Air Accident Investigation Unit Ireland

FORMAL REPORT

ACCIDENT
BRM Aero, Bristell NG5, G-OJCS
Belan, Co. Kildare

13 June 2019

An Roinn Iompair
Department of Transport

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 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.

Extracts from this Report may be published providing that the source is acknowledged, the material is accurately reproduced and that it is not used in a derogatory or misleading context.

[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 14 June 2019, appointed Mr Howard Hughes as the Investigator-in-Charge to carry out an Investigation into this Accident and prepare a Report.

Aircraft Type and Registration:	BRM Aero, Bristell NG5 '*Speedwing*', G-OJCS	
No. and Type of Engines:	1 x Rotax 912 ULS	
Aircraft Serial Number:	LAA 385-15458	
Year of Manufacture:	2018	
Date and Time (UTC)[4]:	13 June 2019 @ 18.21 hrs	
Location:	Belan, Co. Kildare	
Type of Operation:	General Aviation	
Persons on Board:	Crew – 2	Passengers – Nil
Injuries:	Crew – 2 (Fatal)	
Nature of Damage:	Aircraft Destroyed	
Commander's Licence[5]:	Private Pilot Licence (PPL) Aeroplane (A) issued by the Irish Aviation Authority (IAA)	
Commander's Age:	58 years	
Commander's Flying Experience:	298 hours, of which 11 were on type	
Notification Source:	An Garda Síochána/Irish Coast Guard	
Information Source:	AAIU Field Investigation	

[4] **UTC**: Co-ordinated Universal Time. Unless otherwise stated, all times in this Report are quoted in UTC; Local time was UTC + 1 hour on the date of the accident.
[5] In this Report, the Commander is taken to be the Pilot in the left seat of the aircraft.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

SYNOPSIS

On 13 June 2019, at 18.02 hrs, the aircraft, a Bristell NG5 '*Speedwing*', took off from Kilrush Airfield (EIKH), Co. Kildare, with two pilots on board. The purpose of the flight was to familiarise one of the new owners with the aircraft. During the flight, two stall exercises were carried out. Both stall exercises were commenced from an altitude of approximately 3,300 ft. During recovery from the second stall, the aircraft departed from controlled flight and commenced a rapid descent, entered a spiral dive, following which the aircraft entered a flat spin. The aircraft remained in the flat spin until it impacted the ground in an agricultural grass field, approximately 5.2 nautical miles (NM) south of EIKH, at Belan, Co. Kildare. The aircraft was destroyed. Both occupants were fatally injured. There was no fire.

Ten Safety Recommendations are made as a result of this Investigation.

NOTIFICATION

On 14 June 2019, at 02.30 hrs, the AAIU Duty Inspector was informed by An Garda Síochána that an aircraft had been reported missing. At 03.29 hrs, the AAIU Duty Inspector was notified by the Irish Coast Guard, that the wreckage of a light aircraft had been found. Two Inspectors of Air Accidents deployed to the accident site and commenced an investigation.

PREAMBLE

The aircraft, registration G-OJCS, had recently been purchased by a syndicate comprising three pilots. It was delivered to Ireland on 24 March 2019 by a UK pilot who was involved in the sale of the aircraft to the syndicate. The syndicate members agreed that they all required familiarisation with the aircraft. To facilitate this, the syndicate asked an acquaintance, who was a pilot and a flight instructor, with 2,735 hours flying experience, to familiarise himself with the aircraft by flying with the delivery pilot, and then to pass on the knowledge so gained, to each of them. This would be accomplished by the acquaintance accompanying each member of the syndicate in turn, during the first few months of their ownership of the aircraft.

The Investigation was informed that syndicate members would occupy the left (the commander's) seat, and act as Pilot Flying (PF), when accompanied by the acquaintance they had asked to assist them in become familiar with the aircraft. In this Report, the member of the syndicate who was seated in the left (the commander's) seat is referred to as the '*Left Seat Pilot*'. The right seat was occupied by the acquaintance, and is referred to as the '*Right Seat Pilot*'. On the day of the accident, the aircraft's previous flight had been flown by one of the other syndicate members, who had also been accompanied by the Right Seat Pilot.

The Investigation asked the syndicate members what was the likely nature of the flight. The Investigation was informed that they believed the Left Seat Pilot was going to carry out some general handling which might include practice stalls[6], and stall recovery.

[6] A stall occurs when the angle of attack of an aerofoil (the angle of the aerofoil relative to the incident airflow) exceeds the value which creates maximum lift as a consequence of airflow across it. This angle varies very little in response to the cross section of the (clean) aerofoil and is typically around 15°. At the stall, the airflow across the upper cambered surface of the aerofoil ceases to flow smoothly, and becomes turbulent, thus greatly reducing lift and increasing drag.

The accident aircraft was constructed in the UK from a kit under what the UK Civil Aviation Authority (CAA) refers to as the '*51% rule*'[7]. The kit was derived from an aircraft originally designed and produced as a factory-built aircraft. In this Report, the term '*Aircraft/Kit Manufacturer*' is used to denote the company that designs and produces both the kits and completed aircraft. Therefore, in addition to examining the subject aircraft, the Investigation also examined aspects of the factory-built versions of the aircraft, where appropriate.

1. FACTUAL INFORMATION

1.1 History of the Flight

On 13 June 2019, at 18.02 hrs, the aircraft took off from Runway 29 at EIKH. Shortly after take-off, the aircraft took up a northerly track and climbed initially to 1,600 ft. It then turned slightly left, and took up a north-westerly track. As the aircraft approached a point approximately 6 NM to the north-west of EIKH, it descended to 1,300 ft, and performed a left orbit at this altitude. Following this, the aircraft routed on a southerly track for approximately 4 NM, before turning onto a south-south-easterly track for approximately 7 NM. The aircraft then climbed to an altitude of approximately 3,300 ft.

Between approximately 18.12 hrs and 18.15 hrs, whilst maintaining the south-south-easterly track, the aircraft descended from 3,300 ft, to approximately 2,900 ft, on two occasions, each time returning to approximately 3,300 ft. During both descents the aircraft maintained a wings-level attitude, whilst there were variations in aircraft pitch, airspeed, and engine power. As the aircraft climbed back to 3,300 ft the second time, it turned onto a south-easterly track and at 18.16 hrs, the aircraft commenced a 360° turn to the left. This was followed immediately by a 360° turn to the right.

Following these turns, the aircraft maintained a south-south-easterly track during which the engine power was reduced to idle, airspeed was reduced, and a stall exercise was performed, during which the right wing dropped. The aircraft then rolled to the left and descended. The aircraft was recovered to wings level and continued a descent to 2,500 ft. The aircraft then turned onto a westerly track and commenced a climb back to approximately 3,300 ft.

On this track, another stall exercise was performed, during which the right wing dropped again, following which the aircraft once more rolled to the left and descended. The aircraft entered a spiral dive, and from the spiral dive it entered a flat spin[8], which continued until the aircraft impacted level terrain. Both occupants were fatally injured. There was no fire.

[7] **51% Rule**: The 51% rule as related to a '*Permit to Fly*' issued for the purpose of operating an amateur built aircraft means that when the aircraft is completed, the majority of the fabrication and assembly tasks have been performed by the amateur builder(s) who submitted the application for the '*Permit to Fly*' (Ref CAP 659).

[8] **Flat Spin:** '*A flat spin is characterized by a near level pitch and roll attitude with the spin axis near the CG* [Centre of Gravity] *of the airplane. Recovery from a flat spin may be extremely difficult and, in some cases, impossible*'. (FAA Advisory Circular AC No: 61-67C, 25 September 2000).

1.1.1 Witness Observations

One witness, located to the northwest of EIKH, saw the aircraft overhead their location. This witness informed the Investigation that the aircraft appeared to be flying normally, and that the engine sound appeared normal.

The accident site was located in a grass field, approximately 290 m north of a dwelling. The occupants of the dwelling informed the Investigation that those present in the house, at the time of the accident, did not hear any noise of an aircraft or the sound of an impact.

Appeals were made through An Garda Síochána[9] for possible witnesses and/or dash-cam footage from a nearby motorway. However, no information relating to the accident was forthcoming.

1.1.1.1 Other Syndicate Members

The Investigation spoke to the other two members of the aircraft syndicate. The Investigation was informed that the syndicate members and the Right Seat Pilot had watched an on-line video of what they believed was the same type of aircraft as the one they had just purchased. The video showed an aircraft (not the subject aircraft type) in what appeared to be an unrecoverable flat spin, during which a ballistic recovery parachute was deployed. The syndicate members noted that intentional spins are prohibited by the aircraft's Pilot Operating Handbook (POH) and Flight Permit, and after watching the video they all agreed that the aircraft should never be intentionally spun, or put in a situation where it might spin.

The Investigation was also informed that the Right Seat Pilot had pointed out the importance of safe practices such as not having any side-slip[10] or yaw on the aircraft during stalling exercises, as this could lead to inadvertent spins during stalling. One of the syndicate members told the Investigation that, during subsequent stall exercises, the Right Seat Pilot would always ensure that the aircraft was not yawing when a stall was being performed. The syndicate members also noted that the Right Seat Pilot emphasised the importance of performing HASEL[11] checks prior to stalling, part of which involved ensuring that seat harnesses were secure.

The syndicate members also informed the Investigation that the Left Seat Pilot (the syndicate member on board) was very conservative in how he would handle an aircraft. He was described as being '*somewhat cautious of even stalling an aircraft, but knew it was something he should become familiar with and that should be practised*'. One of the syndicate members informed the Investigation that he believed the Left Seat Pilot had not yet practised stalling the subject aircraft. He also told the Investigation that, in his experience, the Right Seat Pilot would not demonstrate stalling, but would observe the syndicate members carrying out stalls themselves.

[9] **An Garda Síochána:** The national Police Service of the Republic of Ireland.
[10] **Side-slip:** A condition where an aircraft's fore-aft axis (X-axis), is offset to the oncoming airflow.
[11] **HASEL:** An acronym standing for Height, Airframe, Security (Including seat harness), Engine, Lookout (usually carried out by performing '*clearing turns*'). HASEL is a check aimed at ensuring the aircraft and the area around it is safe to perform a particular manoeuvre.

The Investigation enquired of the syndicate members as to aircraft behaviour during a stall. The Investigation was informed that the aircraft would always drop a wing, often the right wing, and that the amount of wing-drop was in the region of 10-15°. The syndicate members said that their stall recovery technique involved un-stalling the wings by moving the control stick forward to reduce the angle of attack and at the same time correcting any wing-drop with opposite rudder input. They would then allow the indicated airspeed to increase, before gradually increasing engine power.

The syndicate members also informed the Investigation that, compared to other aircraft they had flown, the subject aircraft displayed a greater tendency to yaw left when engine power was applied, such as during take-off.

1.2 Injuries to Persons

Both pilots sustained fatal injuries.

Injuries	Crew	Passengers	Others
Fatal	2	0	0
Serious	0	0	0
Minor /None	0	0	

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

The aircraft impacted a grass field. There was associated impact damage to the ground surface. The aircraft fuel tanks ruptured on impact, resulting in some ground surface contamination from fuel.

1.5 Personnel Information

1.5.1 Left Seat Pilot Details

The Left Seat Pilot was a male, aged 58 years. Records indicate that he held a European Union PPL(A) issued by the IAA in July 2014. The Left Seat Pilot held a Single Engine Piston (SEP) (land) rating, valid until 31 July 2020. The Left Seat Pilot underwent regular pilot medical examinations with an Aeromedical Examiner (AME), the most recent of which had been carried out on 2 May 2019. Following the medical examination, the Left Seat Pilot was issued with an EASA Class 2 medical certificate, which was valid for one year. The Left Seat Pilot had previously been issued with a Canadian PPL in 1998.

1.5.2 Left Seat Pilot's Flying Experience

The Investigation obtained copies of the Left Seat Pilot's personal flying logbooks. Whilst regular entries had been made, the Left Seat Pilot had not yet commenced recording his flight time in the accident aircraft in his personal logbook. However, notes obtained from a separate document showed that the Left Seat Pilot had flown for 11 hours in the accident aircraft. There was no record in the Left Seat Pilot's flying logbooks, or the separate notes of his recent flights, that he had practiced stalling in the subject aircraft. The Left Seat Pilot's flying experience is shown in **Table No. 1**.

Total all types:	298 hours
Total on type:	11 hours
Total on Type P1:	11 hours
Last 90 days:	11 hours
Last 28 days:	4 hours
Last 24 hours:	0 hour

Table No. 1: Left Seat Pilot's Flying Experience

A review of the Left Seat Pilot's flying logbook indicated that approximately 90% of his flying experience was on a high-wing light aircraft, commonly used for flight training. For both his Canadian and Irish PPLs, the Left Seat Pilot had trained and undergone his flight test on such an aircraft type, which was also the type in which the Left Seat Pilot would have carried out most of his stall recovery training. The Left Seat Pilot's only recorded previous experience in a Light Sports Aircraft category, other than the accident aircraft, was of two short flights (30 minutes and 25 minutes respectively), as P2, 12 months previously.

1.5.3 Right Seat Pilot Details

The Right Seat Pilot was a male, aged 70 years. He had been issued with a PPL(A) in 1978 and, at the time of the accident, held a Commercial Pilot Licence (Aeroplane), CPL(A), which was first issued by the IAA on 30 May 2005. The CPL(A) contained the following ratings: SEP (Single-Engine Piston) (land), Flight Instructor (Aeroplane) – SEP (land), both of which were valid until 2021.

Records indicate that on 26 February 2019, he underwent a medical examination administered by an AME. The Medical Certificate that was issued covered both Class 1 (required for CPL), and Class 2 (required for the PPL). It was issued on 21 May 2019, with the Class 1 Certificate valid until 26 August 2019, and the Class 2 Certificate valid until 26 February 2020.

The Investigation was provided with copies of the Right Seat Pilot's personal flying logbooks. His flying experience is shown in **Table No. 2**.

Total all types:	2,735 hours
Total on type:	23 hours
Last 90 days:	43 hours
Last 28 days:	15 hours
Last 24 hours:	1 hour

Table No. 2: Right Seat Pilot's Flying Experience

The UK agent for the aircraft kit informed the Investigation that he had demonstrated a stall and recovery to the Right Seat Pilot, and that the Right Seat Pilot then practiced one stall and recovery. This was done with the Right Seat Pilot seated in the right seat. Records indicate that the Right Seat Pilot had been on board the aircraft when stalling exercises were carried out by the other syndicate members.

1.6 Aircraft Information

1.6.1 General

The Bristell NG5 '*Speedwing*' aircraft, (**Photo No. 1**), is a single-engine, all metal, low-wing monoplane of semi-monocoque construction with two side-by-side seats. The aircraft is equipped with a fixed tricycle undercarriage with a steerable nose-wheel. The subject aircraft was fitted with a Rotax 912 ULS, 4-cylinder, 4-stroke engine.

A number of variants of the NG5 are available, some with a 9.13 m wingspan and some with an 8.13 m wingspan. The Bristell NG5 '*Speedwing*' variant is understood to refer to the kit-built version available in the UK, and that the '*Speedwing*' designation refers to it having the shorter wingspan.

Each seat position was fitted with a four-point restraint harness, with a rotary quick-release mechanism (**Section 1.6.9**). The aircraft was not fitted with a stall warning device, nor is one required to be fitted to an aircraft that exhibits sufficient aerodynamic warning of the approaching stall, e.g. pre-stall buffet. The post-construction flight test report prepared by a UK LAA inspector noted that the aircraft exhibited pre-stall buffet.

Photo No. 1: The accident aircraft.

The aircraft was equipped with dual flight controls, allowing persons seated in either the left or right seat to control the aircraft. A key-operated engine start switch was located on the far left side of the main instrument panel, in front of the left seat, where the cockpit side wall meets the instrument panel (**Figure No. 1**). The start switch cannot be reached by a person seated in the right seat, with their shoulder straps securely fastened.

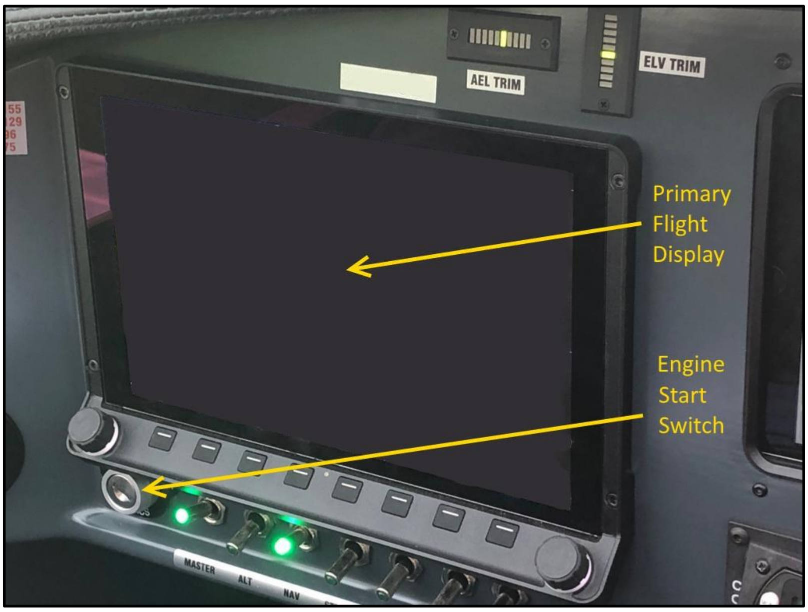

Figure No. 1: Location of Engine Start Switch

The aircraft was fitted with trailing edge wing flaps. The position of the flaps could be changed by an electrical actuator, controlled by a rotary selector switch on the central console. Four flap positions could be selected: flaps 0° (flaps up), flaps 10°, flaps 20°, and flaps 30°.

The aircraft design included a number of options for baggage stowage. The subject aircraft had two wing lockers, one in each wing and an area behind the cockpit seats which included a raised portion meeting the rear bulkhead. This is referred to as the '*parcel shelf*' in this Report.

The POH supplied by the UK agent for the Aircraft/Kit Manufacturer, stated that the maximum take-off weight was 600 kg, and that the Mean Aerodynamic Chord (MAC)[12] was 1.367 m, from the leading edge of the wing. Technical data for the short wing ('*BASIC AERODYNAMIC CALCULATION OF BRISTELL UL HD*', dated 25 June 2011), provided to the Investigation by the Aircraft/Kit Manufacturer, showed that the MAC was located 2.0705 m outboard of the aircraft's axis of symmetry.

The Aircraft/Kit Manufacturer subsequently provided the Investigation with new data for the short wing, in a document dated 9 August 2021. This showed a MAC of 1.3745 m, located 1.854 m outboard of the aircraft's axis of symmetry.

[12] **MAC:** The distance between the leading and trailing edge of the wing, measured parallel to the normal airflow over the wing, is known as the chord. For tapered wings the chord length changes along the span of the wing. The average length of the chord is known as the mean aerodynamic chord (MAC). Aircraft centre of gravity limitations are often expressed in terms of percent MAC, i.e. how far aft the CG is from the front of the MAC.

The aircraft wing is made up of three sections: the centre-wing, with a leading edge perpendicular to the longitudinal axis of the aircraft; and two outer-wing sections. Both the original aerodynamic data and the 'new' data provided by the Aircraft/Kit Manufacturer indicated that the leading edge of the outer-wing had a sweep-back angle of between 1.745 degrees and 1.747 degrees.

Figure No. 2 shows an extract from Section 2 of the aircraft POH, which contains information about aircraft Centre of Gravity and Approved Manoeuvres:

2.7 Center of gravity

Operating C.G. range.. *25 to 35 % of* MAC

2.8 Approved manoeuvres

Airplane Category: Group 'A'

The BRISTELL SW is approved for normal and below listed manoeuvres:

- Steep turns not exceeding 60° bank
- Lazy eights
- Chandelles
- Stalls (except whip stalls)

WARNING

Aerobatics and intentional spins are prohibited !

Figure No. 2: Extract from Section 2 of Aircraft POH (Revision 1.1 dated April 2015)

Section 2.9 of the POH gave the aircraft manoeuvring load factor limits. These were stated as:

- Maximum positive limit load factor ....+4 *g*
- Maximum negative limit load factor ....-2 *g*

In addition, the Investigation was informed by the UK LAA, that as part of the Aircraft/Kit Manufacturer's development testing program, the aircraft outer wing was tested to the equivalent of +6.85 *g* without showing permanent deformation.

