speed by lowering the nose of the airplane. Touchdown should be made with power off and on the main wheels first. Immediately after touchdown, lower the nose wheel and apply heavy braking as required. For maximum brake effectiveness, retract the flaps, hold the control wheel full back, and apply maximum brake pressure without sliding the tires.'*

The landing distance required for a given pressure altitude (the air pressure at the airfield) and temperature is calculated by interpolating the '*LANDING DISTANCE*' table in Section 5 ('*PERFORMANCE*') of the Aircraft Flight Manual. The required conditions are: Flaps 30^{o}; Power off; Maximum braking; Paved, level, dry runway; Zero wind. The '*Notes*' section of the table states:

1. *Short field technique as specified in Section 4* [reproduced above].
2. *Decrease distances 10% for each 9 knots headwind. For operation with tailwinds up to 10 knots, increase distances by 10%.*
3. *For operation on a dry, grass runway, increase distances by 45% of the "ground roll" figure.*

Using the table, and factoring for operation on a dry, grass runway, the Investigation calculated that the total landing distance required for the local temperature and pressure conditions at the time of the accident was 466 m, which includes a ground roll of 240 m.

1.9 Meteorological Information

Met Éireann, the Irish Meteorological service, provided the Investigation with the following aftercast for Craughwell Airfield, Co. Galway, for 11.40 hrs on 4 August 2018 (**Table No. 2**):

Meteorological Situation:	High pressure of 1029 hPa [hectoPascals], centred 200 NM southwest of Valentia gives a slack flow over Ireland.
Surface Wind: **Wind at 2,000 feet (ft):** **Between Surface and 300 ft:**	West 3-5 KT [Knots] Northwest 5 KT Stable conditions, coupled with the slack flow would have resulted uniform conditions in this layer.
Visibility:	Greater than 30 km [kilometres].
Weather:	Cloudy or overcast skies, with some light patchy drizzle.
Cloud:	A broken (5-7/8th oktas[11]) or overcast stratocumulus layer with cloud base around 2,000-2,500 ft.
Surface Temperature/Dew Point:	16/12 degrees Celsius.
Mean Sea Level (MSL) Pressure:	1028 hPa.
Freezing Level:	Greater than 12,000 ft.

Table No. 2: Meteorological conditions for Craughwell Airfield

1.10 Aerodrome Information

1.10.1 Airfield Details

Craughwell Airfield is a private, unlicensed airfield situated 3.5 km north-east of Craughwell, Co Galway. Its elevation is 120 ft AMSL[12]. The airfield has a single grass runway, designated 16/34. There is a dry stone wall approximately 1 m in height at the airfield boundary, 6.7 m before the start of RWY 34 and another stone wall, approximately 1.7 m in height, 4.7 m from the far end of the runway (RWY 16 threshold) (**Photo No. 4**). The Investigation measured the distance between the two boundary walls as 620 m (2,034 feet). The Investigation confirmed this distance with the airfield owner. The active runway on the day of the accident was RWY 34. Apart from a single tree situated a short distance to the left of the threshold of RWY 34, there were no significant obstacles in the approach path. The Pilot informed the Investigation that prior to the flight he had checked the available runway length with the airfield owner and that permission to land at the airfield was obtained. He said he was advised that the runway was 580 m long.

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[11] **Oktas:** An estimate of cloud coverage in the sky on a scale from 0 to 8; completely clear sky is described as 0 oktas, while completely overcast sky is described as 8 oktas.
[12] **AMSL**: Above Mean Sea Level.

On the day of the accident, the left-hand and right-hand edges of the runway were identified with white and red coloured markers, placed at intervals along the runway edge. These markers were not permanent. The end of RWY 34 was identified with larger red-coloured markers (visible in **Photo No. 4**). These were positioned at the edges of the runway and in-line with its end and were painted with the number '*16*', which was facing the direction of approach to that runway.

The runway surface was level and the grass was short and dry. The distance from the boundary wall at the threshold of RWY 34 to the red markers placed adjacent the end of the runway, was 530 m. There was approximately a further 90 m of runway surface between the red markers and the boundary wall at the end of RWY 34.

Photo No. 4: View of the runway at Craughwell Airfield opposite to direction of landing (boundary wall approximately 90 m from marked end of RWY 34 is visible in the foreground)

1.10.2 Published Airfield Information

In the course of the Investigation, it was found that the runway length is identified in an airfield guide as 700 m and that the presence of the stone walls is not highlighted. The publisher was advised of this and has updated the publication's associated '*Errors and Omission*' webpage, in accordance with the procedures outlined in the publication.