1.6.2 Stall speeds

Table No. 3, which shows the stall speeds for the aircraft type, is taken from the POH supplied with the aircraft:

Conditions: Max. take-off weight. Engine idle run	Wing flaps pos.	KIAS[13]	KCAS[14]	Altitude loss at recovery [ft]
Wing level stall	0°	43	43	85
	10°	40	40	124
	30°	34	34	164
Co-ordinated turn 30° bank	0°	46	46	118
	10°	42	42	164
	30°	37	37	197

Table No. 3: NG5 Stall speeds (kts) and expected altitude loss during stall recovery

1.6.3 Propeller Variable Pitch Mechanism

The aircraft was fitted with a Fiti Design, Eco Competition, Variable Pitch, three-bladed propeller. The direction of rotation of the propeller was clockwise, as viewed from the cockpit. The propeller was constructed from composite materials, and the stated diameter was 1,580 mm. The propeller pitch was adjustable in flight via a switch in the cockpit, which operated an electrically driven pitch-change mechanism. Two pitch settings were available: fine-pitch and coarse-pitch.

Examination of the aircraft at the accident site showed that the cockpit propeller pitch selector switch was set to '*FINE*'. Examination of the pitch-change mechanism at the AAIU wreckage facility indicated that the mechanism had been operating in fine-pitch at the time of the accident.

1.6.4 Aircraft Construction

The aircraft was available as a home-build kit in the UK under the UK CAA's 51% rule, set out in UK Civil Aviation Publication (CAP) 659[15]. The subject aircraft kit had been assembled, weighed, and test-flown by the previous owner, under the auspices of the UK LAA. The kit itself was manufactured in the Czech Republic by the Aircraft/Kit Manufacturer which produces both completed aircraft and aircraft kits. The original owner acquired the kit in 2017, from a UK agent for the Aircraft/Kit Manufacturer. Construction commenced that year, and was completed in 2018[16].

The aircraft first flew on 5 June 2018, when it underwent a post-construction flight test schedule carried out by a UK LAA inspector. As part of the schedule the aircraft's stall characteristics were assessed. They were noted as satisfactory, and that the aircraft exhibited a left wing drop at the stall, that was categorised as '*slight*' (the flight test schedule notes '*Wing drop to be contained within 20° angle of bank*').

[13] **KIAS:** Knots Indicated Airspeed.
[14] **KCAS:** Knots Calibrated Airspeed. Indicated Airspeed corrected for instrument and position error.
[15] **CAP 659**: *Amateur Built Aircraft – A Guide to Approval, Construction and Operation of Amateur Built Aircraft.*
[16] UK CAA records show the year of construction for the aircraft as 2017.

The UK LAA issued a Type Acceptance Data Sheet (TADS) for the aircraft type. The TADS included the following '*LAA Required Modifications*':

'*2.6 <u>LAA Required Modifications (including LAA issued AILs[17], SBs[18], etc)</u>*

The modifications (to the standard aircraft as produced by BRM Aero) required by the LAA for acceptance of the type in the UK are as follows (details of these changes supplied by the agent, as required):

MOD-385-001 *Addition of fuel strainers at fuel pick-ups in wing tanks, to prevent blockage of fuel flow by debris entering tank. Drawing NG5W_04-KZ 24 and sketch dated 29.6.12 refers.*

MOD-385-002 *Reinforcement of nosewheel steering actuating arm by increasing thickness from 1.59mm to 3.175mm, drawing NG5C_02_0201_02 refers.*

MOD-385-003 *Inclusion of a warning light and two microswitches mounted on the cockpit sills adjacent to the latches, to warn the pilot if the press-to-latch canopy was not securely locked down. Drawing UK-2012-003 refers. This can be omitted if a placard is positioned in clear view of the pilot stating "check both sides of canopy are locked before flight by pushing up canopy in the centre".*

MOD-385-004 *Substitution of larger span tailplane from the standard wing LSA* [Light Sports Aircraft] *variant.*

MOD-385-005 *Inclusion of a rate controller to slow down the pitch trim to achieve a stop-to-stop time of between 19 and 25 seconds. Acceptable controllers are the Maplin pulse width modulator part number WC76H or RS Components 238-9816.*

MOD-385-006 *Fitment of Facet pump type 40106 (Rotax 912-ULS engine) or type 40105 (Jabiru engines) as electric boost pump. Not required on Rotax 912iS engines.*'

The TADS also included a statement that a '*UK Pilots Operating Handbook has been created for the UK model and is available from the agents*'.

[17] **AIL**: Airworthiness Information Leaflet
[18] **SB**: Service Bulletin.

1.6.5 Certificate of Design

The UK LAA issued a document, known as a '*Certificate of Design*' on 31 May 2018, specific to the subject aircraft. The document noted that there had been no modifications or changes to the subject aircraft. Under the section titled '*Other Changes*', was the following statement:

> *Changes falling into the following categories need not be recorded here, but **<u>must be recorded in the aircraft's logbook(s)</u>**:*
>
> - *MPDs[19] applying to the type or installed equipment*
> - ***<u>Modifications promulgated by LAA AIL</u>***
> - *Standard options for the type as listed in Section 3.2 of the current TADS for the type (if available)*
> - *Changes as a result of the aircraft manufacturer's published service information*
> - *Modifications or repairs approved by LAA after the issue of this certificate (these will be issued with further Certificates of Design)*
> - *Changes made In accordance with current LAA published procedures (e.g. Standard Modifications and minor repairs)*

Note: ***<u>emphasis added</u>*** by the Investigation.

The following Declaration was also included in the Certificate of Design:

> '*I certify that the above aircraft complies with the stated design standard and has been constructed to acceptable aeronautical standards.*'

The Investigation did not find a record in Part C (Modifications and Other Technical Instructions) of the aircraft logbooks, of any of the promulgated modifications having been incorporated. However, documented records, which form part of the build process, did show that the relevant modifications required in the TADS had been carried out[20]. In respect of MOD-385-003, the records for the aircraft stated that the fitting of an '*open canopy warning light*' was not applicable as placards had been fitted. The Investigation did not find such a warning placard in the accident aircraft. However, the UK LAA inspector, that oversaw the build process, informed the Investigation that he recalled the relevant placard as having been fitted to the subject aircraft.

1.6.6 Cockpit Canopy

The aircraft is fitted with a large bubble canopy, which opens up and forward on hinges mounted on either side of the fuselage, just aft of the firewall. The lower rear portion of the canopy is fitted with two latch receivers, which lock into two rotary latches in the cockpit side walls beside each cockpit seat.

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[19] **MPD:** Mandatory Permit Directives. Issued by the UK CAA, these summarise actions that are required to be complied with by UK Owners and Operators of '*Permit to Fly*' aircraft.

[20] LAA Inspection Record for Construction (part d) LAA Required Modifications.

The canopy latches are released by a lever located on the central console between the cockpit seats, or a push-to-release button located on the left side of the fuselage exterior, adjacent to the left rotary latch.

The canopy is supported in the open position by two gas springs, also known as gas struts.

In relation to the UK kit version of the subject aircraft type, the UK LAA issued the following advisory information:

'*3.5 Special Test Flying Issues*

• *If the aircraft exhibits a marked wing drop at the stall, check adjustment of the canopy latch mechanism and the wing lower gap seals.*'

As this issue related to test flying of the aircraft, the other syndicate members were not aware of this advisory information. One syndicate member informed the Investigation that on occasion, there was a noticeable draught from the right side of the canopy, where the bottom edge of the canopy closed against the sidewall of the cockpit.

1.6.7 Flight Instruments

Three analogue instruments were located on the instrument panel in front of the right seat. These consisted of an altimeter, an airspeed indicator and a magnetic compass.

The aircraft was fitted with an electronic display panel, which was located on the cockpit instrument panel in front of the left seat. This panel, referred to as a Primary Flight Display (PFD) system in this Report, was capable of displaying, *inter alia*, aircraft airspeed, magnetic heading, magnetic track, attitude, altitude, and engine parameters. The digital information supplied to the PFD was received from an Air Data, Attitude and Heading Reference System (ADAHRS) unit, which was mounted in the rear fuselage on the lower skin of the aircraft, behind the passenger seat. This unit received inputs from various probes and sensors, and, in addition, contained accelerometers measuring acceleration forces in the 'X' (longitudinal) axis, 'Y' (lateral) axis, and 'Z' (normal[21]) axis. The ADAHRS unit also contained solid state gyroscopes, measuring rotation rates about the 'X', 'Y', and 'Z' axes[22]. The diagram in **Figure No. 3** shows the aircraft axes, and the control surfaces used to rotate the aircraft about each axis.

[21] The Normal axis of an aircraft refers to the axis at right angles to both the longitudinal and lateral axes. It is sometimes referred to as the vertical axis.
[22] Aeronautical convention defines 'roll' as acting about the longitudinal X-axis, positive values indicating right (starboard) wing down; 'yaw' is about the normal Z-axis, positive values indicating a clockwise rotation (rotation to starboard); 'pitch' is about the lateral Y-axis, positive values indicating a nose up pitch.

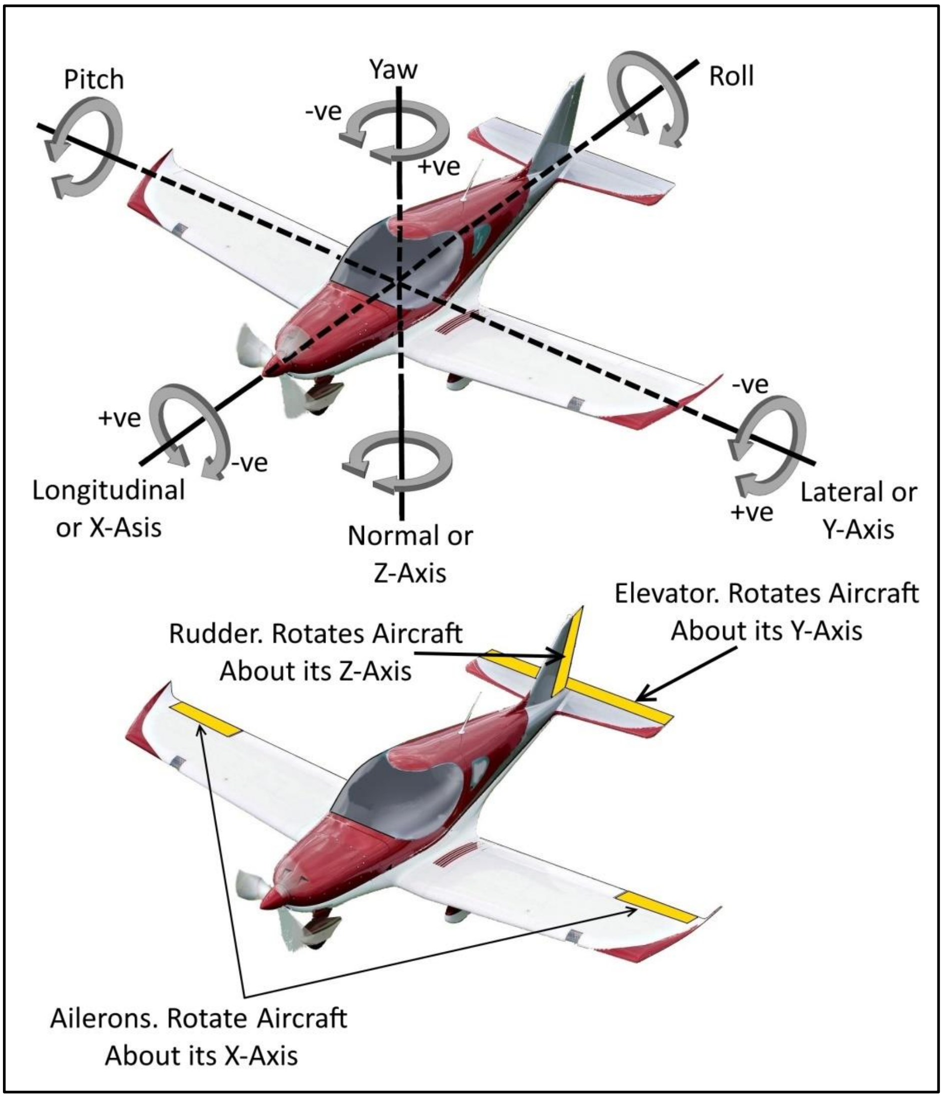

Figure No. 3: Diagram showing the aircraft axes, and the control surfaces used to rotate the aircraft about each axis

1.6.8 Pilot and Passenger Seat Dimensions

The aircraft was fitted with two side-by-side seats, with the seat backs reclined at 25° to the vertical (**Figure No. 4, Section 1.6.10.3**).

Each aircraft seat comprised a separate base and back plate made from moulded sheets of composite material approximately 15 mm thick. For comfort, these had cushioning material bonded to the surface. The subject aircraft's cushion material was measured, and found to have a thickness of 56 mm, uncompressed. The cushion material could be compressed to a minimum thickness of approximately 11 mm.

The rear portion of the seat base rested on the fuselage floor. The seat base was angled up such that the forward portion of the seat base rested on the aircraft's main-spar.

1.6.9 Seat Restraint Harness

Each of the two seating positions in the aircraft was equipped with a four-point restraint harness. Each harness consisted of two lap straps, and two shoulder straps. The straps were anchored to the aircraft structure. There was no inertial release mechanism on the shoulder straps. One lap strap was permanently attached to a rotary cam-lock mechanism, into which the other lap strap and the two shoulder straps could be secured. Once latched, the straps released by rotating a lever located on the cam-lock mechanism approximately 90° left or right of its neutral position (**Photo No. 2**); all straps are released at the same time.

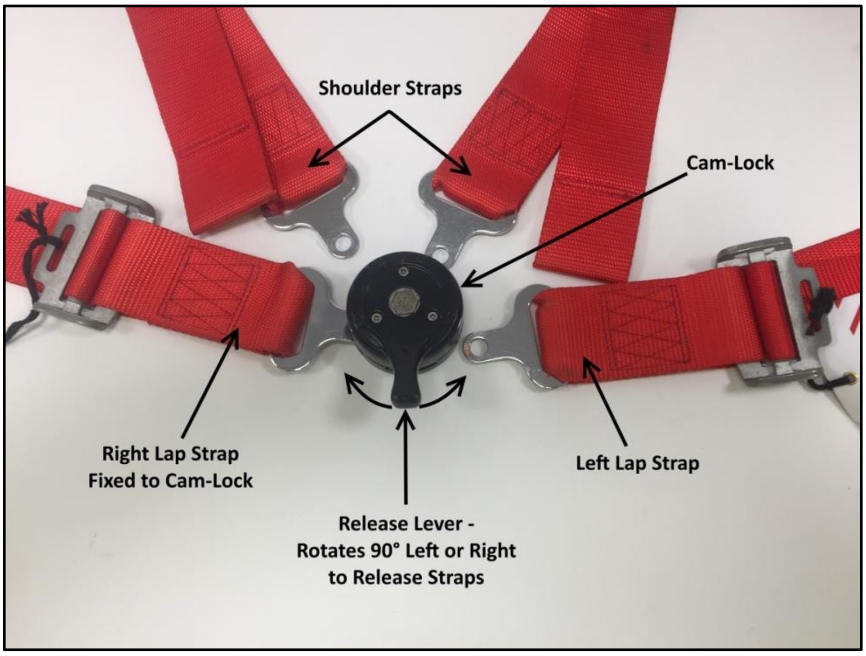

Photo No. 2: Aircraft Left Seat Harness (with release lever shown in neutral position)

The lap strap that was permanently attached to a rotary cam-lock mechanism was anchored inboard of its associated seat, adjacent to the central arm rest. When unfastened, the lap strap with the attached rotary cam-lock mechanism would rest either across the armrest, and partially on the opposite seat, or on the base of its associated seat.

1.6.10 Weight and Balance

1.6.10.1 General

A number of forces act on an aircraft in flight: thrust, which is opposed by drag, and lift[23], which opposes weight. In level flight, lift opposes the downward force of weight. Weight is the combined mass of the aircraft, crew, fuel, and cargo or baggage, multiplied by gravity (*g*). Weight acts vertically downward through the aircraft's centre of gravity (CG).

[23] The total lift of an aircraft, i.e. the sum of all lift generated by the various aircraft sections, such as the wings, control surfaces, and aerodynamic fuselage parts, is said to act through the centre of lift (abbreviated to COL, CoL, or CL). For a conventional aircraft, where the wings are ahead of the horizontal tail section, the CL is normally behind the CG.

The relative position of the CG is an important factor in the stability and flight characteristics of an aircraft. For the safe operation of an aircraft, it is important that the CG of a loaded aircraft, and the total weight of the aircraft, remain within certain defined limits. The CG of an aircraft is usually determined by measuring how far from a known datum point the various loads, which make up the total weight, are acting. The distance of a load (or weight) from the datum is termed its '*arm*', often referred to as the moment arm.

In flight, the location of the aircraft's centre of lift and CG are not normally co-located, and the aircraft's horizontal stabiliser is used to provide the longitudinal balance between these opposing forces. Therefore, the position of an aircraft's CG will have an effect on the degree of elevator deflection needed to supply the appropriate tail force for equilibrium. The CG position, therefore, has a significant effect on aircraft stability and its stall/spin entry and recovery. FAA AC 61-67C '*Stall and Spin Awareness Training*', states:

> *'The CG location has a direct effect on the effective lift and AOA of the wing, the amount and direction of force on the tail, and the degree of stabilizer deflection needed to supply the proper tail force for equilibrium. The CG position, therefore, has a significant effect on stability and stall/spin recovery. As the CG is moved aft, the amount of elevator deflection needed to stall the airplane at a given load factor will be reduced. An increased AOA will be achieved with less elevator control force. This could make the entry into inadvertent stalls easier, and during the subsequent recovery, it would be easier to generate higher load factors due to the reduced elevator control forces. In an airplane with an extremely aft CG, very light back elevator control forces may lead to inadvertent stall. Recovery from a flat spin is often impossible'.*

The weight and CG limits for an aircraft, and the details required to calculate the aircraft weight and CG are usually set out in the Flight Manual, sometimes referred to as the POH, or Aircraft Operating Instructions (AOI), which is produced by an aircraft manufacturer.

1.6.10.2 Subject Aircraft Weight and Balance Documentation

The Aircraft/Kit Manufacturer informed the Investigation that it did not supply a POH with kit-built aircraft, as individual builders might introduce variations during the construction, e.g. installing a different engine. The UK agent for the Aircraft/Kit Manufacturer had supplied a document titled '*Pilot Operating Handbook*' with the aircraft which, the Investigation was informed, was based on a POH from the Aircraft/Kit Manufacturer's factory-built aircraft, and had the Aircraft/Kit Manufacturer's logo on each page. Two pages from the POH supplied with the subject aircraft are shown in **Appendix A**.

The UK LAA informed the Investigation that a POH is not required for kit-built aircraft. The UK LAA stated that *'where a POH exists, unless the POH is identified on the Permit to Fly, the information contained in the POH is considered advisory'.* The UK LAA also informed the Investigation that *'the wording of the Permit to Fly makes clear that where a conflict exists between the manufacturer's advice (eg in a POH) and the limitations document forming part of the Permit to Fly, the limitations on the limitations document apply'.*

The UK LAA also requires, amongst other things, that an aircraft is weighed and that a '*Weight and Balance Report*', and a '*Weight and Balance Calculation*' is prepared, prior to an aircraft being recommended for a *'Permit to Fly'*. Both documents for the subject aircraft showed the datum point as being the leading edge of the wing at the fourth rib[24], and the moment arm for a pilot and passenger as being 600 mm aft of that datum. The Investigation notes that these are the same values as published in the POH produced by the Aircraft/Kit Manufacturer. The weight and balance limitations set out in the Aircraft/Kit Manufacturer's POH and the UK LAA Operating Limitations document were also found to be the same.

Following build-completion of the subject aircraft, a '*Weight and Balance Report*' was prepared by the original owner. The aircraft weighing, and the Weight and Balance Report preparation was supervised by a UK LAA Inspector. The report stated that the CG limits for the aircraft were between 338 mm and 472 mm aft of the datum point. In the '*Weight and Balance Report*' the empty aircraft weight was reported as 327.49 kg, and the empty aircraft CG was reported as 361 mm aft of datum[25]. This is equivalent to 26.4% MAC.

The Irish owners of the accident aircraft were in possession of the POH that had been provided with the aircraft, into which had been entered the aircraft empty weight data. This matched the data that had been entered on the UK LAA Weight and Balance Report Form. The accident aircraft POH also contained a section for calculating aircraft laden CG, which listed the moment arms for the various variable load items such as pilot, passenger, and fuel, etc. These variable load moment arm values were compared to those specified in a POH for a factory-built aircraft, and were found to be the same[26].

The Investigation was informed by one of the syndicate members that they had been shown how to determine the correct loading of the aircraft, and how to calculate the CG of their aircraft, by the Right Seat Pilot. They also informed the Investigation that they understood that the POH supplied with the aircraft was a valid document and that by loading the aircraft according to the moment arms, and variable load limit contained in the POH, the aircraft would be within the prescribed CG limits when they were flying.

The various variable loads[27] that were on the subject aircraft at the time of the accident are shown in **Table No. 4**, in **Section 1.6.10.4**. Using this data, the Investigation calculated the weight of the aircraft at take-off as 570.5 kg. The Investigation also calculated the laden aircraft CG for the accident flight at the time of take-off and at the time of the accident.

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[24] Due to the nature of the wing construction the Investigation notes that it is difficult to locate the fourth wing rib.

[25] The UK LAA informed the Investigation that in its Weight and Balance documentation, the fore and aft CG limits are defined as a distance from Datum, and not with reference to % MAC.

[26] A difference in moment arm for baggage stowed in the fuselage (behind the cockpit seats) was noted in some POHs. In one case it was given as 2.0 m aft of datum, in another case the area behind the seats was divided into two areas, that directly behind the seats was given as 1.4 m aft of datum, and the area aft of this (the parcel shelf) was given as 2.0 m aft of datum. The POH supplied with the accident aircraft gave just one moment arm for baggage stowed in the fuselage, which was 2.0 m aft of datum. The UK LAA weight and balance documentation gave a moment arm of 1.4 m aft of datum for baggage stowed behind the cockpit seats, referred to as Baggage Bay 1.

[27] In this Report, '*Variable Load*' refers to items on an aircraft which may vary in terms of weight and/or location, e.g. pilot weight, baggage weight and location, and fuel load.

The moment arm for a pilot and passenger, as contained in the POH supplied with the aircraft, was 0.6 m (600 mm) aft of datum, (see section highlighted in red in **Appendix A**). The same moment arm for a pilot and passenger was given in the UK LAA Weight and Balance Report Form. Using the variable load moment arms as given in the POH, to calculate the aircraft's laden CG position, the result was 31.9% MAC. This result would suggest that the aircraft was within the CG limits as stated in the POH, which were given as between 25% and 35% MAC. However, the Investigation identified discrepancies with the moment arms and MAC that adversely affected this result (**Section 1.6.10.3** refers).

The UK LAA weight and balance documentation, the subject aircraft POH, and POHs viewed by the Investigation, for other NG5 aircraft, all gave the moment arm for the wing stowage lockers as 0.63 m (630 mm) aft of the wing rib number four datum, i.e. further aft than the moment for a pilot and passenger.

It should also be noted that, due to the location of the fuel tanks in the forward portion of each wing, with a moment arm of 0.2 m, the greater the fuel load, the more forward the aircraft's laden CG. Conversely, as fuel is consumed, the aircraft CG moves aft.

1.6.10.3 Subject Aircraft Pilot and Passenger Moment Arm Determination

As noted in **Section 1.6.10.2,** both the UK LAA weight and balance documentation, and the POH provided with the aircraft stated that the moment arm for persons seated in the aircraft was 0.6 m (600 mm), aft of the datum point.

In order to determine where this moment arm was located relative to the aircraft structure, the Investigation requested details of the pilot and passenger seat locations within the cockpit from the Aircraft/Kit Manufacturer. A technical drawing of a cross-section of the cockpit showing a seat, and its reference dimensions was provided by the Aircraft/Kit Manufacturer. This also showed that the aircraft seats reclined at 25° to the vertical.

Using a proprietary CAD[28] program, anthropometric[29] data, and the centre of mass (CM) of the human adult when seated in a 25° reclined position, as obtained from a research document on the subject [30], in conjunction with the seat dimension data provided by the Aircraft/Kit Manufacturer, the Investigation calculated the most probable location for a pilot and passenger CM, when seated in the aircraft type. From this it was determined that the CM of an adult male seated in the aircraft, and thus the moment arm, was located 0.780 m (780 mm) aft of the Datum Point of the aircraft, and not 0.6 m (600 mm) as stated in the POH and the weight and balance document.

These findings were sent by the Investigation to the Aircraft/Kit Manufacturer, on 25 June 2020, with a request for the Manufacturer '*to review the Weight and Balance document, as set out for this aircraft in its POH, with a view to confirming that the moment arm for a pilot and passenger, accurately reflects the current seat layout of the aircraft*'.

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[28] **CAD:** Computer-aided design.

[29] Anthropometry involves the systematic measurement of the physical characteristics of the human body, including body size shape, and weight, and plays an important role in industrial design.

[30] Human Centre of Mass (CM) document provided to the Investigation by a University Aeronautical Engineering Department. This showed the CM of a 100 kg person is located 139 mm ahead of where the seat back meets the seat base, when reclined at 25°.

The Aircraft/Kit Manufacturer responded to the Investigation and suggested that its value for the moment arm, as published in various POHs was correct and that the Investigation's method for determining the moment arm was incorrect. The Aircraft/Kit Manufacturer also advised how its value had been determined. The Aircraft/Kit Manufacturer stated that seat cushion thickness was 100 mm; this detail had not been provided when information on seat dimensions had been requested.

Based on measurements taken of the subject aircraft seats, an adjustment was made for seat cushioning material (which was 56 mm thick, and not 100 mm as advised by the Manufacturer), and its effect on the seated position of a pilot and passenger. Using these aircraft seat and seat cushion dimensions, the moment arm was calculated using the CAD program. If no allowance was made for any compression of the cushion material in the subject aircraft, the moment arm for a pilot and passenger was found to be 754 mm aft of the datum point. However, allowing for 50% compression of the seat cushion the moment arm was found to be 768 mm aft of the datum point, (**Figure No. 4**). (Note: If the seat cushion was to be compressed to the full extent found in **Section 1.6.8**, i.e. 11 mm, then the moment arm for a pilot and passenger would be 777 mm aft of aircraft datum.)

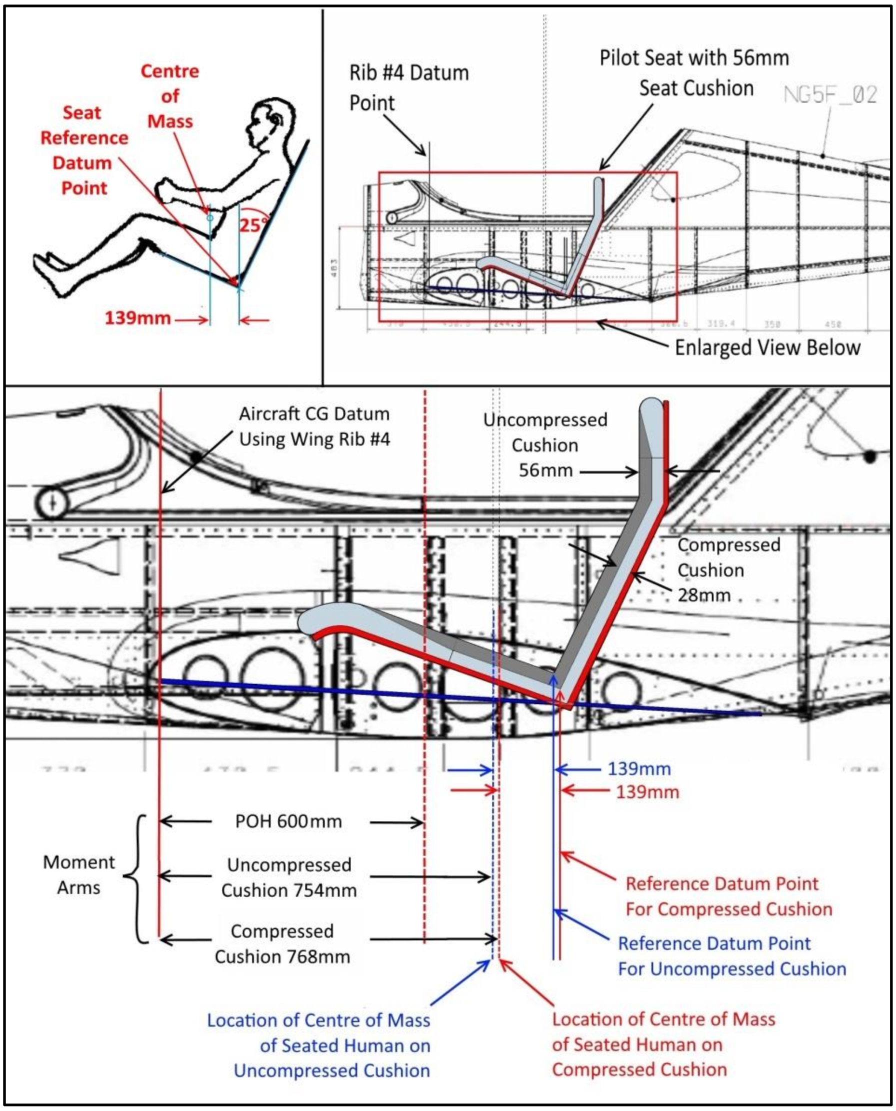

Figure No. 4: Diagram showing how the moment arm for a person seated in the NG5 was determined.

1.6.10.4 Variable Loads on Accident Aircraft

The Investigation determined the weight of the variable loads that were on the subject aircraft at the time of the accident. **Table No. 4** lists these loads.

Item	Weight (kg)
Fuel (71 Litre prior to engine start)	51.12[31]
Fuel (estimated as 65.5[32] Litre at time of accident)	47.16
Estimated Weight of Left Seat Pilot	97.30
Estimated Weight of Right Seat Pilot	89.10
Items in Wing Lockers (0.75 + 1.2 kg)	1.95
Baggage Stowed Behind Cockpit Seats	3.00

Table No. 4: Variable Loads on the Aircraft at the time of the Accident

These weights were then used for determining the laden aircraft CG at the time of the accident as follows:

1. Using the pilot/passenger moment arm of 768 mm aft of datum, as determined by the Investigation, see **Section 1.6.10.3** (see also **Appendix B**).

2. Using the amended pilot/passenger moment arm of 750 mm aft of datum, as adopted by the UK LAA and the Aircraft/Kit Manufacturer (**Sections 1.6.10.6**, **1.6.10.8**, and **Appendix H**).

1.6.10.5 Laden Aircraft Centre of Gravity

Using the moment arm for a seated pilot and passenger, with a 50% compressed seat cushion as determined in **Section 1.6.10.3**, and using the variable loads on board the aircraft at the time of the accident, as shown in **Table No. 4**, in **Section 1.6.10.4**, the Investigation determined that the CG of the aircraft at the time of the accident was 35.9% MAC (491 mm aft of datum). This is greater than the aft CG limit of 35% MAC (438 mm aft of datum), stated by the Aircraft/Kit Manufacturer. See also **Appendix B**.

1.6.10.6 Weighing of Sample NG5 Aircraft in the UK

The results of the of the Investigation's determination of the subject aircraft pilot and passenger moment arm were also sent to the UK AAIB and through them to the UK LAA. Following discussions with the UK AAIB and UK LAA, it was decided to use an alternative method to determine the moment arm for a person seated in an NG5 aircraft. The method would involve carrying out weight and balance measurements on an extant NG5 aircraft. As no NG5 aircraft were available within Ireland, the Investigation requested the assistance of the UK AAIB and LAA to source an NG5 aircraft in the UK. The weight and balance measurements were carried out by an independent agency, specialising in aircraft weighing, using a number of calibrated aircraft weight and balance scales. Due to COVID-19 travel restrictions in place at the time, this process was overseen by the UK AAIB, on behalf of the AAIU. A UK LAA inspector was also present, and assisted the UK AAIB during the weighing process.

[31] The Investigation used a standard Specific Gravity of 0.72 to convert gasoline volume to weight.
[32] Based on a fuel consumption of 17 l/hr, which was the fuel consumption found from the previous flight.

In order to determine the moment arm for a pilot and passenger, the process involved placing each of the aircraft's three wheels on separate, calibrated scales, levelling the aircraft, and taking a reading of the load on each scale. This was first done with an un-laden aircraft, to determine the un-laden CG. Then, the load for which the moment arm was to be calculated, (in this case a pilot/passenger) was placed in the aircraft, the aircraft levelled again, and the weight on each of the scales noted. This process was repeated a number of times. Following this, the formulae shown in **Appendix C**, were used to calculate the moment arm for a pilot and passenger seated in an NG5 aircraft[33].

The data obtained during this initial measurement of a sample NG5 aircraft, resulted in a range of values, but showed that the weight of a pilot and passenger, when seated in the aircraft, would be acting further aft of the datum line than the 0.6 m (600 mm) pilot/passenger moment arm indicated in the aircraft's POH. Therefore, another sample NG5 aircraft was assessed, on two separate occasions, using this same method. Again there was variation in the data obtained from the three aircraft assessments. However, the results indicated that the effective moment arm for a pilot/passenger was in excess of 720 mm aft of datum.

Regarding the variation in results, the UK AAIB noted that it was difficult to accurately level[34] the aircraft, and that there was also movement of the nose-gear as the load on the aircraft was varied, and that both of these factors could account for the variation observed in the results.

The UK LAA had assisted with the above testing, and was a party to the results obtained. Following discussions with the Investigation and the UK AAIB, the UK LAA agreed that the moment arm of 0.6 m (600 mm) for a pilot and passenger, as published in its weight and balance documentation for the NG5 '*Speedwing*' in the UK, was incorrect. During the discussions it was agreed that, as the AAIU Investigation was ongoing, the UK LAA would adopt a figure of 750 mm aft of datum for a pilot and passenger, on an NG5 aircraft, '*whilst further investigations are being carried out to determine a more accurate moment arm for a pilot and passenger*'.

1.6.10.7 Action Taken by the UK LAA

The accident aircraft was operating on a *'Permit to Fly'*. In the UK, the CAA was the issuer of the *'Permit to Fly'* on the recommendation of the UK LAA. The Investigation was informed by the UK LAA in July 2020, that there were 39 NG5 '*Speedwing*' variants operating, or under construction in the UK, and those that were operating, were doing so under a UK *'Permit to Fly'*. Following the UK LAA's decision to adopt an amended moment arm for pilot and passenger in the NG5 '*Speedwing*', the UK LAA informed both the UK CAA, and those of its members who operated this aircraft type, of the issues surrounding the weight and balance of the aircraft. This was done through the issuing of an Airworthiness Information Leaflet (AIL), (LAA/MOD/385/011 Issue 1, issued on 17 July 2020) and an Airworthiness Alert, (LAA/AWA/20/18, issued on 20 July 2020), advising UK owners and pilots of NG5 aircraft of a change in the pilot and passenger moment arm measurement to be used in pre-flight CG calculations. The documents are contained in **Appendices D** and **E**.

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[33] The Investigation understands that this same method was used by the Aircraft/Kit Manufacturer to determine a revised moment arm for persons seated in the NG5 aircraft (**Section 1.6.10.8**).
[34] With the CAD program used in **Section 1.6.10.3**, the Investigation found that a 1° change in aircraft tilt angle could result in a 15 mm change in CM location for persons seated in the aircraft.

1.6.10.8 Action Taken by the Aircraft/Kit Manufacturer

As stated in **Section 1.6.10.3**, the Aircraft/Kit Manufacturer was informed by the Investigation of its initial findings and concerns relating to NG5 pilot and passenger moment arm values as published in the POH and its effect on CG calculations. In addition, following the data obtained during aircraft weighing in the UK, both the Investigation, and the UK LAA informed the Aircraft/Kit Manufacturer of these findings.

The Investigation subsequently learned that the Aircraft/Kit Manufacturer had issued revised weight and balance documentation. The Investigation therefore requested the Aircraft/Kit Manufacturer to inform it as to the nature of any documentation issued, and whether or not any notification had been issued globally to Pilots, Operators, Training Organisations, and Maintenance Organisations, informing them of the issues surrounding CG calculation on this family of aircraft (NG5).

The Aircraft/Kit Manufacturer responded to the Investigation by an email, dated 18 August 2020, stating:

'Here are the steps we did already following the emails and communication [with] *LAA UK:*

1. *Both short wing/long wing versions of Bristell were weighed with the pilot and passanger onboard* [sic] *to check crew arm and aircraft CG position. Similar numbers as those ones found by* [LAA UK] *were found and* [they were] *informed by us.*
2. *12 pilots of various height and weight (from 55 to 140 kg) were seated to find a relation between crew weight/height and crew arm and effect on aircaft* [sic] *CG position.*
   It was found that crew [moment] *arm variates between 715 and 750 mm* […].
3. *Neutral point position and MAC length both for long/short wing were computed by an external aerodynamic specialist to check distance between CG and Neutral point.*
4. *Several flight tests on the aft C&G with two persons onboard* [sic] *were performed to re-check acft* [aircraft] *handling characteristics. The tests did no* [sic] *show any problem with handling and flight qualities at aft CG.*
5. *We have contacted instructors having more than 1000 flight hours on the Bristell to discuss their operating experience with two persons on board and heavy luggage behind the seats.*
6. *They have confirmed us that they didn't have any case, when it would be difficult to control the plane easily without any problems.*
7. *Knowing all above mentioned and after discussion with* [LAA UK] *that people may have problem to find Datum of MAC on the wing, we have decided to change Datum and use the Firewall as the Datum, so pilots can easily and directly measure any item arm on aircraft.*

As a result of above mentioned and on the basis of compliance with [UK LAA] *findings we have prepared enclosed updates of the flight manuals to inform the pilots on changes of Datum, MAC and arms of items. Also the weighing scheme was updated to show new schematic and that the aeroplane is to be leveled* [sic] *at weighing and its fuselage longitudinal axis paralel* [sic] *with the ground.*

BRM Aero is also going to issue and distribute a Mandatory Bulletin - Safety Alert (acc.to ASTM[35] *F2295) which will require the Bristell owners/users/operators to immediately start to use for W&B pre-flight check new WB scheme (Datum – firewall) and correct arms of crew, baggage, fuel to the new Datum. We are just working on the bulletin*[36]*. It will be released on our web page, distributed to the aviation authorities/bodies, to our local dealers, to Bristell owners'.*

The response from the Aircraft/Kit Manufacturer also included two documents, which the Investigation was informed were revisions to the Weight and Balance sections of the Aircraft Operating Instructions (and POH), for two NG5 variants. The pages of one document were titled '*BRLW-AOI-AU_Ra*', and the pages of the second document were titled '*BRSW-AOI-AU_Ra*'. The documents are contained in **Appendices F** and **G**. The Investigation understands that the '*LW*' and '*SW*', refers to '*Long Wing*' and '*Short Wing*', respectively.

As stated in **Section 1.6.10.4**, the Investigation had determined the weights of the variable loads on the accident aircraft. Using the amended pilot/passenger moment arm[37] issued by the Aircraft/Kit Manufacturer for pilot and passenger (equivalent to 0.750 m (750 mm) aft of wing rib number 4), it was determined that, at the time of the accident, the accident aircraft laden CG would have been 35.5% MAC, which is outside the published aft limit of CG, see **Appendix H**. The Aircraft/Kit Manufacturer's revisions of the weight and balance section of the POHs for the NG5 variants re-stated that the CG limits for the aircraft were 25-35% MAC.

However, the Investigation subsequently received information that there were actually 15 persons weighed in the aircraft, and not 12 as stated in item 2 of the email above, and that the Aircraft/Kit Manufacturer also carried out two weighing procedures where two persons were seated side-by-side in the aircraft. Therefore, 17 weighing procedures were carried out in total. Of these, just over 29% resulted in a moment arm value greater than 750 mm aft of datum. A maximum value of 757 mm aft of datum was recorded. The data from the weighing exercises did not include data on the seat cushion thickness that was present in the aircraft.

1.6.10.9 Neutral Point of the Accident Aircraft

The Neutral Point (NP) is the position of the centre of mass of an aircraft where the aircraft would be neutrally stable. Stinton (1998)[38] notes that the NP may not be fixed, and may move forward due to rearward slipstream from the propeller, when engine power is applied.

The Aircraft/Kit Manufacturer provided the Investigation with a document relating to the accident aircraft, which stated that the Neutral Point (NP), which is aft of the aircraft CG position, was located 514.62 mm aft of the wing-rib number 4 datum point. The document stated that this would equate to 37.6% MAC. The document also stated that the '*airplane will be stable in all CG range*'.

[35] **ASTM:** American Society for Testing and Materials. (See also **Section 1.6.14**.)

[36] Aircraft/Kit Manufacturer's Bulletin Number: ALL-SA-0-0-0-0001-2020, issued 7 August 2020; Bulletin Description, '*Change of crew arm for aeroplane C.G. calculation. (Rev.1 – Re-classification to Safety Directive on FAA request)*'

[37] **Note**: At the same time as amending the moment arm for a pilot and passenger, the Aircraft/Kit Manufacturer also changed the location of the Weight and Balance datum point from the leading edge of the fourth rib of the main wing, to the aircraft firewall.

[38] Stinton, D., 1998. *Flying qualities and flight testing of the airplane*. Reston, VA, American Institute of Aeronautics and Astronautics, pages 420 and 461.

The Aircraft/Kit Manufacturer subsequently provided the Investigation with a new value for the NP of 44.4% MAC, which is 610.55 mm aft of the wing-rib number 4 datum point, contained in a document dated 9 August 2021, for the short wing variant. This change to the location of the NP is an addition of approximately 96 mm to the original value of 514.62 mm, without any change to the aircraft structure.