1.11 Video Recording

A person at the airfield recorded a video of the aircraft during its ground roll after landing. This person was standing approximately 15 m from the edge of RWY 34, 20 m from the marked end of RWY 34, and approximately 110 m from the boundary wall (at the end of RWY 34). The video, which was recorded on a mobile phone, had a recording frame rate of 30 Frames Per Second (FPS). It shows the aircraft after it touched down (following the bounce) on RWY 34. There was minimal noise from the engine at that stage and a person can be heard commenting that the aircraft was '*coming fast*'.

The aircraft then passed from right to left directly in front of the camera and by two adjacent markers positioned on the left-hand edge of the runway, which were almost directly in front of the camera. The video had recorded the aircraft travelling on the runway for approximately four seconds at this stage. Less than one second after the aircraft had passed by the camera, and when it was on the additional section of runway beyond its marked end, the engine noise became louder and the aircraft became airborne just before the boundary wall. The video shows that the aircraft marginally cleared the stone wall and climbed to a height of approximately 10 m above ground level as it travelled over the field immediately beyond the boundary wall. It then sank and disappeared from view. This was followed by the sound of an impact. The field beyond the boundary wall slopes upwards immediately after the wall to a height of approximately 2 m above the runway surface, before sloping slightly downwards towards the line of trees.

1.12 Wreckage and Impact Information

The accident site was preserved by An Garda Síochána pending the arrival of the AAIU. On arrival, a site survey was carried out at the location of the wreckage and at the airfield, in order to establish the points of contact with the runway during the attempted landing and the subsequent impact sequence, and damage to the aircraft. Witnesses at the airfield, who were standing close to where the video was recorded, pointed out to the Investigation markers they had placed at the runway edge, in line with where they estimated the initial points of contact with the runway were and also the points of contact following the bounce. The marker that had been placed in line with where it was estimated that the aircraft initially made contact with the runway, was approximately 350 m from the boundary wall located 6.7 m from the threshold of RWY 34. The marker that had been placed in line with where it was estimated that the aircraft touched down after the bounce was 30 m further along the runway. One of the witnesses noted that after this touchdown, the aircraft was briefly not fully in contact with the runway. The Investigation did not observe any clear contact marks on the runway.

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The Investigation's site survey indicated that following the rejected landing[13], the aircraft struck a tree situated in a line of trees at the far boundary of the 220 m-long field that was immediately beyond the airfield boundary (**Photo No. 5**). The tree that was struck was located slightly to the left of the extended centreline of the runway. Debris from the tree extended for 20 m into the next field. The aircraft impacted the ground at a distance of approximately 33 m from the line of trees. Ground marks show that the aircraft then continued along the grass surface for a further 30 m approximately, resulting in the detachment of the nose landing gear and the right main undercarriage assembly, before the aircraft came to rest on a heading of 360^{o} (N). Acrylic window fragments were also present in the wreckage trail.

[13] **Rejected Landing:** In the context of this report, the term '*rejected landing*' refers to a go-around manoeuvre initiated after touchdown of the main landing gear.