1.6.11 Maintenance

The accident aircraft's logbooks were provided to the Investigation by the syndicate members. The last logbook entry indicated that the aircraft, engine and propeller had completed 25 hours 40 minutes flight time since the aircraft was newly constructed. This last entry was on the date of the delivery flight to Ireland, on 24 March 2019.

Other records obtained by the Investigation show that the aircraft had completed a further flight time of 22 hours 55 minutes since the last aircraft logbook entry. The aircraft had therefore completed a total flight time of 48 hours 35 minutes at the time of the accident.

The first inspections carried out on the aircraft were logged as annual inspections of the aircraft, engine and propeller. They were carried out by a UK LAA inspector. These inspections are recorded as having been carried out on 6 March 2019, at 20 hours 35 minutes recorded flight time, and the log entries stated they were valid until 25 June 2019. The aircraft logbook stated that the Annual Inspection was '*carried out as per the Bristell Manual*'.

1.6.11.1 Nose-wheel Steering Linkage

The aircraft was fitted with a steerable nose-wheel. Turning of the nose-wheel was achieved by means of a flexible telescopic control cable that linked the rudder pedals to the nose landing gear. The Investigation was informed by the syndicate members that due to damage to the original control cable, it had been replaced, following which a function check (taxi) was then carried out, with no faults noted. During subsequent flights there were no reported issues relating to the nose-wheel steering mechanism.

The Investigation was informed by other owners of this aircraft type, that misalignment of the nose-wheel could occur due to undetected faults within the control cable, or incorrect adjustment of the control cable between the rudder pedals and the nose landing gear attachment point. The Investigation was further informed that this misalignment could result in the aircraft exhibiting unwanted roll tendencies during a stall.

1.6.12 Permit to Fly

Since construction, the aircraft had operated under a *'Permit to Fly'* issued by the UK CAA.

When ownership changed, the IAA issued an interim '*Permission To Fly GA-04-2019*', which permitted the subject aircraft to fly in Irish airspace without a Certificate of Airworthiness being in force. The '*Permission To Fly*' was issued on 25 April 2019, and was valid until 18 March 2020. The IAA '*Permission To Fly*' also stated that it was only valid when attached to the UK CAA *'Permit to Fly'*.

1.6.13 Flight Test Reports

Prior to accepting the NG5 as an aircraft type suitable as an amateur-built aircraft for use by UK LAA members, the UK LAA carried out a number of test flights at the Aircraft/Kit Manufacturer's facilities in the Czech Republic. The following is an extract from a flight-test report published in a General Aviation Magazine, in August 2012:

> '[The author's] *only concern about the handling of the LSA was that as with many of the torquey* [Engine Manufacturer's name] *powered LSA's, a fair bit of right rudder is needed to keep straight in the full power climb, and this meant that the right rudder authority became increasingly limited with full power if the airspeed was allowed to bleed back towards the stalling speed. To help deal with cross winds from the left side* [the author] *would have liked to have seen a bit more right rudder authority available, either perhaps from a bigger rudder or maybe a little more engine side-thrust could be used so as to counteract the left turning tendency under full power. Of course, one shouldn't normally explore very low airspeeds while at full power, as common sense would keep you at least thirty percent above the stall speed while climbing out or during a go-around. However when taking off on bumpy grass with these lightweight machines you do sometimes find yourself thrown up into the air before you intended to, and this can put you inadvertently into this potentially hazardous part of the flight envelope so* [the author's] *view is that you need reasonable degree of control authority even in this normally avoided speed regime'.*

The UK LAA also advised the Investigation that a '*First of Type*' flight test was carried out in the UK, in order to evaluate the suitability of the aircraft type, to be issued with a UK *'Permit to Fly'*. In terms of aircraft handling, the flight test report noted:

> '[Aircraft registration] *has been flight tested to LAA flight test schedule FT/NEW and a handling check has also been carried out against CS-VLA*[39] *requirements by* [test pilot name]. *The aircraft has been assessed as benign handling and compliant with the CS-VLA handling requirements, except that developed spin tests have not been carried out.*'

In addition, following build completion, the subject aircraft underwent a post-construction flight test, which was carried out by a UK LAA inspector. There were no unusual handling characteristics noted in the associated post-construction flight test report.

[39] **CS-VLA**: (European) Certification Specifications-Very Light Aeroplanes. Note: CS-VLA 221 Spinning (a) states that '*The aeroplane must be able to recover from a one-turn spin or a 3-second spin, whichever takes longer, in not more than one additional turn, with the controls used in the manner normally used for recovery*'. It also states in 221 (a) (3) that: '*It must be impossible to obtain uncontrollable spins with any use of the controls*'.

1.6.14 Warning and Cautions Published in the Aircraft POH

A review of the POH supplied with the subject aircraft, and a number of POHs for other NG5 variants, found that they did not contain text that might draw the operator's attention to the possibility of the aircraft rolling and yawing to the left, when high engine power is applied at low airspeeds. The POH for the aircraft does not include a '*recommended'* technique for stall recovery, nor does it include a warning of non-approved techniques for stall recovery, that should not be used.

1.6.15 NG5 Certification and Approval in the Czech Republic

The Investigation requested information on the design, certification and approval process for the aircraft type, within the Czech Republic. The Investigation was informed that Type Certification was carried out by the Amateur Aviation Association of the Czech Republic (LAA-CR). The LAA-CR supplied a document that explained their Type Certification process. The document stated that:

> '*The LAA CR system of proving the airworthiness is based on technical inspectors. For the three-axis control UL* [Ultralight] *category there are 24 appointed inspectors. The technical inspectors are appointed and managed by the Chief Technical Inspector, who is an employee of the LAA CR. The inspectors are not employees of the LAA CR and their duty is carried out on the voluntary* […] *basis.*
>
> *Participants of the Certification process include a Technical Board* [or] *Technical and Development group* [which is]*:*
>
> - *a person or group of people*
> - *makes technical reports required for the certification process*
>   - *calculations,*
>   - *tests design,*
>   - *test reports,*
>   - *drawings.*
> - *The group usually consists of manufacturer's employees or by a hired specialized engineering company*.'

The LAA-CR informed the Investigation that it is:

> '*the Competent Authority for Sports Flying Equipment (this is the name which is used in Czech legislation and includes microlights). The LAA CR does not have any responsibility for Czech manufactured microlight aircraft exported outside Czech Republic unless we have bilateral agreement with foreign authorities. At the moment we have such agreement for bilateral validation/acceptance of TC with German DULV and DAeC and Chinese CAAC.*
>
> *Because microlights are either OPT-OUT or Annex I* [see **Section 1.18.2**] *the airworthiness acceptance of such aircraft is the sole responsibility of each state where they are exported and operated.*'

The Investigation asked for clarification with respect to the certification process as it applied to '*microlight*' vs '*LSA*' aircraft. The LAA-CR responded, '*if we are talking about aircraft up to 600kg MTOM* [maximum take-off mass] *the process is the same*.'

1.6.16 Aircraft Spin Testing

The Aircraft/Kit Manufacturer provided the Investigation with a document titled '*REPORT ON THE SPIN TESTING OF* [Aircraft/Kit Manufacturer's Name] *LSA AIRCRAFT COMPLETED*'. The document is dated as being originally issued on 26 August 2011, and '*Upgraded: 22th February 2020 on the request of CASA*'[40]. The Investigation notes the following information contained within the report:

> *'Since intentional spins with microlights are prohibited in the Czech Republic, the aircraft was tested in Russia at our Russian dealer's base in Voronezh. The aircraft was equipped with a ballistic recovery rescue system*[41] [name of BRS manufacturer] *in case there were any problems with recovery from the spin.*
>
> *Some ballast was needed to reach the required CG position according to the approved aircraft documentation:* […] *rear CG and MTOW - 78 kg pilot plus 13 kg of ballast under each seat* […]
>
> *The spin tests were carried out on a long wing, fixed gear version of NG-5 BRISTELL LSA, S/N 002/2011, registered RA-1662G.*
>
> *For* [additional tests on the short wing version] *the original spin matrix table was reduced on the basis of previously proven spin characteristics on all versions of BRISTELL aircraft tested to date. The short wing version of the aircraft was chosen for the* [additional] *tests as previous tests had determined that this version was the worst configuration for the spin recovery.*
>
> *It has been determined that the short wing version is the critical configuration* […]'

The spin test report repeatedly used the word '*spiral*' in parentheses, beside the word '*spin*', or used phrases indicating the aircraft would enter a spiral rather than a spin: '*Pro-spin ailerons "improved" the spin, the aircraft mostly entered into a spiral rather than a true spin'.*

> *'During first 2 turns, there is practically no difference between the left and right spin. After 3 turn, the plane goes into a very steep negative spiral, therefore spin with more than 1 turn should be avoided'.*

[40] **CASA:** Civil Aviation Safety Authority (Australia).

[41] An Aircraft Ballistic Parachute System, also known as an Aircraft Ballistic Recovery System is a rocket-deployed parachute that enables an aircraft that encounters problems (such as engine failure, loss of control, icing and fuel exhaustion, etc.), to gradually descend to the ground, thus giving a greater chance of survival or avoidance of serious injury.

The spin test report also stated:

> '*To recover the aircraft from the spin it is necessary first to vigorously up to the rudder stop to depress the pedal in the direction opposite to the rotation of the aircraft, followed by pushing the control stick to the neutral position. Pushing the control stick fully forward is not recommended. If the pilot were to increase engine speed to the maximum during spin or at spin recovery, the aircraft will raise up its nose and enters into a flat spin.*'

In a Final Report published on 29 June 2020, relating to an accident involving a Bristell LSA that occurred on 5 October 2018, the Australian Transport Safety Board (ATSB) notes that CASA found that there was insufficient information in the initial test data to provide assurance that the aircraft type met the ASTM International[42] standards for spin recovery. The original Aircraft/Kit Manufacturer's spin test report was dated 26 August 2011, and this spin test report is annotated as '*Upgraded*' on 22 February 2020. CASA also found that assessment of new flight testing data and further information supplied by the Aircraft/Kit Manufacturer's still did not confirm that the aircraft met the required ASTM standard for spin recovery (see **Section 1.18.4.3**). The Investigation notes that CASA subsequently revoked the additional operating limitation in respect of BRM Aero Light Sport Aircraft, by a letter dated 21 June 2021, following receipt of new compliance information from BRM Aero Ltd and fundamental corrections ('*important corrections to the centre of gravity calculations for the affected aircraft*') having been made to the Aircraft Operating Instructions (AOI). See **Section 1.18.5.1** and **Appendix L**.

In addition to the spin test report, the Aircraft/Kit Manufacturer informed CASA that '*Initially spin testing of the short wing NG5 was not carried out as our engineering evaluation determined to our satisfaction that the long wing testing would adequately cover the short wing version*'.

1.6.16.1 Installation of Anti-Spin Parachute System

As noted in **Section 1.6.16**, the aircraft used for spin testing was fitted with a BRS system. The Investigation was subsequently informed by the Aircraft/Kit Manufacturer in an email dated 3 August 2021 that the aircraft used for spin testing was also fitted with an anti-spin safety system, in addition to the BRS system. The Aircraft/Kit Manufacturer informed the Investigation that this system was fitted under the tail of the aircraft, and weighed 6.5 kg. The Investigation notes that whilst the addition of other systems and ballast were stated in the spin test report, there is no mention of such an anti-spin system being fitted to the aircraft used in the spin test. The Aircraft/Kit Manufacturer stated that it considered that the installation of this system under the tail of the test aircraft, in addition to the other masses loaded on the test aircraft '*covered that mass configuration* [of the accident aircraft] *in full*'.

[42] **ASTM International:** Formally known as the American Society for Testing and Materials; provides guidance for aircraft manufacturers in design and certification standards.

1.6.17 Aircraft Ballistic Parachute Systems

During construction of the aircraft, an option was available to have an aircraft ballistic parachute system fitted. G-OJCS was not fitted with such a system, nor was it required to be.

1.7 Meteorological Information

Met Éireann, the Irish Meteorological Service, provided the following aftercast for the accident location:

Report Validity	**13th June 2019 at 1800Z - 2000Z**
Meteorological Situation	A moderate north to north-westerly airflow covers Ireland, as an area of low pressure of 997 hPa[43], in the North Sea moves slowly north-eastwards and deepens. A weak occlusion moves south-eastwards across the country.
Surface Wind	Northwest 5 kts
2,000 ft Wind	Northwest 10-12 kts
Visibility	30 km
Precipitation	Nil
Cloud	Few (1-2/8th) cumulus with bases 2,500-3,000ft and a broken (5-7/8th) layer of stratocumulus with bases between 3,000 and 4,000ft.
Surface Temp / Dew point	10/6 degrees Celsius
Mean Sea Level Pressure	1006 hPa

1.8 Aids to Navigation

Not applicable.

1.9 Communications

Examination of available Air Traffic Control (ATC) recordings for the time of the accident flight, showed the aircraft as it climbed away from EIKH, until the point at which it commenced a rapid descent prior to the accident. The ATC recordings did not reveal any communications with ATC from G-OJCS. The aircraft was operating in Class G (uncontrolled) airspace, and as such, would not have needed to communicate with ATC on a routine basis.

1.10 Aerodrome Information

Not applicable.

[43] **hPa**: Hectopascal

1.11 Recording Devices

1.11.1 General

The aircraft was not equipped with a Flight Data Recorder or a Cockpit Voice Recorder, nor was it required to be.

The aircraft was equipped with two systems used for navigation by pilots of the aircraft, both of which recorded data[44] from the accident flight:

1. A tablet computer system, running a navigation application.
2. A Primary Flight Display (PFD) system, used primarily as an instrument panel for a pilot seated in the left seat.

1.11.2 ATC Radar Data

The Investigation asked the Air Traffic Services to retain any ATC radar recordings that might contain data relating to the accident flight.

The ATC radar data for the period of the 13-14 June 2019 was quarantined and retained by the Station Manager at Shannon Air Traffic Services for analysis by the Investigation. The aircraft was equipped with a transponder and the radar data obtained showed a secondary radar return with a conspicuity code of 7000[45] present in the area where the aircraft flew on the date and time in question.

1.11.3 Tablet Computer, Running a Navigation Application

The tablet computer was recovered from the aircraft at the AAIU wreckage examination facility, and a successful download of time, groundspeed, GPS elevation, and position data was made.

It was noted that data was not recorded at a constant rate, but varied between once every five seconds, and three times per second, depending upon the rate at which parameters were changing.

1.11.3.1 Aircraft Position Data on Tablet Computer Application

Using the position data recovered from the navigation application on the tablet computer, the Investigation plotted the ground track of the aircraft for the period from take-off from EIKH until the time of the accident. The ground track showed a high degree of correlation with that obtained from the PFD, and that obtained from the ATC radar data, up until 32 seconds before impact. After this point, the aircraft's track, as recorded by the tablet-based navigation application, was in a generally southerly direction, towards the position at which the impact occurred.

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[44] **Note**: The navigational devices fitted were primarily designed to aid navigation. Neither was designed to accurately record dynamic manoeuvres.

[45] Flights under visual flight rules use the 7000 transponder code to assist in identification by ATC.

The yellow line in **Figure No. 5** shows the ground track of the aircraft, as recorded by the tablet-based navigation application, in the final 38 seconds preceding the impact (the white line shows the ground track as recorded by the PFD, see **Section 1.11.4.3**).

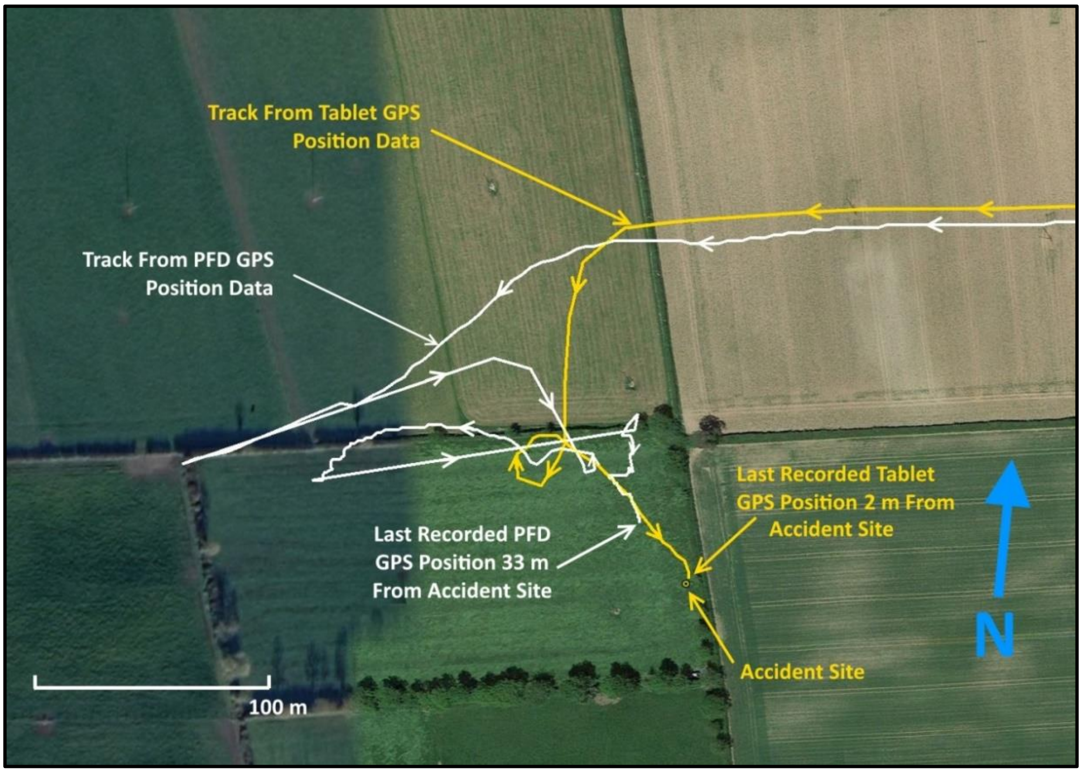

Figure No. 5: Ground track of aircraft from both the Tablet Application (Yellow), and the PFD GPS data (White)

A portion of the ground track from the tablet application suggests the aircraft performed a tight 360° right orbit prior to tracking towards the accident site. The final position recorded by the tablet navigation system was approximately 2 m from the accident site.

1.11.3.2 Aircraft Elevation Data on Tablet Computer

The tablet-based navigation application recorded aircraft GPS elevation data in metres. In order to make comparisons with the altitudes recorded by the PFD (recorded in feet), the Investigation converted this data to units of feet. The elevation data recorded on the tablet-based navigation application correlated closely with that seen from the PFD-recorded aircraft pressure altitude.

1.11.4 Primary Flight Display System

The PFD was removed from the aircraft at the AAIU wreckage facility, for further examination. The PFD was brought to the UK, where the OEM's agent for the equipment successfully downloaded a number of data files recorded on the PFD memory. Once downloaded, data was extracted from those files normally accessible to the PFD user. The OEM's agent informed the Investigation that the remaining files contained data for diagnostic purposes, and could only be opened by the OEM of the PFD.

1.11.4.1 User-Accessible Parameter Overview

Depending on the sensors and equipment fitted to the aircraft, data on up to 102 parameters could be recorded and accessed by the user of the PFD. On the subject aircraft, values for 57 parameters were recorded. The data for these parameters was recorded 16 times per second. The PFD system did not record flight control inputs or flight control surface position. The recorded parameters of primary interest to the Investigation were:

- GPS Date and Time
- Aircraft GPS Position (Latitude and Longitude)
- Aircraft Altitude
- Airspeed
- Magnetic Heading
- Aircraft Attitude in Pitch and Roll
- Aircraft Turn Rate
- Engine Data
- Vertical Speed
- Lateral and Vertical Acceleration
- Aircraft Battery Voltage
- Wing Flap Position

It should be noted that the PFD is not a Flight Data Recorder for the purposes of Air Accident Investigation, and despite the large amount of data recorded and recovered from the PFD, a review of the data indicated a number of anomalies. The anomalies found largely related to the aircraft attitude data (pitch and roll angle) that were recorded in the final 26.5 seconds leading up to the impact.

The user-accessible data recorded vertical acceleration values up to a maximum of +10 *g*[46].

1.11.4.2 Wing Flap Position

The wing flap position was recorded as being at zero (flaps up) throughout the flight. The Investigation was informed by the syndicate pilots that flap position was not displayed on the PFD. The OEM for the PFD informed the Investigation that if flap position was not displayed on the PFD, it would likely be recorded as zero in the data.

1.11.4.3 PFD-Recorded Aircraft Position for Final 38 Seconds of Flight

A plot of the aircraft track in the final 38 seconds, using recorded GPS latitude and longitude from the PFD is shown in white in **Figure No. 5**, (**Section 1.11.3.1**). As the ground track could not have been followed by the subject aircraft, and the final recorded aircraft position is approximately 33 m northwest of the accident site, this shows that the recorded GPS positions from the PFD data became inaccurate during the final moments.

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[46] The OEM for the PFD informed the Investigation, that whilst user-accessible data recorded vertical acceleration values up to a maximum of +10 *g*, any vertical acceleration above this value would be recorded as +9.9 *g*.

1.11.4.4 PFD-Recorded Aircraft Attitude

The PFD recorded data for both aircraft roll angle, in degrees left or right of wings level, and aircraft pitch angle, in degrees above or below the horizon. This data is provided by an ADAHRS unit mounted behind the aircraft seats.

With respect to the PFD and ADAHRS, the Investigation notes the following as stated in the PFD User Manual:

> '***Attitude Calculation***
>
> *The* [PFD] *artificial horizon display (attitude) is generated via a complex algorithm using a multitude of sensors as described in* [table not reproduced here]*. In normal operation,* [product name] *uses airspeed to provide superior attitude accuracy.* […]'

As the ADAHRS unit containing the accelerometers and gyroscopes was located behind the aircraft seats, and not located close to the aircraft CG, the values of vertical and lateral acceleration are not being sensed at the aircraft CG point. As this could have an effect on the recorded attitude data, the Investigation asked the OEM for further information in relation to the effect on attitude data of the ADAHRS location. The OEM responded as follows:

> '*It does make a difference to the accelerometers (mainly the x and z) but not the gyros. Long term correction of gyro integration errors by the accelerometers could introduce an attitude error (mainly in pitch) while rapidly yawing (like the flat spin) or pitching. If the sensors are mounted on the centerline,* [we] *would not expect any accelerometer error while rolling. However, this correction is filtered over many seconds so events in the short term (like the wing drop) are mostly processed by the gyros*'.

1.11.4.5 Review of the Recorded Data by the UK AAIB

The aircraft attitude as recorded on the PFD at the time of impact showed the aircraft to have impacted in a 50° nose down, 80° left wing down, attitude. However, evidence from the wreckage and impact examination (**Section 1.12**), showed that the aircraft had impacted the ground in a near wings level attitude. Due to this anomaly observed in the recorded aircraft attitude data, the Investigation requested the UK AAIB to assist in analysing the user-accessible data that had been downloaded from the PFD. The UK AAIB provided the following information to the Investigation:

> '[The recorded data from time 18:21:06] *starts with the aircraft flying at a recorded 47 kt IAS with 14 degrees of nose up pitch, 3 degrees of left roll and an engine speed of 1877 rpm. The data indicates a slight right roll* [wing-drop] *and pitch down at 1821:10 hrs, approximately a second later a step increase in engine rpm with slight pitch up is apparent and a left roll levelled the wings. By 1821:12 hrs the wings were level but the roll to the left continued and the nose dropped at the same time. The left roll briefly stopped with the left wing 90° down and the nose continued to drop. Just before 1821:14 hrs the rpm of the engine reduced, along with a brief reduction in left roll which then increased again approximately a second later. The aircraft continued to roll to the left and reaching a near vertical nose down attitude at 1821:16 hrs. The data indicates that after this the left roll continued* [aircraft rolled through 180°] *and the nose attitude rose.*

The roll and heading parameters are not well defined when the aircraft direction is nose down. It is not clear whether the high roll rates and change in heading recorded as the nose rose, accurately reflect the actual roll and yaw rates and so reached the reasonable sensing limits or whether this is an artefact of coming from close to a vertical nose down attitude. However, one second after the nose attitude rise, the magnetic heading parameter glitched in a manner unlikely to reflect a real yaw motion and soon after that it is difficult to reconcile the pitch and roll parameter behaviours with the recorded accelerations. The accelerometers are not affected by rotation rate limits but are affected by centrifugal forces due to the location of the sensor and rotation rates.

The Gz parameter indicated increasing normal [normal axis or Z-axis] *acceleration with a component that varied with an approximate two second cycle. If the cyclic variation was associated with a roll rate then this would be in excess of the capability of the ADAHRS to accurately resolve the motion of the aircraft. 12 seconds after the initial pitch down the recorded Gz peaked at 5g, after which the recorded data behaviour changed in nature.*

At the start of this period the engine speed decayed to zero. The Gz reduced and held between 1.5g and 2.0g until impact. There was a reduction in vertical speed in this period but insufficient to account for the recorded Gz values. A centrifugal Gz component can be generated by a spin which is not entirely flat relative to the orientation of the sensor. The magnitude is dependent on the rate of spin, the distance between the sensor and the centre of rotation of the spin and the orientation of the sensor relative to the spin axis. The lateral acceleration also became positive and held steady between 0.3 and 0.5g and is similarly affected by orientation and spin geometry.

Comparison with previous manoeuvre

The initial stages of the accident manoeuvre had some similarities with that of the previous manoeuvre. The intent of the manoeuvres is not known but a comparison may be of some use.

The two manoeuvres had similar starting conditions and motion, up to the point at which the aircraft approached a nose down pitch of approximately 45° and the roll was reducing from 90° left wing down.

During the [previous manoeuvre commencing at time 18:18:26] *the aircraft nose remained pitched down between 30° and 45° nose down before it recovered to straight and level flight whereas during the accident manoeuvre, the left roll started to increase once more, which accelerated after a short increase in engine speed and the nose down pitch continued to nearly vertical. Other than the aircraft response, the most notable difference between the manoeuvres is the engine speed reducing earlier in the previous manoeuvre. Control inputs are not recorded so cannot be directly compared'.*

Given the anomalies found in some of the data, and the bank angles observed in the data, the Investigation sought a means of confirming whether or not the recorded aircraft attitude data accurately reflected the motion of the aircraft. In addition, the Investigation believed it would be helpful in ascertaining the motion of the aircraft after it rolled left through 180°.

The UK AAIB informed the Investigation that the diagnostic data files, accessible by the OEM of the PFD, might contain data parameters useful for this purpose.

1.11.4.6 PFD Diagnostic Data

Depending on the sensors and equipment fitted to the aircraft, a further 80 parameters may be recorded as diagnostic data on the PFD, for use by the OEM. The OEM informed the Investigation that the data sampling rate for the diagnostic data was 64 times per second. The diagnostic system did not record flight control inputs or flight control surface position.

A review by the OEM of the user-accessible data, in conjunction with the diagnostic data, confirmed that the recorded user-accessible data, and thus the motion of the subject aircraft, was valid up to the point that the aircraft rolled left through 180°.

After this point, the OEM for the PFD considered that a number of parameters including aircraft attitude became invalid due to the dynamic nature of the aircraft upset[47]. Therefore, the Investigation requested the OEM to review additional information that might have been recorded as PFD diagnostic data in order to better understand the nature of the aircraft upset. The OEM provided the Investigation with the diagnostic data for the accident flight, and provided assistance in interpreting this data.

The OEM carried out a review of the Gyro-Rotation Rate data for the period after the aircraft rolled left through 180° about its X-axis. This was carried out in conjunction with the recorded airspeed and the rate of descent data. The OEM for the PFD considered that the data indicated that the most likely scenario was that the aircraft entered a spiral dive[48] which continued for approximately three turns. During this period, the indicated airspeed and vertical acceleration (*g* loading) data was recorded as increasing.

During the third turn of the spiral dive the vertical acceleration peaked at +5 *g*, following which there was a marked change to the Gyro-Rotation Rate data. The OEM informed the Investigation that at this point the rotation rate about the Z-axis (yaw rate) exceeded the limit of the sensor. The OEM informed the Investigation that this would indicate that the aircraft was rotating counter-clockwise about the Z-axis, at more than -180° per second, which '*would correspond to the aircraft entering a flat spin with a high rate of anticlockwise rotation*'.

1.11.5 Comparison of Flight Path Data

The Investigation noted that the final PFD-recorded position of the aircraft was 33 m north-west of the accident site. In addition, it would not have been possible for the aircraft to have followed the ground track recorded by the PFD after the aircraft began rolling left through 180° as it descended through 3,104 ft.

The OEM of the PFD stated that the erroneous position data from the PFD was likely due to shielding of the GPS aerial as the aircraft rolled, and that a portion of the track described by the Tablet-based GPS position data, where the aircraft appeared to have performed a tight 360° right turn, was also likely to be erroneous, and a result of shielding of the Tablet-based GPS receiver as the aircraft rolled.

[47] **Upset**: an event that unintentionally exceeds the parameters normally experienced in flight; see also **Section 1.16.6**.
[48] **Spiral Dive**: A steep descending turn with the aircraft in an excessively nose-down attitude and with the airspeed and *g*-load increasing rapidly; see also **Section 1.16.6**.

The Investigation therefore used a smoothed flight path, from the final descent from 3,276 ft until impact, onto which other data has been mapped, **Figure No. 6**.

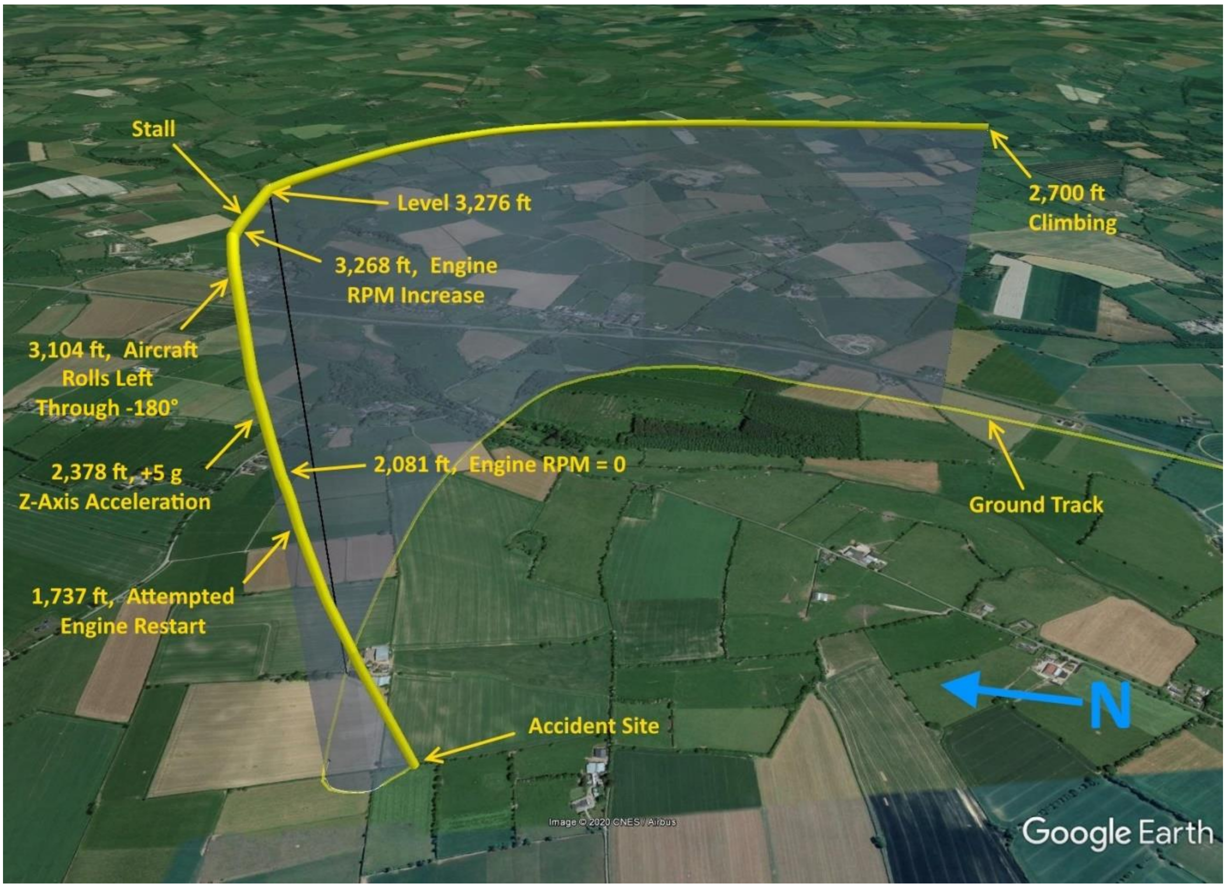


Figure No. 6: 3D Representation (smoothed) of flight profile from final descent from 3,276 ft until impact

1.11.6 Manoeuvres Carried Out by the Aircraft

1.11.6.1 Earlier Manoeuvres Carried Out by the Aircraft

During the course of the Investigation, it was noted that the recorded data showed two other manoeuvres that the subject aircraft carried out approximately nine minutes prior to the accident.

The data relates to an approximate three minute period commencing at time 18:12:30. During this time, the recorded data indicates that the aircraft maintained a magnetic track of 153.5° +/- 2.5°. The data shows that during this period, the aircraft descended twice from an altitude of approximately 3,300 ft to approximately 2,900 ft. The recorded data for these two manoeuvres shows changes to engine power, airspeed and aircraft pitch attitude, and that the aircraft maintained a wings-level attitude, with no noticeable wing drop. The data also indicates that these manoeuvres were performed following a period of straight flight, i.e. the manoeuvres were not preceded by any turns.

The recorded data indicates that, following these two manoeuvres, the aircraft carried out a level turn to the left and a level turn to the right before taking up a south-south-easterly track. This was followed by two further manoeuvres, the first at time 18:18:26, and the second and final manoeuvre, at time 18:21:09. Both manoeuvres commenced with the aircraft flying level, with engine power at idle, and a gradual reduction in airspeed. This was followed by a pitch-down motion, accompanied by a right wing-drop. The following two sections show the sequence of events for each of these manoeuvres, from the time the aircraft pitched down.

1.11.6.2 The Manoeuvre at Time 18:18:26

Using the PFD User-Accessible Data, **Table No. 5** and **Figure No. 7** show the sequence of events during this manoeuvre.

Recorded Time	Time From Pitch-Down (sec)	Altitude (ft)	Event	Fig. 6 Ref
18:18:26.93	0.00	3,260	Reduction in aircraft pitch angle from +15.6°.	A
18:18:27.12	0.19	3,260	Commencement of right wing-drop.	B
18:18:27.87	0.94	3,248	Nose pitches down through the horizon.	C
18:18:28.12	1.19	3,245	Start of engine RPM increase[49].	D
18:18:28.37	1.44	3,242	Maximum right roll to +28.6°. Nose down pitch stops and nose up pitch commences.	E
18:18:28.50	1.57	3,242	Right roll stops and left roll commences.	F
18:18:28.69	1.76	3,239	Nose pitches up through horizon.	G
18:18:29.19	2.26	3,233	Aircraft rolls left through wings level.	H
18:18:29.87	2.94	3,222	Engine RPM reduction.	I
18:18:30.50	3.57	3,204	Left roll reaches -102.7°.	J
18:18:30.62	3.69	3,200	Commencement of right roll. Right roll continues with a momentary reversal at 18:18:32.00 for 0.75 sec, when roll goes left from -54° to -60°, before right roll commences again back to wings level.	K
18:18:46.00	19.07	2,514	Aircraft maintaining altitude and wings level.	L

Table No. 5: Outline of manoeuvre at time 18:18:26, from user-accessible PFD data

[49] The OEM of the navigation system advised the Investigation that engine RPM data might be written to memory with an approximate delay of 0.25 seconds.

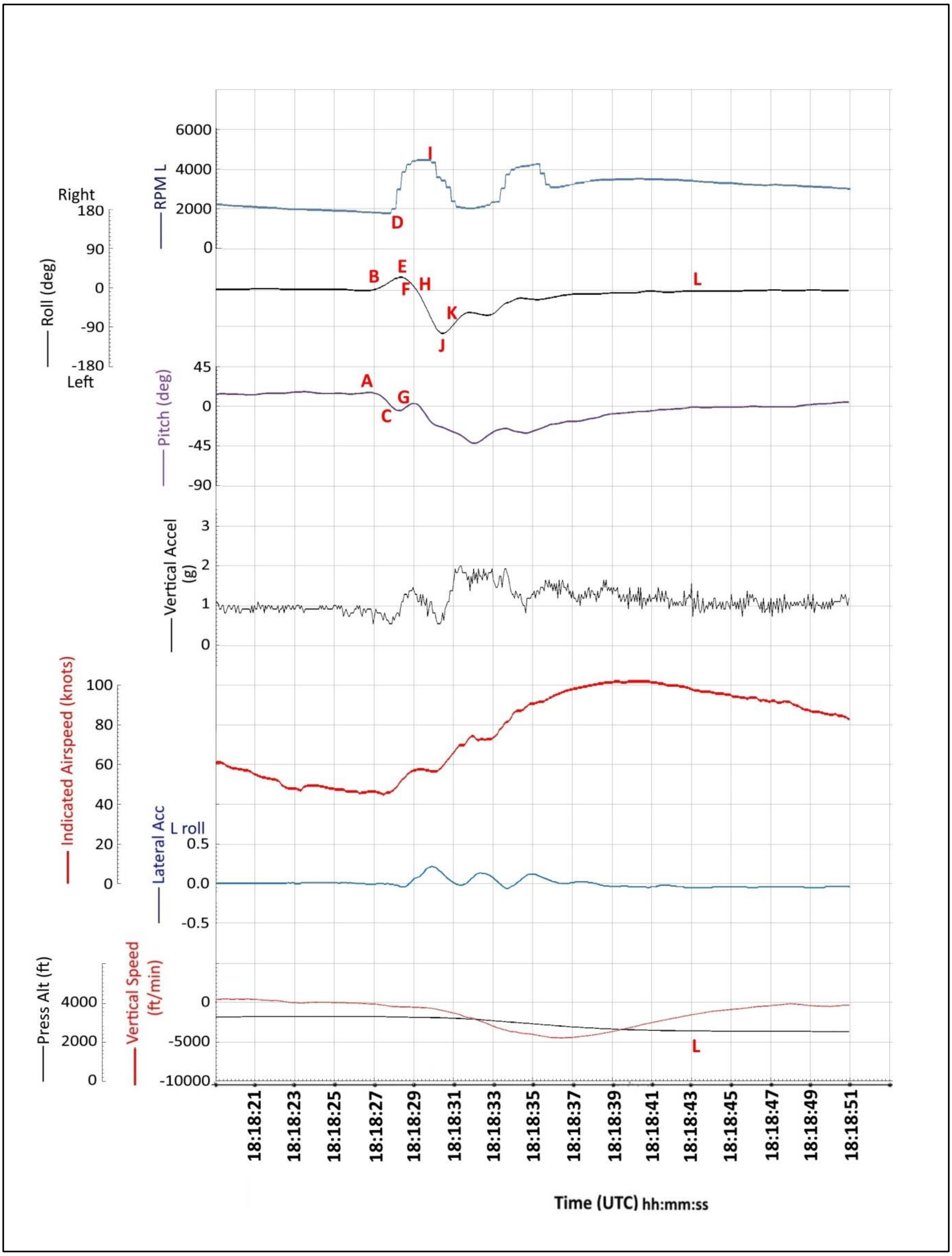


Figure No. 7: Graph of recorded user-accessible PFD data for the period 18:18:21 to 18:18:51, showing the manoeuvre at time 18:18:26

1.11.6.3 The Manoeuvre at Time 18:21:09

Following the previous manoeuvre, the recorded data shows that the aircraft climbed to 3,276 feet. **Table No. 6** and **Figure No. 8** show the sequence of events during this final manoeuvre and the subsequent impact.