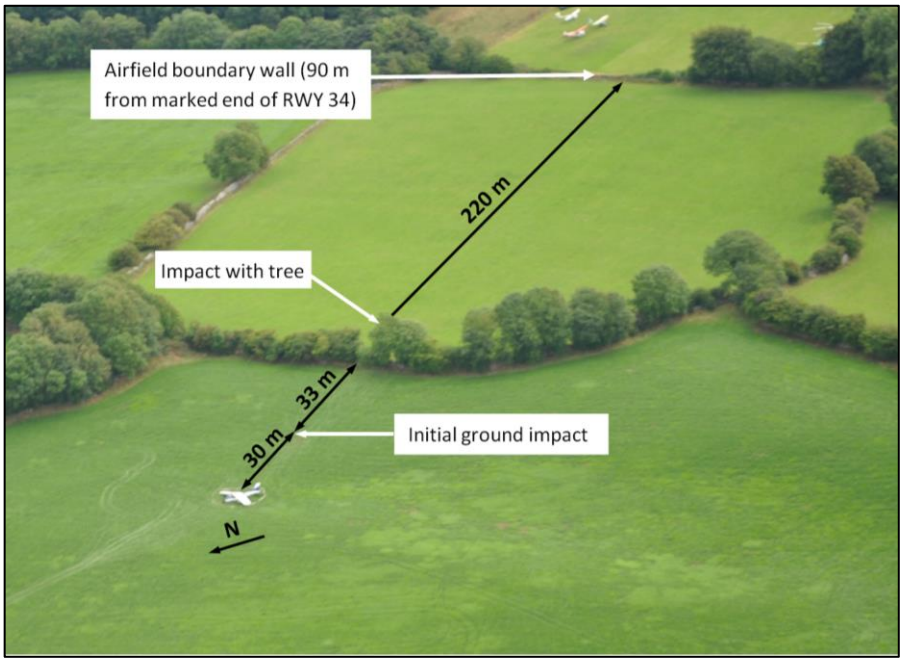

Photo No. 5: Aerial image showing location of impact points and aircraft's final resting position (image used with permission of photographer)

The flap selector switch in the aircraft cockpit was found to be at the '*30°*' (full down) position. However, the actual position of the flaps was less than this. Based on photographic evidence provided by the Investigation to the Aircraft Manufacturer, it was determined that the flaps were in the 20° position. The Aircraft Manufacturer advised that following aircraft accidents, the switch position often does not agree with the flap extension and suggested that this may be due to occupants striking the switch during the impact sequence. The carb heat was found in the ON position.

1.13 Aerodynamic Considerations

1.13.1 Drag

(Based on Thom, 1997[14]): The resistance experienced by an aircraft as it moves through the air is known as drag, which comprises two elements – parasite drag and induced drag. Parasite drag is caused by resistance to the movement of a body through the air, whereas induced drag is associated with the production of lift.

For a normal aircraft wing to produce lift, the air pressure above the wing will be less than the air pressure below the wing. As the air flows rearwards around the wing, some of the air will spill around the wingtip, from the higher pressure region at its lower surface to the lower pressure region at its upper surface. There is an associated span-wise flow of air from wing root to wingtip on the lower wing surface, and from wingtip to wing root on the upper wing surface. This span-wise airflow results in vortices being generated at the trailing edge of the wing and at the wing tip, where the vortices are strongest. The net effect of the vortices is a downwash behind the wing, which deflects the airflow downwards, causing the wing to experience a local airflow (i.e. an average relative airflow) and the total aerodynamic force generated by the wing to be tilted rearwards (**Figure No. 1**).

[14] Thom, T. (1997). The Air Pilot's Manual 4, The Aeroplane – Technical. Shrewsbury: Airlife Publishing Ltd.

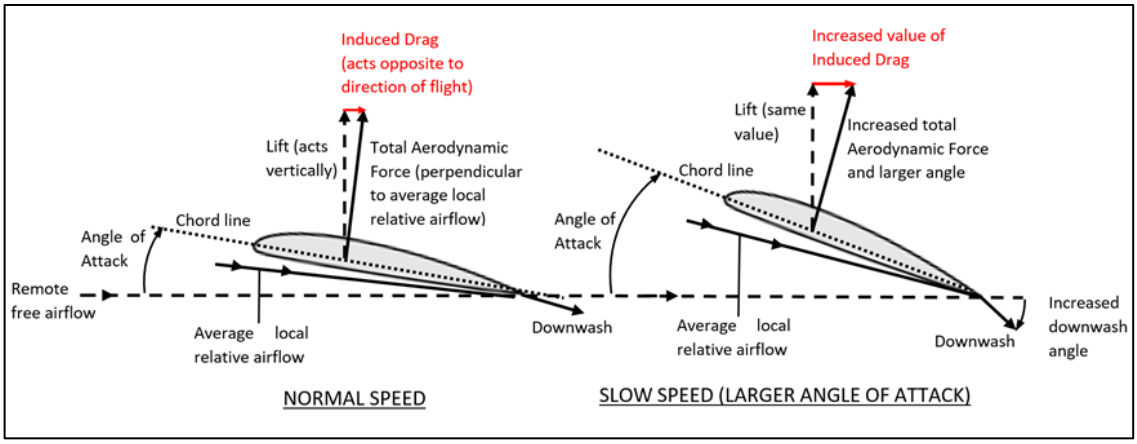

Figure No. 1: Induced drag greatest at slow speeds/larger angles of attack (based on *Thom*)

An aerofoil's chord line runs from the aerofoil's leading edge to its trailing edge. The angle between the chord line and the remote free airflow is known as the angle of attack. To maintain lift at lower speeds, or when manoeuvring, an increase in angle of attack is necessary. This increased angle of attack increases the pressure difference between the upper and lower surfaces of the wing, causing the total aerodynamic force to increase. The strength of the vortices will also be increased, as will the downwash. The greater downwash causes the average local airflow to be inclined downwards even more, and the total aerodynamic force to tilt further to the rear. This results in a larger component of the total aerodynamic force being in the drag direction – this element of drag is known as induced drag. It is greatest at slow speeds (large angle of attack) and lowest at high speeds (small angle of attack), whereas parasite drag is directly proportional to the square of speed.