Recorded Time	Time From Pitch-Down (sec)	Altitude (ft)	Event	Code Letter on Data Graph
18:21:09.62	0.00	3,276	Reduction in aircraft pitch angle from +14.4°.	A
18:21:10.00	0.38	3,276	Commencement of right wing-drop.	B
18:21:10.81	1.19	3,269	Nose pitches down through the horizon.	C
18:21:10.87	1.25	3,268	Start of engine RPM increase.	D
18:21:11.06	1.44	3,266	Maximum right roll to +28.5°.	E
18:21:11.19	1.57	3,264	Nose down pitch stops and nose up pitch commences. Right roll stops and left roll commences.	
18:21:11.56	1.94	3,259	Nose pitches up through horizon.	F
18:21:12.00	2.38	3,251	Wings roll left through wings level.	G
18:21:13.43	3.81	3,219	Left roll reaches -93.3°.	H
18:21:13.50	3.88	3,219	Commencement of right roll, and roll angle reduces to -63.1°.	I
18:21:13.62	4.00	3,216	Power reduction.	J
18:21:14.81	4.81	3,187	Rapid increase in left roll	K
18:21:15.06	5.25	3,168	Momentary (0.3 seconds) increase in power to 3,100 RPM.	L
18:21:15.87	6.25	3,104	Aircraft continues the left roll through 180°.	M
18:21:16.37	6.75	3,055	Increasing vertical acceleration, airspeed and rate of descent.	N
18:21:22.25	12.63	2,378	Vertical acceleration peaks at +5 *g*.	O
18:21:24.94	15.32	2,081	Engine stoppage. Indicated by RPM going to Zero. Note: the RPM begins reducing at 18:21:22.25, reaching zero at 18:21:24.94.	P
18:21:26.00	16.38	1,963	Following the peak in vertical acceleration of +5 *g*, there is a marked reduction in vertical acceleration, indicated airspeed and vertical speed.	Q
18:21:28.37	18.75	1,737	Attempted engine start. Indicated by engine data recording 450 RPM for 2 seconds, and battery voltage drop (not included in graph).	R
18:21:42.50	32.88	Surface	Impact.	S

Table No. 6: Outline of manoeuvre commencing at time 18:21:09

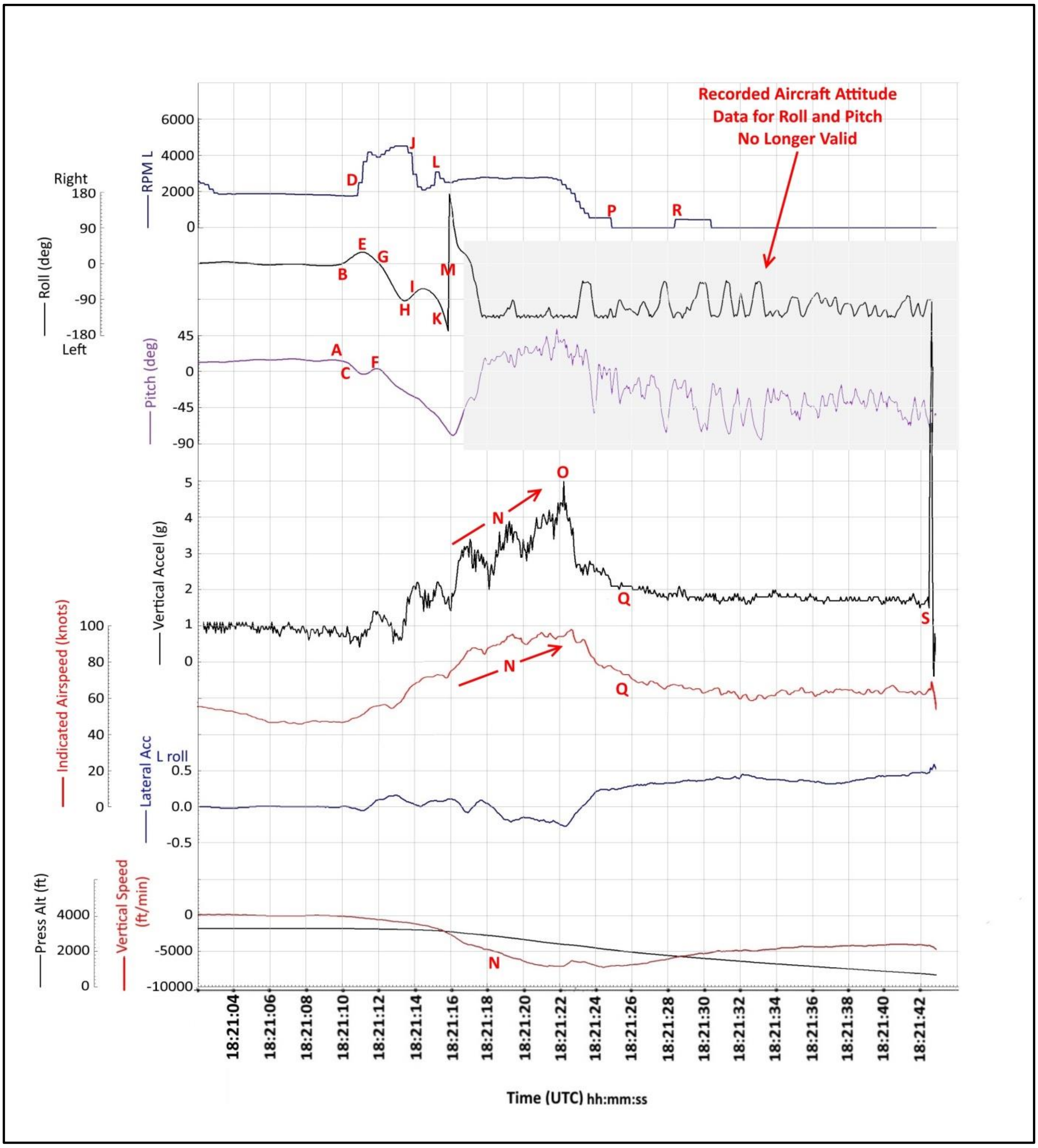


Figure No. 8: Graph of recorded user-accessible PFD data for the period 18:21:04 to 18:21:42, showing the manoeuvre at time 18:21:09. (Shaded area indicates the data that the OEM for the PFD considered to be invalid)

1.12 Wreckage and Impact Information

1.12.1 General

The accident site was located in a grass field, 5.2 NM south of EIKH. The site was compact, and the aircraft was found upright, with all parts of the aircraft structure and all components present at the accident site. The aircraft had come to rest oriented on a magnetic heading of 320°, approximately 29 m east of an electricity power line support pole, (**Photo No. 3**).

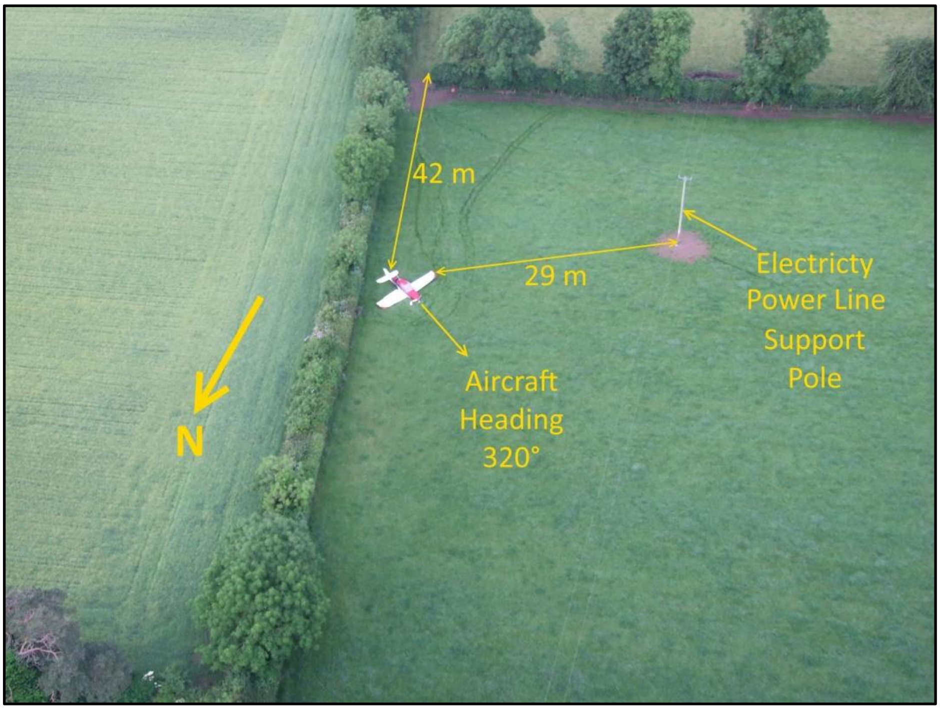


Photo No. 3: Aerial view of accident site (courtesy of Irish Coast Guard)

Prior to the AAIU's arrival at the accident site, the aircraft had been located by a helicopter of the Irish Coast Guard (IRCG), two crew members of which attended the accident aircraft to render assistance to the occupants. They determined that there were no signs of life. The Investigation was informed by one of the crew members that they found the aircraft with its canopy closed and latched. They had to press the latch release button on the outside of aircraft to open the canopy. The crew members stated that nothing in the cockpit was moved, and that prior to leaving the aircraft they closed the canopy carefully. They informed the Investigation that the Left Seat Pilot was found in the left seat, with his restraint harness unfastened.

1.12.2 Site Examination

The aircraft was located less than 2 m west of a 4 m high boundary hedge. Examination of the hedge showed no evidence that the aircraft had made contact with it prior to impact. One propeller blade had been broken into four unequal lengths; one portion of the blade, approximately 150 mm in length, remained attached to the propeller mounting plate. The outermost portion, comprising the propeller tip and approximately 240 mm of propeller blade, was found completely embedded in soil, 1.2 m forward of the right wing. The aircraft nose-wheel, complete with its fairing, had separated from the aircraft. The nose-wheel and fairing had left an imprint in the ground. There was also an imprint in the ground from the left main-wheel. A section of the right elevator balance horn was found embedded in soil at a distance of 0.5 m behind the left wing (**Figure No. 9**).

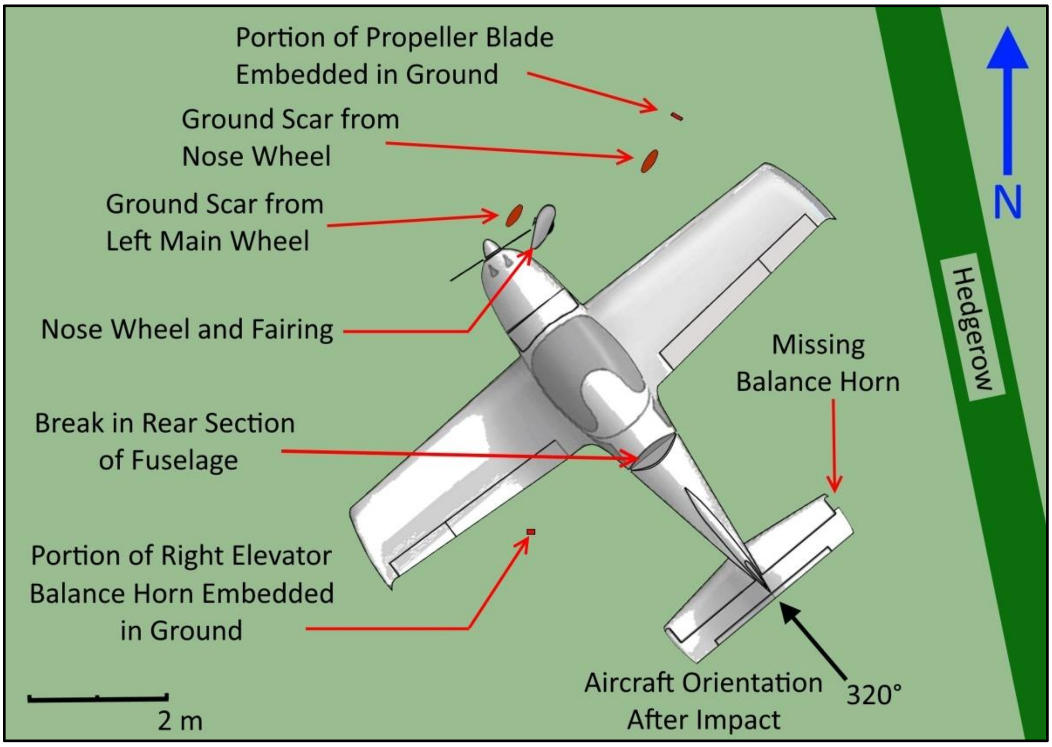


Figure No. 9: Diagram of final orientation of aircraft and wreckage distribution

1.12.3 Aircraft Examination On-Site

There was evidence of significant vertical compression damage to the metal skin of the fuselage and both wings, resulting in folding and creasing of these structures. The rear section of the fuselage had separated along the top and side portions of the bulkhead rivet line, aft of the cockpit rear bulkhead. However, it was still attached to the forward section of the fuselage along the lower rivet line (**Photo No. 4**).

Photo No. 4: Aircraft at accident site

Witness marks on the forward face of the engine cowling just behind the propeller spinner showed that the propeller was not rotating at the time of impact.

The left main-gear strut was found to have deformed to the extent that it had forced part of its fuselage mounting and the cockpit side-wall, inwards, into the left side of the cockpit area just below the level of the left seat. The right main-gear strut had remained attached to the aircraft, but showed significant vertical deformation. The nose wheel strut had remained attached to the aircraft but was bent upwards into the underside of the engine compartment.

The integrity of the wing fuel tanks had been compromised during the impact, and there was a noticeable smell of fuel at the accident site.

Examination of the aircraft at the accident site established continuity of the control linkages from the cockpit controls to the rudder and elevator. The elevator trim tab was found in the neutral position. Continuity of all engine control linkages was also established. The linkages to the wing flaps had been disrupted. Continuity of the aileron control linkages could not be established on site.

The aircraft was removed from the accident site and brought under escort to the AAIU Wreckage Facility in Gormanston, Co. Meath.

1.12.4 Examination of Aircraft at AAIU Wreckage Examination Facility

The Investigation conducted a detailed examination of the wreckage at the AAIU Wreckage Examination Facility.

1.12.4.1 Flight Controls

Examination revealed no evidence of pre-existing damage to the ailerons, elevator and rudder or to their respective control linkages. Continuity of the aileron control linkages was established. Examination of the wing flaps and their control linkages revealed damage due to impact forces, but no pre-existing damage was found. The rotary flap selector switch was found in the Flap 0° position. Examination of the wing flap actuator and its associated linkages showed that the flap actuator was in the flaps retracted configuration at impact.

1.12.4.2 Aircraft Structure

Measurements of the accident aircraft were taken. Allowing for distortion of the aircraft structure due to the impact, these measurements showed that the aircraft dimensions matched those given in the POH that accompanied the aircraft, i.e. wingspan 8.13 m; length 6.45 m; horizontal stabiliser 2.9 m.

The engine mountings had been distorted during the impact such that the engine thrust line was approximately 10° to the right of the aircraft centreline, (looking forward). The tail fin was found to be approximately 4° off vertical, to the right. The right wing had been rotated forward by approximately 2°, and the left wing rotated rearwards by approximately the same amount.

The Investigation also measured the location of the pilot and passenger seats, and the thickness of the seat cushioning material of each seat, see **Section 1.6.8.**

1.12.4.3 Bubble Canopy

The bubble canopy was intact, and remained attached to the aircraft structure at its two hinge points. The underside of the canopy frame where it seated onto the top surface of the cockpit sidewalls was undamaged. The impact forces had caused damage to the left latching mechanism. The right gas spring appeared undamaged, and remained attached to the canopy and cockpit side wall. The left gas spring was attached to the cockpit side wall. The left gas spring attachment to the underside of the canopy had sheared in a manner consistent with the left side of the canopy being shunted forward on aircraft impact. There was corresponding compression deformation of the canopy structure close to the canopy's left hinge.

1.12.4.4 Four-Point Seat Restraint Harness

The two seat restraint harnesses were found securely attached to anchor points on the aircraft structure. Both harnesses were removed from the aircraft for examination.

No damage was found to the webbing or stitching of the straps. Examination of the cam-lock release mechanisms showed that they were functioning as designed, with the latched ends of the shoulder and lap straps of each harness not releasing until its cam-lock lever was rotated approximately 90°. The male latching plates on the ends of the shoulder straps and lap strap (that would be inserted into the cam-lock) showed some slight scoring consistent with regular latching and release of the harnesses. No damage to the latching plates was evident that would have prevented them from operating as designed.

1.12.4.5 Nose-wheel Steering Linkage

The flexible telescopic control cable, used for nose-wheel steering, was found still attached to the rudder pedal linkage. The end of the control cable that attaches to the nose landing gear had detached due to impact forces. The control cable was removed from the aircraft and examined. The inner cable was found to move freely inside the outer sheath. The inner cable was removed and no internal damage was found. See also **Section 1.6.11.1**.

1.12.4.6 Aircraft Engine

Examination of the aircraft engine found no defect that might have contributed to it stopping during the flight. A review of literature on aircraft spinning indicated that it is not unknown for normally aspirated aircraft piston engines to stop during aircraft spinning, unless the engine has been specifically modified to cope with such manoeuvres, e.g. aerobatic aircraft. The engine in the subject aircraft had not been modified for such manoeuvres.

The OEM of the aircraft engine informed the Investigation that:

> '*During* [a] *spiral drive the centrifugal forces* […] *would force* […] *the* [carburettor] *floats to dive* [sink] *deeper into the fuel than intended, the needle valve to open and the float chamber to be filled. Within 7.5 seconds there might be enough fuel supplied to the engine to cause a fuel air mixture which is rich enough to cause the engine to fail for this reason*'.

1.13 Medical and Pathological Information

1.13.1 The Left Seat Pilot

The Left Seat Pilot, who was fatally injured, was located in the left cockpit seat. The Left Seat Pilot was not secured by his four-point restraint harness. The harness was found with each of the four straps secured at their respective anchor points, but with the quick-release buckle undone. The shoulder straps were found resting on the rear parcel shelf, behind the Pilot's seat, and the two lap straps were found on the seat base, underneath the Left Seat Pilot.

The Investigation was provided with a copy of the autopsy report which was conducted on 14 June 2019. The report stated that the cause of death '*was due to traumatic head injuries*'. The report also stated that '*there was no evidence of a seat belt mark on the torso'*. In addition, the report stated that '*The pattern of injury suggests that the deceased was not strapped in at the time of impact*'.

Post-mortem blood samples from the Left Seat Pilot were sent for toxicological analysis. The Toxicology Test Report stated that neither ethanol nor drugs were detected. A further test carried out on the blood sample for carboxyhaemoglobin saturation (a test for exposure to carbon monoxide), showed it was less than 10%, which would be considered as normal.

1.13.2 The Right Seat Pilot

The Right Seat Pilot, who was fatally injured, was found secured in the right cockpit seat by the four-point restraint harness.

The Investigation was provided with a copy of the autopsy report which was conducted on 14 June 2019. The report stated that the cause of death '*was due to traumatic head injury*'. The report also stated that '*there was no evidence of a seat belt mark on the torso'*. In addition, the report stated that '*The pattern of injury would imply that the deceased was strapped in at the moment of impact*'.

Post-mortem blood samples from the Right Seat Pilot were sent for toxicological analysis. The Toxicology Test Report stated that neither ethanol nor drugs were detected. A further test carried out on the blood sample for carboxyhaemoglobin saturation showed it was less than 10%, which would be considered as normal.

1.14 Fire

There was no fire.

1.15 Survival Aspects

As noted in **Section 1.6.17**, the aircraft was not fitted with an aircraft ballistic parachute system, nor was it required to be.

The aircraft, Left Seat Pilot and Right Seat Pilot were subject to high deceleration forces on impact. The main deceleration component was in the vertical axis.

1.16 Tests and Research

1.16.1 Literature Review

The Investigation reviewed a number of publications relating to aircraft stalling, spinning and loss of control. The following list shows a number of items taken from the literature review. A bibliography is given in **Appendix M**.

CASA AC 61-16 v 1.0. ‘*Spin avoidance and stall recovery training*’ has the following:

> ‘*A rearward centre of gravity, use of aileron or application of power (or a combination of them) are likely to increase angle of attack, deepen the stall, and 'flatten' the spin. This may also push the tail of the aircraft further from the axis of rotation of the spin and, in turn, stall the empennage surfaces and require different initial recovery control inputs until it steepens again, or may render the spin unrecoverable.*’
>
> ‘*In some instances the application of power, when available, can induce a secondary stall or lead to an increased loss of height if applied too early in the recovery. Abrupt or aggressive use of elevator in the recovery also has the potential to induce a secondary or accelerated stall as a result of the increased load factor or 'g' loading.*’
>
> ‘*It is common for light aircraft to exhibit spiral characteristics; the wings unstalling at some point after entering the spin and the aircraft accelerating into a spiral dive with rapidly increasing airspeed.*’
>
> ‘*Light Sport Aircraft standards have been made simpler and less costly to comply with by reducing the amount of testing specified before a manufacturer may bring a new aircraft to market at a lower price point than more thoroughly tested normal and utility category certified aircraft. Despite the requirement for an aircraft to not exhibit an uncontrollable tendency to spin after the aeroplane has stalled, some light sport aircraft may demonstrate stall characteristics in which a wing drop can rapidly and unpredictably result in an unrecoverable spin entry, particularly in accelerated stalls.*’

Rich Stowell, in his book ‘*The Light Airplane Pilot's Guide to Stall/spin Awareness*’, 2007, makes the following points:

> ‘*Seemingly minor changes to the wing can have a dramatic influence on stall spin behaviour.*’
>
> *Center of gravity definitely influences stall and spin behaviour.* […] *a forward CG provides a longer moment arm for the rudder and elevator; therefore, stronger anti-spin moments are possible when recovery inputs are applied. Sliding the center of gravity aft, by comparison, shortens the moment arm and decreases the anti-spin potential of the rudder and elevator.*’
>
> ‘[…] *Although unrecoverable spins may be possible at any center of gravity position, they become increasing more likely as c.g. moves aft.*’

'*Recovering from stalls and spins requires pilots to make control inputs that are foreign to the normal reflexes. Some common reflexive actions observed during stall and spin training include the following:*

- *freezing on the controls*
- *Continuing to hold the elevator control aft because of the dramatic nose-down attitude*
- *Inadvertently applying opposite aileron as the wing dips at the stall break or as the airplane rolls into a spin*
- *Pressing both legs against the rudder pedals, making it difficult to apply the opposite rudder fully.*'

'*Interestingly several of these reflex actions are responsible for causing inadvertent stall and spin departures in the first place. And these are not just the reactions of low time pilots to their first encounters with stalls and spins but also experienced pilots - even highly trained test pilots - who have become confused or excited during encounters with spins.*'

'*Stall and spin recovery movements are counterintuitive.*'

'*Remaining oriented in the rotary* [rotating] *world of spins takes planning, practice, and conditioning. Even so, limitations in our vestibulo-ocular* [ear-eye] *system can make remaining oriented difficult at best, impossible at worst.*'

In their book, '*Flight Test Guidelines for Homebuilt/Experimental Aircraft*', 2014, Desmond Barker, and Alan Sutherland make the following observation:

51 *'If any modifications or alterations have been made to the airframe's original design or configuration it is not safe to assume that the aircraft still has the same spin recovery characteristics as the prototype aircraft'.*

In '*The Aeroplane Spin Motion and an Investigation into Factors Affecting the Aeroplane Spin*', 2014, Rein Hoff states '*There have been reports suggesting that even small modifications to the wing or tail design can result in dramatic changes in spin behaviour*'.