1.13.2 Power and Drag Curves

Power required, power available, and the different types of drag, when compared with airspeed, are illustrated in **Figure No. 2**.

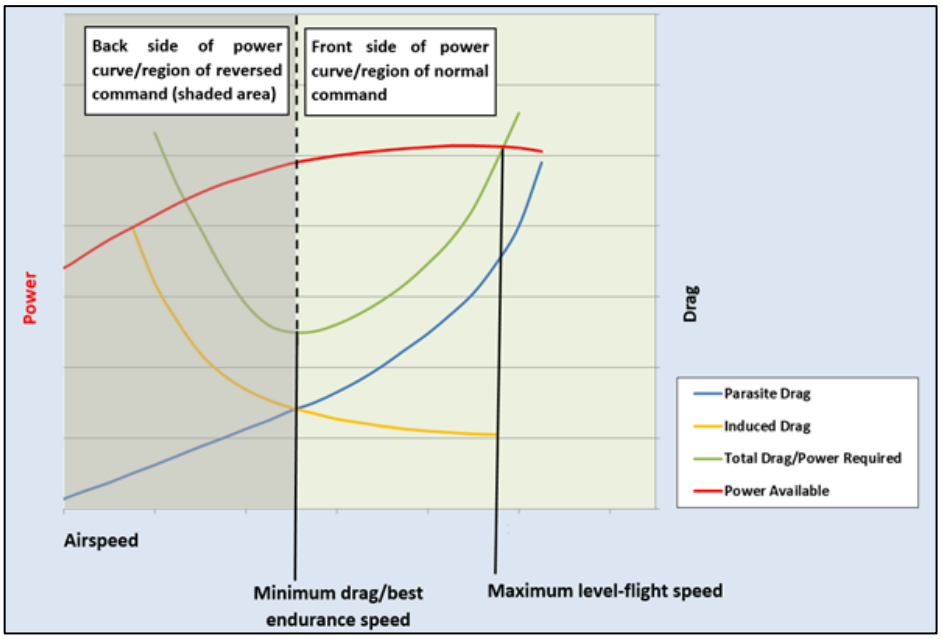

Figure No. 2: Power and drag curves (Illustrative only)

As outlined earlier, induced drag is greatest at slow speeds/large angles of attack (yellow line in **Figure No. 2**), whereas parasite drag is directly proportional to the square of airspeed (blue line in **Figure No. 2**). In stable, level flight (equilibrium), lift equals weight and thrust equals drag. The green line in **Figure No. 2** represents the total drag (induced + parasite), and therefore the power required. The red line represents the power available. The difference between the power required and the power available (excess power) can be used, to accelerate or to climb. There is no excess power available where the red and green lines cross.

The shaded area in **Figure No. 2** is known by various terms, including '*the back side of the power curve*', '*the back of the drag curve*' or '*the region of reversed command*'. When operating in this region, the lower the airspeed, the more power that is required to maintain altitude. This is because of the increased induced drag at low airspeeds due to the larger angle of attack needed to maintain sufficient lift. If the angle of attack is further increased by pulling back on the yoke, induced drag will increase and the aircraft will descend unless more power is added. When no more power is available, level flight is not possible and the aircraft will descend. The only way to increase airspeed, and therefore lift, is to lower the nose of the aircraft and descend. This is not an option when close to the ground.

1.13.3 Ground Effect

An aircraft is in ground effect when it is within a height above ground equal to approximately the length of its wingspan. When an aircraft is operating in ground effect, the surface of the ground will restrict the formation of wingtip vortices and therefore the downwash due to the vortices is reduced. This reduces the rearward angle of the total aerodynamic force, which decreases induced drag and increases lift. The closer to the surface an aircraft flies, the greater the ground effect will be.

Because the Cessna 172 is a high-wing aircraft, the downwash generated by the wings can act on the tail of the aircraft. Therefore, when the aircraft climbs out of ground effect, in addition to the decrease in lift and increase in induced drag as the downwash increases, the effect of the downwash on the horizontal stabiliser becomes progressively stronger. This causes a downward load on the horizontal stabiliser and results in a nose-up pitching moment.

1.13.4 Trailing Edge Flaps

When trailing edge flaps are extended, the camber[15] of the wing increases, thereby increasing lift (and drag), and causing the centre of pressure (the point through which the total aerodynamic force generated by the wing acts) to move rearwards. Conversely, when the flaps are retracted, in addition to a reduction in lift, the centre of pressure of a wing moves forward; this can cause the aircraft to pitch up.

[15] **Camber:** In this case, the convexity of curvature of an aerofoil from its leading to its trailing edge.

1.14 Go-Arounds/Rejected Landings

According to the Federal Aviation Administration's '*Airplane Flying Handbook*' (FAA-H-8083-3B, 2016, Chapter 8, Approaches and Landings), '*if a landing cannot be made on the first third of the runway* […]*, execute a go-around'.* The handbook gives guidance on the performance of go-arounds and states that '*the earlier a condition that warrants a go-around is recognized, the safer the go-around/rejected landing is*'. Two main reasons for delaying the decision to go-around are also outlined:

'*1. Landing expectancy or* **[mind]***set – the anticipatory belief that conditions are not as threatening as they are and that the approach is surely terminated with a safe landing.*

2. Pride – the mistaken belief that the act of going around is an admission of failure – failure to execute the approach properly'.

Another possible factor, as described in a previous AAIU Report (2018-003) is '*plan continuation bias*' (also known as '*get-there-itis*'), which is '*a deep-rooted tendency of individuals to continue their original plan of action even when changing circumstances require a new plan*'.

2. ANALYSIS

2.1 Accident Sequence

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2.1.1 The Approach and Landing

The total distance between the boundary walls located at each end of the runway at the airfield is 620 m. The threshold of RWY 34 was 6.7 m from the boundary wall. The length of the runway from the threshold of RWY 34 to the red runway end markers that were in place on the day of the accident was approximately 523 m. The distance from the marked end of RWY 34 to the boundary wall, located 4.7 m beyond the end of the runway, was 90 m. Therefore, the total length of runway surface was slightly less than 610 m (620 – (6.7 + 4.7) = 608.6). The presence of the walls at each end of the runway would reduce its useable length.

According to the Aircraft Flight Manual, the landing distance required for the local temperature and pressure conditions at the time was 466 m using the short field landing technique, at the prescribed approach speed of 61 kts and a 30^{o} flap setting, and when factored for the dry grass conditions present. This includes a ground roll of 240 m and equates to a touchdown point of 226 m beyond the threshold of RWY 34.

The Pilot said that he was '*carrying about an extra ten to fifteen knots coming over the threshold*' (with reference to 65 kts). This suggests that the aircraft's touchdown speed was in the order of 75-80 kts. The runway contact points, as estimated by witnesses at the airfield, indicated that the aircraft initially touched down 350 m after the boundary wall at the threshold of RWY 34 (this was more than halfway along the runway), before bouncing and touching down again approximately 30 m later. However, the Pilot, having initially thought that he touched down '*three hundred feet into the runway*', subsequently stated that it was '*prior to the mid-point*'.

The witness video was recorded from a position that was approximately 130 m further along the runway than the estimated second touchdown point and 20 m before the marked end of the runway. Therefore, when the aircraft was in line with the camera, it was 110 m from the boundary wall located just beyond the end of RWY 34.

By using the frame rate of the video (30 FPS) and the length of the aircraft compared to the distance between two adjacent runway markers located at the runway edge directly in front of the camera, it was possible to estimate the aircraft's ground speed as it passed between the two markers. The Pilot said that he didn't recall applying aircraft's wheel brakes during the landing roll; nevertheless, there would have been some deceleration of the aircraft due to drag and friction during the ground roll on the grass runway. As the aircraft passed by each marker in turn, the ground speed between the two markers was conservatively estimated to be in the region of 60 kts (not accounting for any deceleration between the two markers). This was after 130 m of ground roll (with reference to the estimated second touchdown point) and is therefore consistent with the estimated touchdown speed of 75-80 kts. The witness video first records the aircraft when it was travelling on the runway surface. It took four seconds for the aircraft to reach a position in line with the camera. A distance of approximately 134 m would be covered in four seconds at an average ground speed of 65 kts (33.4 m/s).