Darrol Stinton, in his book, '*Flying Qualities and Flight Testing of the Airplane*', 1996, notes that an aircraft Neutral point is affected by power application. For a propeller driven aircraft with a tractor propeller (i.e. a propeller located at the front of the aircraft), the application of engine power has an effect on the aircraft's neutral point (NP). The neutral point N, represents the case when gliding i.e. with power off. '*Slipstream (propwash), is usually adverse, involving a forward shift of the neutral point to* $\overline{N}$.' See **Figure No. 10.**

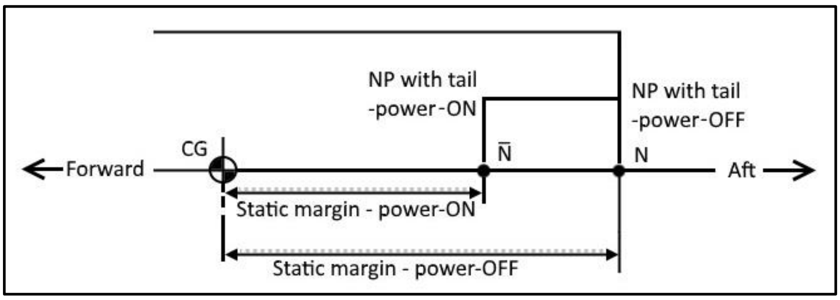


Figure No. 10: The Effect of Engine Power (Propwash) on Aircraft Neutral Point (*after Stinton*)

In a paper on the effect of power on the stick-fixed neutral point, White M. D., (1944), notes that with power on, the neutral point usually shifted forward of the power off location. '*With flaps neutral and for lift coefficient up to 1.2, the maximum forward shift of the neutral point, with respect to the power off location at low lift coefficients, was 4 to 5 percent of the mean aerodynamic chord (MAC) in most cases and 8 percent in one case*.'

Hoffman W. C., Hollister W M. '*General Aviation Pilot Stall Awareness Training Study*', 1976, includes the following:

> '*Stability, stalling characteristics, and spin recovery are all affected by the center of gravity position. As the center of gravity moves aft* […]*, the effective length at which the horizontal tail is located is decreased. This reduces its stabilizing effect. In spins at aft center of gravity locations, the pitch attitude in a stabilized spin is more level. This produces increased angle of attack on the horizontal tail and may make the elevators ineffective in spin recoveries*'.

Sammy Mason, in his book '*Stalls, Spins, and Safety*', 1982, makes the following points:

> '*It should be understood that the spin-chute package itself can change the spin characteristics. The* [weight] *can produce inertial effects that can be detrimental to the character of the spin.*'
>
> '*An aft c.g. is certainly conducive to easy spin entries. The nose-down pitching moment is less, and it is far easier to obtain a complete stalling angle of attack. Not only does this aft weight tend to raise the nose and flatten the spin, but the damping arm is shorter and the amount of fuselage surface available for damping is less. In addition, the destabilizing lever arm forward of the c.g. becomes longer as well as adding more surface to contribute to the destabilizing effect. It can be seen that if the c.g. was far enough aft, there would be more area ahead of the c.g. than aft of it.*'

The UK CAA, in their Handling Sense Leaflet 02 '*Stall/Spin Awareness*', Section 3 '*Stall Avoidance*', advises pilots to:

- *Be ready to apply **immediate** recovery action whenever you feel that the aeroplane is not responding correctly:*
    - *Move the control yoke (column) centrally forward to unstall the wings.*
    - ***Simultaneously** apply full power (if available), keeping the aircraft in balance.*

The Investigation also found similar stall recovery advice on the simultaneous application of full engine power in other General Aviation training literature. This is commonly referred to as the '*Standard Stall Recovery technique*'.

1.16.2 Weighing of NG4 Aircraft

While the NG5 weighing was being carried out in the UK on behalf of the AAIU, the Investigation noted that a number of very similar aircraft – the Roko Aero[50] NG4 – were being operated in Ireland. In particular, the fuselage dimensions of the NG4 showed that it had a distinct resemblance to that of the NG5. In addition, the Aircraft/Kit Manufacturer has stated that '*the NG4 is aerodynamically virtually identical to the NG5*'[51]. It was therefore decided to carry out weight and balance measurements on an NG4 in order to give a comparison to the accident aircraft and the NG5 aircraft being assessed in the UK.

The Roko Aero NG4 was launched in 2007, and was available in Light Sports and Ultralight variants. The Investigation obtained copies of POHs for a number of variants of the NG4. In all cases the weight and balance section of these POHs stated that the moment arm for a seated pilot and passenger was 0.6 m (600 mm) aft of datum. **Appendix I** shows two pages from an NG4 POH weight and balance section issued in 2008, with the published moment arm for a pilot and passenger highlighted.

The NG4 examined by the Investigation was the Ultralight variant. During the weighing of this aircraft in Ireland, it was noted that there was a similar anomaly between the moment arms as published in the NG4 aircraft POH, and that determined during aircraft weighing.

Data obtained during the aircraft weighing showed that the moment arm for a pilot and passenger in the NG4 aircraft that was examined was approximately 730 mm aft of datum. This larger moment arm means that the CG of the aircraft will be further aft when persons are seated in the aircraft, and it is possible, depending on pilot and passenger weight, and other variable loads, such as baggage stowed behind the aircraft seats, that the CG of the aircraft could move beyond the permitted maximum aft limit of 35 % MAC, without the pilots being so aware.

The above determination of pilot and passenger moment arm was carried out using the seats as fitted in the aircraft being examined. It was noted that the seat cushioning was thicker than that on the NG5 accident aircraft. It was also noted that the NG4 seat cushioning and seat position could be altered by individual owners. This could change the laden aircraft CG. **Note**: The moment arm of 730 mm aft of the wing rib number four datum for a pilot and passenger relates specifically to the NG4 aircraft that was examined and therefore the moment arm for other NG4 aircraft may differ.

On the 29 July 2020, due to the issues identified with the NG4, the Investigation made the following Interim Safety Recommendation (SR) to the Irish Aviation Authority:

> The Irish Aviation Authority should immediately notify owners and operators of NG4 aircraft operated and registered in the State, that the moment arm for a pilot and passenger, currently stated in the aircraft Pilot Operating Handbook, is incorrect and that owners and operators should have their aircraft weighed and measured and the moment arm for pilot and passenger be determined for their aircraft (**IRLD2020005**).

[50] **Roko Aero:** Another company that made Ultralight and Light Sports Aircraft.
[51] As quoted in Appendix M of a publically available document, available at https://aopa.com.au/wp-content/uploads/2021/03/Submission-to-CASA-Edited-for-Distribution_Redacted.pdf

1.16.2.1 Safety Action Taken by the Irish Aviation Authority

The Irish Aviation Authority responded to the AAIU on 5 August 2020, by email, advising as follows;

‘Below is the text of the letter sent to the owners of NG4 Aircraft:

The Air Accident Investigation Unit (AAIU) is currently investigating the subject fatal accident and has issued the following interim recommendation concerning NG4 aircraft which are of a similar design to the accident aircraft (NG5):

The Irish Aviation Authority should immediately notify owners and operators of NG4 aircraft operated and registered in the State, that the moment arm for a pilot and passenger, currently stated in the aircraft Pilot Operating Handbook, is incorrect and that owners and operators should have their aircraft weighed and measured and the moment arm for pilot and passenger be determined for their aircraft (IRLD2020005).

Further details of the investigation are provided in attachment A which explains the moment arm discrepancy for the pilot.

In order to investigate these anomalies, as the registered owner of Roko Aero NG4 aircraft with registration marks EI-### as soon as practical, weigh the aircraft to determine the […] *empty (zero fuel) weight and to follow the process in attachment B to determine the moment arm for the pilot and passenger.*

Report the results of the weighing process to the Registration and Certification section of the Irish Aviation Authority at registration@iaa.ie.

The National Microlight Association of Ireland, the Irish Micro Light Association, or a licenced aircraft engineer, as appropriate, can assist you in the weighing process.
In the interim, based on the anomalies reported, you are advised to limit flights to single pilot with no passenger or baggage’.

The Irish Aviation Authority further responded to the AAIU, on 6 August 2020, by email advising as follows;

‘[The] *last letters were issued to the registered owners of the 4 NG4 aircraft. These were also sent via email.*

Notifications were also sent to the 2 approved organisations that maintain these aircraft types’.

The AAIU has noted the IAA response to the SR and has classified it as ‘Implemented – Closed’

The Irish Aviation Authority also informed the Investigation that an NG4 aircraft, on the Irish Register, was operating on an EASA Permit. The Investigation therefore informed EASA of the issues that had been found relating to Weight and Balance on this type of aircraft. EASA informed the Investigation that it would carry out an investigation into this, and inform the AAIU of any findings.

1.16.2.2 Action Taken by EASA

EASA subsequently informed the Investigation that:

> '[EASA has] *received updated measurements of W&B and pilot arms for 2 of the serial numbers of model NG4 approved by EASA, with this data we have corrected the approved flight conditions. The investigation findings are confirmed in the NG4,* […].
>
> *For the other 2 serial numbers, there* [was] *no reply from the holders so* [EASA] *will inform the respective NAAs to revoke the* [EASA Permit to Fly].'

EASA sent the Investigation a copy of the updated measurements of weight and balance and pilot arms that it received for the two NG4 aircraft noted above. The Investigation reviewed the revised weight and balance document for the NG4, and notes the following:

- The aircraft type to which the document pertained was the NG4 HD.
- According to the logo on the document, it had been issued by the Aircraft/Kit Manufacturer of the NG5 aircraft variants.
- The changes to the moment arm for a pilot and passenger were the same as those issued by the Aircraft/Kit Manufacturer for the NG5 short wing variant (see **Appendix G**).

1.16.3 Accelerated Stalls

An aerofoil, such as an aircraft wing, when it exceeds a certain angle relative to the airflow over it (angle of attack), will stall. This angle is known as the critical angle of attack. This angle is fixed and is not affected by an aircraft's speed or weight. In level flight, the slower an aircraft flies, the greater the angle of attack required to produce lift equal to the aircraft's weight. As airspeed decreases, at some point, the angle of attack will become equal to the critical (stall) angle of attack. The speed at which this occurs is known as the '*stall speed*'. The normal stall speed, usually specified by the term V_S, always refers to the stall speed in straight and level flight, where the load factor (lift divided by weight), is equal to +1 *g*. However, to achieve the extra lift required during manoeuvring, the lift coefficient, and so the angle of attack, will be higher than it would be in straight and level flight at the same speed. Therefore, given that the stall always occurs at the same critical angle of attack, by increasing the load factor (e.g. by tightening the turn, or pitching the aircraft up) the critical angle of attack will be reached at a higher airspeed. An accelerated stall is a stall that occurs under such conditions.

Load factor is the ratio of the lifting force produced by the wings to the actual weight of the aircraft and its contents. Load factors are usually expressed in terms of '*g*'. The aircraft's stall speed increases in proportion to the square root of the load factor. For example, an aircraft that has a normal 1 *g* stall speed of 43 knots can be stalled at 86 knots when subjected to a load factor of 4 *g*, ($43 \times \sqrt{4} = 43 \times 2 = 86$). The possibility of inadvertently stalling the aircraft by increasing the load factor (by putting the aircraft in a steep turn or spiral, for example) is therefore much greater than in normal cruise flight.

1.16.4 FAA Airplane Flying Handbook, on Upset Prevention and Recovery Training

In its introduction to Chapter 5 of The FAA Airplane Flying Handbook, FAA-H-8083-3C: '*Maintaining Aircraft Control: Upset Prevention and Recovery Training*', it states:

> *LOC-I* (Loss of Control Inflight) *includes any significant deviation of an aircraft from the intended flightpath and it often results from an airplane upset.* […] *the FAA considers an upset to be an event that unintentionally exceeds the parameters normally experienced in flight or training.*

With regard to practicing stalls, the Handbook notes:

> *It is recommended that stalls be practiced at an altitude that allows recovery no lower than 1,500 feet AGL for single-engine airplanes, or higher if recommended by the AFM/POH. Losing altitude during recovery from a stall is to be expected.*

The final two manoeuvres conducted by the accident aircraft commenced at approximately 3,300 ft, with an expected altitude loss as per the aircraft POH, of approximately 85 ft, see **Table No. 3, Section 1.6.2**.

The FAA Airplane Flying Handbook, FAA-H-8083-3C, Chapter 5, in the section dealing with Slow Flight states:

> *The objective of maneuvering in slow flight is to develop the pilot's ability to fly at low speeds and high AOAs. Through practice, the pilot becomes familiar with the feel, sound, and visual cues of flight in this regime, where there is a degraded response to control inputs and where it is more difficult to maintain a selected altitude.*

1.16.5 The Difference between a Spin and a Spiral Dive

A spin is a sustained autorotation at angles of attack above the stall, the stall being the aerodynamic loss of lift caused by the wing exceeding the critical angle of attack.

In a spin, the stalled aircraft is yawing toward the down-going wing, which has a greater angle of attack beyond the stalling angle, producing more drag than the up-going wing, causing the aircraft to roll, yaw and pitch, while describing a downward corkscrew path about a vertical axis.

The US National Aeronautics and Space Administration (NASA), has defined four different aircraft spinning modes. The modes are defined by the angle of attack of the airflow on the wing, **Table No. 7**.

Spin mode	Angle-of-attack range
Steep	20 to 30 degrees
Moderately steep	30 to 45 degrees
Moderately flat	45 to 65 degrees
Flat	65 to 90 degrees

Table No. 7: NASA Classification of Aircraft Spin Modes

A spiral dive differs from a spin. Although it might appear similar to an inexperienced pilot, in a spiral dive the wings are not stalled. It is a steep descending turn and is characterised by a low angle of attack and high and/or increasing airspeed.

The FAA '*Airplane Flying Handbook, Chapter 5*' describes the spin as a manoeuvre that is in equilibrium, with the angular rotation rate, airspeed, and vertical speed all stabilised. In a spiral dive the airplane will not be in equilibrium but instead will have a rapidly increasing airspeed, and the *g*-load (vertical acceleration) can rapidly increase as a result.

1.16.6 Effects of Propeller Rotation

The following factors are known to affect single engine, propeller driven aircraft:

- P-Factor
- Roll due to propeller torque effect
- Prop-wash

1.16.6.1 P-Factor

This is the term for asymmetric propeller loading that causes the aircraft to yaw when the propeller disc is not perpendicular to the relative airflow, e.g. when the aircraft is at a high angle of attack.

In the case of a clockwise-rotating propeller (when viewed from the cockpit), the descending right side of the propeller disc, as seen from the rear, has a higher angle of attack relative to the oncoming air, and thus generates a higher air flow and thrust than the ascending left side. This moves the propeller's aerodynamic centre to the right of the aircraft centreline, thus inducing an increasing yaw moment to the left. The effect increases with increasing aircraft angle of attack or increasing engine power.

1.16.6.2 Propeller Torque Effect

Torque effect is the tendency for an aircraft to roll in the opposite direction to the rotation of the propeller. This is exhibited as a left rolling tendency in a single engine propeller driven aircraft, with a clockwise-rotating propeller (when viewed from the cockpit). The effect is greater at slow forward airspeeds.

1.16.6.3 Prop-wash

A propeller pushes air back in a helix around the fuselage. In the case of a clockwise-rotating propeller (when viewed from the cockpit), as the air spirals around the fuselage it pushes against the left side of the vertical tail, causing the aircraft to yaw to the left. The prop-wash effect is at its greatest when the airflow is flowing more around the fuselage than along it, i.e. at high power and low airspeed.

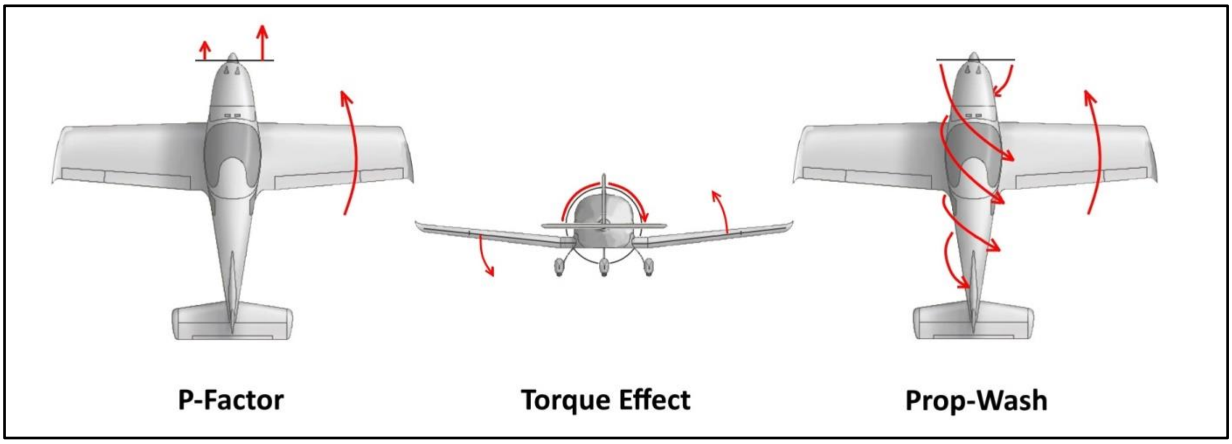


Figure No. 11: The Influence of Propeller Rotation

1.17 Organisational and Management Information

Not applicable.

1.18 Additional Information

1.18.1 Human Factors

The CASA AC 61-16 v 1.0; '*Spin Avoidance and Stall Recovery Training, Section 7.1.3, Human factors and upset prevention and recovery training*', highlights the following human factors that may occur during an aircraft upset:

- *Stress - The physiological, emotional and cognitive response to a perceived threat.*
- *Startle - A reflex, or involuntary and almost instantaneous response, to a sudden, threatening stimulus (such as a wing drop at the stall) which causes muscle reflex action, increased heart rate and increased blood pressure in preparation for a 'fight or flight' reaction to a surprise.*
- *Surprise reaction - Subsequent to the startle reflex, a response to an unexpected event which violates a pilot's expectations. The surprise reaction may also be known as the startle response; fight, flight or freeze.*
- *Disorientation - Conflict between visual, vestibular and proprioceptive*[52] *inputs to the brain which prevent making sense of which way is up and rotation in the three planes.*

It is possible for a pilot to become startled when faced with an unexpected change in aircraft attitude, especially if it has occurred rapidly. Also, control inputs required during spin avoidance and stall recovery may need to be counter-intuitive; however, control inputs in response to the startle reflex can often be intuitive and may be counter-productive.

[52] **Proprioceptive inputs:** Sensory inputs from nerve endings in muscles, tendons, and joints that provides a sense of the body's position by responding to stimuli from within the body.

1.18.2 EASA Annex 1

Regulation (EU) 2018/1139 (the '*Basic Regulation*') relates to the common rules in the field of civil aviation. It superseded Regulation (EC) 216/2008. The principal objective of this Regulation is to '*establish and maintain a high uniform level of civil aviation safety in the Union*'. Annex I of the Regulation lists the categories of aircraft that are exempt from the Regulation. Included in the list is category 'c':

> c) *Aircraft, including those supplied in kit form, where at least 51 % of the fabrication and assembly tasks are performed by an amateur, or a non-profit making association of amateurs, for their own purposes and without any commercial objective*;

The subject aircraft was an amateur-built aircraft, and therefore came under the Annex 1 categorisation, and, as such, was not subject to the Basic Regulation, but subject to national aviation regulations.

The Investigation held a number of meetings with EASA in relation to the issues surrounding the regulation of Annex 1 aircraft. One concern raised by the Investigation related to the large numbers of aircraft now being produced under this category of aircraft, which are not subject to the same level of regulation and oversight as the more '*traditional*' general aviation aircraft.