The Investigation did not observe any clear contact marks on the runway and it is possible that the aircraft touched down prior to the mid-point of the runway as stated by the Pilot, and bounced, or was not fully in contact with the runway surface for a distance longer than 30 m. However, the duration of the ground roll when the aircraft was in contact with the runway surface before it reached a position in line with the camera, as recorded by the witness video is consistent with the position of the second touchdown, as estimated by the witnesses. This was approximately 150 m from the end of RWY 34, as marked by the red markers that were in place at the time of the accident (130 m to a position in line with the camera, followed by 20 m to the marked end). However, there was approximately a further 90 m of runway surface available, before reaching the other boundary wall, i.e. there was likely at least a total distance of 240 m available in which to stop the aircraft. The ground roll (stopping distance) required under ideal braking conditions for a short field landing on dry grass following an approach at 61 kts, is 240 m and therefore it would likely not have been possible to bring the aircraft safely to rest in the distance remaining following the touchdown after the bounce.

2.1.2 The Rejected Landing

The witness video records that less than one second after the aircraft passed by the camera, the engine noise started to increase; this is consistent with the engine power being increased in an attempt to take-off again. At this stage, the aircraft was beyond the marked end of RWY 34 and therefore was less than 90 m from the boundary wall. The Investigation estimated that the aircraft's speed as it passed by the camera was in the region of 60 kts. The speed would have reduced before the engine power was increased. The Pilot said he applied '*full throttle*'. However, engine power and therefore the aircraft's speed would not have increased immediately. The Investigation estimated that the aircraft's landing weight was approximately 1,030 kg. The '*Lift-Off*' speed specified in the Aircraft Flight Manual for an aircraft weight of 998 kg is 49 kts and the aircraft's speed was likely above this when the aircraft became airborne again.

The video also shows that the aircraft became airborne just before reaching the wall and marginally cleared it. The video indicates that the aircraft climbed to a height of approximately 10 m above ground level as it travelled over the field immediately beyond the boundary wall. The aircraft then sank and collided with a tree located in a line of trees at the field's far boundary.

The surface of this field slopes upwards to a height of approximately 2 m above that of the runway surface, before sloping slightly downwards towards the trees at its far boundary. When the aircraft became airborne and cleared the wall, it was likely in ground effect which would have reduced the induced drag, thereby increasing lift. However, as the height above ground increased and the ground effect reduced, there would have been a corresponding increase in downwash, leading to increased induced drag and a reduction in lift, particularly when the aircraft had been pitched up to clear the wall. In addition, on a high-wing aircraft, such as the subject aircraft, the interaction of the increased downwash on the horizontal stabiliser as the ground effect reduced would also tend to pitch the aircraft to a higher angle of attack.

The '*Balked Landing*' checklist in the Aircraft Flight Manual requires the flaps to be retracted immediately, in order to allow the aircraft to accelerate. In this instance, the Pilot said he applied full throttle and the aircraft '*pitched up*', and that he retracted the flaps from 30^{o} to 20^{o}, but that the aircraft nose pitched up further. The Pilot estimated that the aircraft's speed was in the region of 50-60 kts at this stage. However, an increase in angle of attack would result in a corresponding increase in induced drag and an erosion of airspeed; this effect on airspeed was noted by the Pilot. Furthermore, when trailing flaps are retracted, the centre of pressure of a wing moves forward; this can cause the aircraft to pitch up and increase the angle of attack and therefore further increase the induced drag.

The Pilot informed the Investigation that '*full throttle*' was applied to initiate the rejected landing. However, the Investigation's post-accident examination of the aircraft wreckage identified that the carb heat selector was in the ON position. The Pilot said he '*didn't get a chance to remove carb heat*' and it is likely that the carb heat was on throughout the entire rejected landing. This would have reduced the maximum engine power available. When ground effect reduced as the Pilot attempted to climb, it is likely that the aircraft was '*on the back side of the power curve*' and it would not have been possible for the airspeed to be increased, while at the same time holding or gaining altitude, and the aircraft was likely '*mushing*[16]' at this stage. The only way to have increased the airspeed would have been to lower the nose and descend; this was not an option when close to the ground.

The Pilot reported that as well as sinking, the aircraft drifted to the left. The Pilot said that he '*attempted to raise the nose and try a slight turn to the right*' to avoid the tree; raising the nose would further increase the angle of attack and could increase the induced drag to the point that it would exceed the engine power available, resulting in the aircraft descending and/or stalling. The Pilot said that the stall warning sounded before the aircraft struck the tree.

[16] **Mushing:** That condition of flight in which induced drag is high due to a high angle of attack, but in which the angle is not quite high enough to induce a stall (Mason, S. (1982). Stalls, Spins and Safety. New York: McGraw Hill, Inc.).

2.2 Human Factors and Aeronautical Decision Making

The Pilot realised that the aircraft was fast and high on the approach and had contemplated aborting the approach, but decided to continue. The prudent course of action would have been to perform a go-around at this stage, as it would have been unlikely to be able to touch down at the correct speed and position on the runway for a short field landing.

It is important that a pilot makes an early decision to go-around in such circumstances to ensure adequate clearance from obstacles at the end of the runway, or those present in the initial climb out area. This is particularly relevant when operating into airfields with limited runway length and/or obstacles. However, the adverse effects of '*plan continuation bias'* (or '*get-there-itis*') may have minimised the significance of the cues suggesting that a go-around was appropriate. This cognitive bias is similar to what the FAA's Airplane Flying Handbook describes as '*landing expectancy'*, which is the belief that conditions are not as threatening as they are and that the approach will end with a safe landing. Furthermore, two passengers were on board the aircraft which may have inadvertently affected the Pilot's determination to execute a landing from his first approach.

Witness estimates, as measured by the Investigation indicated that the aircraft touched down 350 m (1,148 feet) along the runway, before bouncing and touching down again approximately 30 m later. The Pilot considered that he touched down '*prior to the mid-point*', before bouncing and floating. If the rejected landing was initiated at this stage, the likelihood of a successful outcome would have been increased. However, the video recording, the estimated touchdown speed and the touchdown points as estimated by the witnesses, suggest that the aircraft travelled on the ground for at least a further 150 m before the engine noise increased, and was less than 90 m from the boundary wall (engine rpm would not increase immediately following the movement of the throttle control. It is therefore likely that the throttle was moved before this point). The Pilot said that the presence of the wall resulted in '*a momentary pause and startle effect*'. Such an effect would result in the loss of some of the limited time available in which to initiate a rejected landing. This is consistent with the account of Passenger No. 1, who said he thought that that the Pilot didn't initially realise that they weren't going to stop in time.

Commercial airlines have strict procedures requiring go-arounds to be flown if an aircraft is not at the correct height and speed (stabilised) within a certain distance from the runway or at a certain height AGL and these are usually verbalised/briefed in advance of the final approach. Approaches to airfields in General Aviation may not always permit the implementation of such rigid rules; however, consciously planning for a go-around or a rejected landing in the event that either becomes necessary, and reviewing the steps required, such as immediately retracting flaps to the necessary setting and deselecting carb heat, could reduce the risk of similar accidents occurring in the future.

2.3 Operational Considerations

2.3.1 Flying Experience

The Pilot had a total of 8,161 hours of flying experience, 2,600 of which were on fixed-wing aircraft and included 160 hours on the aircraft type. However, he had only two hours' experience on type in the 90 days prior to the accident and only one hour's experience on type in the 28 days prior to the accident.

Regulation (EU) No 1178/2011 requires that in order to carry passengers, a pilot must have completed at least three take-offs and landings in the previous 90 days. The Pilot reported that he had completed 14 take-offs and landings [in SEP-class aircraft] in the previous 90 days and that several of these were conducted with a Flight Instructor present; therefore, the Pilot had complied with the requirements of the Regulation.

2.4 Survivability

The damage to the aircraft's windscreen and to the leading edge of the left wing and right horizontal stabiliser is consistent with impact with a tree. The Pilot said that following the impact with the tree, he tried to keep the wings of the aircraft level and make a landing. The aircraft made contact with the ground but continued to travel on the grass surface. These factors likely resulted in the aircraft's energy being absorbed gradually, and notwithstanding that Passenger No. 2, who was seated in the rear reported that his feet were initially trapped, no significant deformation of the aircraft cabin was evident. The two cockpit seats were fitted with three-point restraint harnesses and lap belts were installed in the rear seats. The Pilot ensured that the harnesses were fastened before the flight and the Pilot and passengers remained restrained in their seats throughout the impact sequence. There was no post-crash fire and all occupants were able to evacuate the aircraft, albeit with some difficulty; the door on the Pilot's side of the aircraft was jammed and the passenger door required to be kicked open to allow egress, which likely resulted in the detachment of the door's upper hinge.

The Pilot reported that he was uninjured. The front seat passenger (Passenger No. 1) reported minor injuries. The passenger who occupied a rear seat (Passenger No. 2) did not report any injuries as a result of the impact, but stated that a pre-existing medical condition had worsened since the accident.

2.5 Runway Length

The distance between the two walls at either end of the runway, as measured by the Investigation, was 620 m. This distance was confirmed to the Investigation by the airfield owner. The overall runway length was slightly less than 610 m (608.6).The Investigation notes that the maximum useable runway length, due to the presence of the walls, would be less than this. The runway length has been identified in an airfield guide as 700 m. The presence of the stone walls is not highlighted in the publication. In this instance, the aircraft initially landed fast and long, before bouncing and touching down again. Furthermore, the Pilot said that prior to the flight he had been advised that the runway was 580 m long. Therefore, the runway length publication discrepancy was not a factor in the accident. However, it is essential that published information regarding airfields is as accurate as possible. The publisher was advised of the runway length discrepancy and that the presence of the stone walls was not highlighted in the publication, and has updated the publication's associated '*Errors and Omission*' webpage, in accordance with the procedures outlined in the publication. Consequently, no Safety Recommendation is made in this regard.

3. CONCLUSIONS

3.1 Findings

1. The airworthiness certification for the aircraft was valid.

2. The Pilot's licence, ratings and medical certificate were valid.

3. The Pilot reported that he had completed 14 take-offs and landings in the previous 90 days. This exceeds Commission Regulation (EU) No. 1178/2011 requirements.

4. The Pilot's recent experience on the aircraft type was limited.

5. The aircraft's approach to RWY 34 at the destination airfield was fast and high.

6. The aircraft initially touched down long and fast.

7. The distance between the two walls at either end of the runway, as measured by the Investigation, was 620 m. The overall runway length was slightly less than 610 m (608.6).

8. The remaining distance available following the bounce and estimated second touchdown point, combined with the aircraft's estimated speed, indicated that it likely would not have been possible to stop the aircraft before the boundary wall, located just beyond the end of RWY 34.

9. The video recording, the estimated touchdown speed and the touchdown points as estimated by the witnesses, indicated that the rejected landing and attempted go-around was initiated when the aircraft had travelled on the runway for at least 150 m and was approximately 90 m from the boundary wall.

10. The aircraft marginally cleared the boundary wall just beyond the end of RWY 34, climbed briefly, before sinking, drifting left and impacting a tree situated in a line of trees at the far boundary of the next field.

11. The carburettor heat remained in the ON position following the rejected landing.

12. Once the aircraft climbed out of ground effect after it cleared the boundary wall, the engine power available was not sufficient to overcome the increased induced drag and it would not have been possible for the aircraft's airspeed to be increased while at the same time holding or gaining altitude.

13. Further pitching up of the aircraft, due to the flaps being retracted from 30^{o} to 20^{o} and/or due to decreasing ground effect, and/or due to increased back pressure on the yoke in an attempt to gain altitude would have further increased the induced drag and reduced the aircraft's airspeed, causing it to sink and stall.

14. The runway length has been identified in one publication as 700 m, whereas the distance between the boundary walls at either end of the runway was 620 m, with an overall runway length of slightly less than 610 m. This was not a factor in the accident. The publisher was advised of the discrepancy and that the presence of the stone walls was not highlighted and has updated the publication's associated '*Errors and Omission*' webpage, in accordance with the procedures outlined in the publication.

3.2 Probable Cause

Collision with a tree as a result of a loss of lift and stall during an attempted go-around from a rejected landing.

3.3 Contributory Cause(s)

1. The aircraft was high and fast on its approach to the runway, landed long and bounced.

2. Degraded climb performance as a result of a high angle of attack; reducing ground effect; and carb heat remaining in the ON position.

4. SAFETY RECOMMENDATIONS

This Report does not sustain any Safety Recommendations.

- END -

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No. 996/2010, and Statutory Instrument No. 460 of 2009, Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulation, 2009, the sole purpose of this investigation is to prevent aviation accidents and serious incidents. It is not the purpose of any such investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

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An Roinn Iompair
Turasóireachta agus Spóirt
Department of Transport,
Tourism and Sport

Air Accident Investigation Unit,
Department of Transport Tourism and Sport,
2nd Floor, Leeson Lane,
Dublin 2, D02TR60, Ireland.
Telephone: +353 1 604 1293 (24x7): or
+353 1 241 1777 (24x7):
Fax: +353 1 604 1514
Email: info@aaiu.ie
Web: www.aaiu.ie