In terms of aircraft design and certification, EASA informed the Investigation that, '*a Czech Republic manufacturer would need an EASA certification if* [the aircraft was] *not related to Annex I "exceptions"*. *As the* [Aircraft/Kit Manufacturer's aircraft] *is Annex I* [one needs] *to rely* [on Czech] *National Aviation Authority for certification issues*'.

1.18.2.1 Design Oversight

The Czech Safety Investigation Authority (Air Accidents Investigation Institute of the Czech Republic (UZPLN)), informed the Investigation that oversight of design of the aircraft type was carried out by the LAA-CR, and not by the National Aviation Authority of the Czech Republic. Approval/certification of the aircraft type, by the LAA-CR, was applicable to the Czech Republic only.

1.18.3 UK Legislation

As the aircraft kit was purchased and constructed in the UK, under the UK CAA's 51% rule, UK CAA publication '*CAP 659, Amateur Built Aircraft, A Guide to Approval, Construction and Operation of Amateur Built Aircraft*', would have applied. This document describes the applicable requirements for construction, approval, and operation of this class of aircraft in the UK.

Section 7.3.2, of CAP 659, titled '*Meeting General Design and Construction Requirements*', states:

> *'We* [UK CAA] *do not directly undertake the investigation of designs. Instead we approve organisations to investigate designs on our behalf. When satisfied that a design meets the relevant airworthiness regulations the organisation makes a recommendation to us for an approval to be granted.* […] *The BMAA and PFA*[53] *are approved by us to investigate the designs of certain classes of aircraft intended for amateur construction; and recommend to us when the designs should be approved'.*

Section 7.3.2 goes on to state:

> '*However, please note that due to the less strict airworthiness requirements in most other countries, many amateur built aircraft designs emanating from abroad may not be able to be approved in the UK without first undergoing comprehensive investigation. Which may also require some redesign of the aircraft or, as an alternative imposition of operational limitations in order to show compliance with our standards.*
>
> *Please don't forget that just because a designer claims his product has been designed to meet a specific airworthiness code does not mean to say that an airworthiness authority or its agents have issued a certificate to say that it does. The only evidence we will accept of a design meeting an airworthiness code is the issuance of a certificate saying so by an airworthiness authority.'*

Section 11, of CAP 659, titled '*Flight Manual*', states:

> '*11.1 These days all newly registered aircraft are required to have a flight manual. This is sometimes referred to as the Pilot's Operating Handbook or the Owners Manual, but properly, it is called the Flight Manual*'.

Section 11.6 of CAP 659 notes that the Flight Manuals (and Pilot Operating Handbooks) are accepted, but not formally approved, by the UK CAA:

> '*11.6 The Design Surveyor can not finalise any outstanding design approvals and neither can the RO Surveyor issue the full Permit to Fly until your flight manual has been accepted by us.*
> ***NOTE:*** *The CAA do not formally approve flight manuals for amateur built aircraft as would be done for aircraft with Certificates of Airworthiness*'.

[53] **PFA:** in the UK the Popular Flying Association is now known as the LAA, Light Aircraft Association.

In addition, CAP 659 states:

> *19.5 Weight and Balance*
>
> *19.5.1 When you have completed your aircraft you will have weighed it and produced, from the weighing report, a weight and balance schedule. Using the weight and balance schedule in conjunction with the aircraft's airworthiness limitations relating to weight and balance, you must ensure that the aircraft is correctly loaded and the Centre of Gravity is within limits at all times.*
>
> *19.5.2 Failure to operate within the permitted weight and centre of gravity limits could result in failure to achieve minimum take-off performance, handling difficulties, loss of control or structural failure of the aircraft.*

During the course of the Investigation, the UK CAA informed the Investigation that it had identified weight & balance and POH data as focus areas for future oversight activities.

In addition, the UK CAA confirmed to the Investigation that a comprehensive review of CAP 659 (Amateur-Built Aircraft) is due to take place and will include an update to Section 11 (Flight Manual) to clarify the guidance on flight manuals/POH and to make clear that any conditions and limitations associated with the *'Permit to Fly'* override the manufacturer's data.

1.18.4 Other Accidents

The Investigation reviewed accident reports for a number of occurrences involving variants[54] of the subject aircraft type. Below are extracts in connection with four accidents where the aircraft was reported to have entered a spin prior to impact.

1.18.4.1 Bristell NG5 ELSA, Registration OK-VAR 03

This accident occurred near Brodce, Czech Republic, in November 2016 and was investigated by the UZPLN, which published Final Report CZ-16-989 in April 2017.

> *Synopsis*
>
> *On 8 November 2016, the AAII was notified by the FRS operating officer of an air accident of the Bristell NG5 Elsa ULA, identification mark OK-VAR 03, which occurred between Brodce and Luštěnice in the Josefov forest. The ULA was falling in an irregular rotation around the vertical axis with its nose tilted down at an angle of approximately 45 degrees. It hit the high-grown forest covered ground. The ULA was completely destroyed by its crash against the trees, on the ground and the subsequent fire.*
>
> *Two crew members sustained fatal injuries to which they succumbed on the air accident site.*

[54] The accident reports did not give wing and tail configurations for the aircraft involved. There may, therefore, have been some variation between the aircraft involved and the subject aircraft.

The UZPLN report stated:

> *'The cause of the air accident was the inability to manage a piloting technique for a low-altitude flight after the occurrence of an objectively unknown situation ending in a non-recovered spin. The occurrence of this situation has not been explained by air accident investigation.'*

1.18.4.2 BRM Aero Bristell, Registration 24-7954

This accident occurred at Clyde North, Victoria, Australia, in August 2017 and was investigated by Recreational Aviation Australia (RAAus). The accident investigation report is not a publically available document. The following is taken from the publically available ATSB Air Accident Investigation Report into another air accident, but which referenced the RAAus report:

> *'On 3 August 2017, during a training flight, a student pilot was conducting stall recovery training under supervision of an instructor at an altitude of 3,500 ft AGL. Following entry into the stall, the right wing dropped and, despite the correct instructed actions, the student pilot mishandled the stall recovery by applying opposite aileron. Although this is an intuitive response to raise the wing, it exacerbated the stall and the aircraft entered a spin.*
>
> *The instructor took over control of the aircraft from the student and initiated the correct spin recovery technique using ailerons neutral and opposite rudder. Despite having 3,000 ft remaining, the instructor was unable to regain control of the aircraft before it impacted the terrain. The student pilot was fatally injured and the instructor sustained serious injuries.'*

The Investigation subsequently spoke with the pilot of the aircraft involved in the Clyde North accident. He informed the AAIU Investigation that neither the rudder nor the elevator was effective in preventing, or recovering from the flat spin.

1.18.4.3 BRM Aero S.R.O Bristell S-LSA aircraft, Registration VH-YVX

This accident occurred at Stawell, Victoria, Australia, in October 2018 and was investigated by Australian Transport Safety Bureau (ATSB), which published Final Report AO-2018-066 on 29 June 2020.

> *'On 5 October 2018, a BRM Aero Bristell light sport aircraft (LSA), registered VH-YVX, departed Moorabbin Airport, Victoria, with a pilot and passenger on board. The purpose of the flight was a navigation exercise in support of the pilot's commercial pilot training requirements. Following an overfly of the intended waypoint at Stawell Airport, the aircraft was observed by witnesses to conduct a number of aerobatic-type manoeuvres before control was lost. The pilot was unable to recover control of the aircraft before it impacted terrain. The occupants sustained significant injuries and the aircraft was destroyed.*

The ATSB determined that, contrary to the aircraft's limitations and the pilot's qualifications, aerobatic manoeuvres were conducted during the flight, and immediately prior to the loss of control. The aircraft experienced an accelerated aerodynamic stall and entered into an upright, fully-developed spin. Although the pilot did not consistently apply the manufacturer's recommended spin recovery technique, recovery from a fully-developed spin may not have been possible in the aircraft type.

Further data analysis established that while the aircraft was pitching and rolling out from a diving left steep turn, it experienced an accelerated aerodynamic stall while rolling at an indicated airspeed of about 93 kt. The aircraft subsequently flick-rolled and entered a fully developed upright spin at an altitude of about 1,650 ft AGL.

Ground impact marks indicated that the aircraft had impacted terrain in a relatively flat, upright, counter clock-wise spin.'

The ATSB Final Report includes the following on LSA certification:

'***Light sport aircraft certification standards for spin recovery***

Aircraft in the LSA category are certified to the ASTM International standards. The certification process is conducted and self-certified for compliance by the manufacturer themselves, rather than by the regulating aviation authority from the state of manufacture. The LSA process relies on the manufacturer declaring that the aircraft meets all the construction and flight requirements of the LSA standards identified by them in the statement of compliance.

Aircraft certification standards for spin testing

ASTM F2245 standard specification for design and performance of light sport aeroplanes, section 4.5.9 states:

4.5.9 Spinning:

4.5.9.1 For airplanes placarded "no intentional spins," the airplane must be able to recover from a one turn spin or a 3-s[econd] spin, whichever takes longer, in not more than one additional turn, with the controls used in the manner normally used for recovery.

In some aircraft not approved for spinning, recovery may not be possible if the spin progresses to the developed stage.

The standard has various requirements, for example the light sport aircraft category for non-aerobatic aircraft requires the aircraft manufacturer to prove the aircraft type can recover from a one-turn spin.'

In addition, the ATSB Final Report includes a CASA assessment of BRM Aero Bristell LSA spin testing:

'The LSA category relies solely on the aircraft manufacturer declaring that each individual aircraft meets/complies with the standard(s) that they have indicated within the statement of compliance. Each individual aircraft must have its own statement of compliance issued and signed by the aircraft manufacturer that the particular aircraft meets the identified standards. Manufacturers are not required to submit test data, or show compliance to those standards, to CASA or any other regulator.

Following a number of fatal accidents involving Bristell aircraft entering into and not recovering from spins in Australia and overseas, CASA assessed the Bristell LSA self-certification testing documentation against the ASTM certification test standards.

CASA found that there was insufficient information in the initial test data to provide assurance that the aircraft type met the ASTM standards for spin recovery. As a result, CASA requested more certification testing data from the manufacturer. The manufacturer conducted further certification flight tests in the Bristell LSA and provided that data, including video recordings of each flight sequence to CASA. CASA's assessment of the new flight testing data and further information supplied by the manufacturer was that it still did not confirm that the aircraft met the required ASTM standard for spin recovery.'

1.18.4.4 BRM Aero s.r.o., model Bristell UL, Registration CS-USX

This accident occurred at Leiria aerodrome, Portugal, in June 2019 and was investigated by the Portuguese Accident Investigation Authority (GPIAAF), which published Final Report 2019/ACCID/03 on 22 July 2020.

'On June 9th, 2019 shortly after 15:10 UTC, a BRM Aero s.r.o., model Bristell UL aircraft departed from the Leiria aerodrome (LPJF) with two pilots on board for a local training flight.

After 45 minutes of flight with aerodrome circuits performing touch-and-goes and several training manoeuvres, following a low flyby over runway 20, the aircraft initiated a pronounced climb with a slight left turn, followed by an uncontrolled descent with reduced horizontal speed.

As a result of the aircraft loss of control, it rotated counter clockwise and spin, impacting the ground 150 meters NE from the runway 02 threshold. The impact took place with the wings levelled, with a reduced nose down angle with nearly zero horizontal speed.'

The GPIAAF Final Report included the following finding:

'The aircraft aerodynamic characteristics, which probably do not comply with the certification requirements (ASTM), namely the static margin and the ability for spin recover, suggests that pilots should adopt a conservative and cautious attitude during flight manoeuvres.'

The GPIAAF Final Report included the following Probable Cause:

> '*Aircraft loss of control by the pilots when performing an unapproved manoeuvre at low altitude.*'

In terms of certification and approval, the GPIAAF Final Report included the following comments:

> '*The attention to the technical specifications detail with different aircraft characteristics in their different versions, configurations or equipment level, must be analysed and properly addressed.*
>
> *In view of the increasing markets opening and the ease of transferring these aircraft between countries,* [it] *would be useful and desirable* [for] *a requirements harmonization path for the aircraft approval/certification by different authorities. The authorities that opted to not follow a single European standard (EASA, CS-VLA/LSA) should join forces making use of the institutions to which they belong, as example, the ECAC (European Civil Aviation Conference) to reach an understanding for the activity standardization.*'

1.18.5 CASA Safety Notices

Following the fatal accidents involving Bristell LSA aircraft in Australia, the CASA issued two notices. The first of these was a '*Safety Notice*' which was issued on 19 February 2020, to pilots and operators of Bristell LSA aircraft, regarding avoidance of stalls (see **Appendix J**). The Notice included the following statement:

> *'Pilots and operators of Bristell light sport aircraft (LSA) are strongly advised to avoid conducting any manoeuvre that may lead to an aerodynamic stall of the aircraft – either intentionally or unintentionally. This includes any flight training for stalls.*
>
> *The manufacturer has previously declared to CASA that the Bristell LSA meets the applicable certification requirements for LSA.*
>
> *Recent information received by CASA from the aircraft manufacturer shows that the aircraft may not meet the LSA standards as it does not appear to have been adequately tested (as required by the certification standards) for its ability to recover from spins.*
>
> *Worldwide, a number of Bristell aircraft have been involved in fatal accidents following unrecovered spins.'*

On 28 July 2020 CASA issued '*Safety Advisory Notice 01-2020 Issue 2*' (operational limitations under regulation 262APA(4)), in relation to stalling of the aircraft type (see **Appendix K**). Included in this Safety Advisory Notice was the following text:

'A pilot in command of or student under instruction in, a BRM Aero Light Sport Aircraft (including the NG4, NG5 and TDO design variants) engaged in a flight training operation, is prohibited from conducting an intentional stall of the aircraft, or from performing any flight training activities that could reasonably lead to an unintended stall (for example, performance limit turns which occur at high angle of bank, high angles of attack and low airspeed).

Safety Issues

Several fatal accidents have occurred worldwide (including in Australia) where Bristell aircraft appear to have entered a 'flat' spin (including during stall flight training) and failed to recover.

CASA has previously sought confirmation from the manufacturer as to compliance with the ASTM LSA standards and, in particular, spin compliance flight testing. At the present time, CASA has not received sufficient assurance as to the extent of such testing, including testing covering each design variant.

CASA also holds concerns as to the reliability of some of the information already provided.'

1.18.5.1 CASA Safety Advisory Notice 01-2021 Issue 3

On 21 June 2021, CASA issued '*Safety Advisory Notice 01-2021 Issue 3*'. This notice revoked the regulation 262APA(4) operating limitations, following receipt of new compliance information from BRM Aero Ltd and fundamental corrections having been made to the Aircraft Operating Instructions (AOI). The Safety Advisory Notice stated:

'CASA had information that BRM Aero Ltd had recently made and distributed to aircraft owners, important corrections to the centre of gravity calculations for the affected aircraft. The corrections were required to be incorporated into the AOI.

CASA is reasonably satisfied that the corrections made to the AOI have adequately mitigated the safety related concerns held by CASA, such that all participants are meaningfully aware of these corrections and importantly, how they change the loading requirements of the aircraft'.

The Safety Advisory Notice also stated that:

'*Pilots and operators should pay particular attention to the aft movement of the centre of gravity with fuel burn. Dependant on the empty weight and empty CoG of each aircraft, the corrected arm and the effect of an aft moving CoG with fuel burn, may significantly change the revised permitted loading of the aircraft, when compared to previous loading of the aircraft*'.

A copy of CASA '*Safety Advisory Notice 01-2021 Issue 3*' is given in **Appendix L**.

1.18.6 Aircraft/Kit Manufacturer's Stall Test Report

During the course of the Investigation, the Aircraft/Kit Manufacturer stated that it had carried out a stall test flight using a Bristell UL HD aircraft. The test flight was carried out on 28 July 2021. The stall test report, titled '*REPORT NO.: ULHD-REP-2-13-1-EN-0003-2021*', is included as **Appendix N** of this Final Report. The test flight was conducted with two test pilots on board, one from the Aircraft/Kit Manufacturer, and one from the Czech LAA. Details of the aircraft used, and the meteorological conditions during the test are included in the report.

In conclusion, the stall test report states that the flight tests:

> '*clearly demonstrated, that the wing level stall characteristics of Bristell even after exceeding of CG aft limit up to 2% of MAC, are absolutely satisfactory. The aeroplane is controllable up to a stall, which is shown itself by nose pitch down and usually slight right wing drop. The aeroplane has no tendency to enter into a spin. Exceeding of CG aft limit up to 37% MAC does not lead to uncontrollable wing level stall characteristics'. The test pilots were not able to introduce situation similar to the accident.*

The Aircraft/Kit Manufacturer's stall test report includes the following items in its '*Appendix 2 Summary of performed stalls, pilot comments*':

- Item 16: '*Stall input - skid. 25% of right pedal deflection, during stall - left aileron counter steering. Right Wing Drops Down*'.
- Item 18: '*Stall input - skid. 25% of left pedal deflection, during stall - right aileron counter steering. Left Wing Drops Down*'.
- Item 19: '*Standard methdology by elevator pushing down, recovery to horizontal position, in horizont full power. Left wing drops down*'.
- Item 27: '*During stall full throttle, hands off. When hands off, goes to the left spiral*'.
- Item 28: '*Stall, after nose goes to horizont, full throttle - hands off. After full throttle banks 30° to the left descending turn (not a spiral)*'.
- Item 31: '*On 90 IAS during climb full power, hands off. Banks to left*'.

The '*Summary of performed stalls, pilot comments*' also notes that, '*Yellow highlighted*[55] *are the stalls, which may lead to a critical stall behaviour when there are no pilot inputs at all (fully released controls)*'. As no information on the '*critical stall behaviour*' was contained in the Aircraft/Kit Manufacturer's stall test report, the Investigation was not able to establish the nature of the critical stall behaviour.

In addition, with regard to the left roll motion, exhibited by the accident aircraft, in response to the right wing-drop during the final two manoeuvres, the Aircraft/Kit Manufacturer informed the Investigation, in an email dated 3 August 2021, that:

> *'As tested in* [Aircraft/Kit Manufacturer] *on company built* […] *NG5, increase of the engine power is not enough to stop right roll and start left roll without use of opposite ailerons, so in our opinion pilot used also opposite ailerons – his reactions have been intuitive, which is wrong.'*

[55] These are areas highlighted in yellow on the last page of the Aircraft/Kit Manufacturer's stall test report.

The email also stated that the left roll exhibited by the accident aircraft was ‘*possible only by using also opposite ailerons, not only power increase as proven during BRM tests.*’

1.19 Useful or Effective Investigation Techniques

Not applicable.

2. ANALYSIS

2.1 Introduction

In order to best familiarise themselves with the aircraft, and its handling characteristics, the members of the syndicate who purchased the aircraft had asked an acquaintance, who was an experienced pilot and flight instructor, to assist and advise them, by accompanying them in the right seat, as they undertook their initial flights in the aircraft. On the day of the accident, the aircraft’s previous flight had been flown by one of the other syndicate members, who had been accompanied by the Right Seat Pilot. The Investigation was informed by the syndicate members that they believed the Left Seat Pilot was going to carry out some general handling, which might include practice stalls, and stall recovery. According to the syndicate members they would normally handle the aircraft during a flight, and the Right Seat Pilot would offer advice and helpful comment. However, it is not possible to determine with certainty which pilot was handling the aircraft at each stage of the accident flight.

When performing stall exercises, typically an aircraft is flown with engine power at idle, and aircraft pitch is increased to maintain altitude. Without any increase in engine power, aircraft airspeed reduces. When the critical angle of attack is reached, and the stall occurs, the aircraft pitches down, and there is a reduction in altitude.

The available recorded data indicates that the aircraft performed two stall exercises. The recorded data showed that prior to each stall, the aircraft maintained a constant altitude, at idle engine power, with indicated airspeed reducing as aircraft pitch angle increased. The data then showed a reduction in pitch-up attitude with an associated reduction in altitude and a reduction in vertical acceleration below +1 *g*. This is consistent with entry into a stall.

The altitude and flight track data indicate that the flight was conducted in a manner that ensured that the aircraft remained clear of controlled airspace in the EIKH local flying area. The performance of a HASEL check includes ensuring that an aircraft is at an appropriate height for practicing stalls, that the occupants are secured by their restraint harnesses, and that the area is clear of other traffic. The other syndicate members confirmed that the Right Seat Pilot would ensure that HASEL checks were carried out prior to stall manoeuvres, and the recorded data shows that the aircraft was at 3,300 ft and carried out two turns, one to the left, and one to the right, just prior to the first stall exercise. This would be consistent with the syndicate members’ recollection of the Right Seat Pilot’s method for completion of a HASEL check, prior to practicing stalling.

Stall exercises can be performed with, or without, wing flaps extended. Examination of the aircraft wreckage indicated that the flaps were retracted at the time of impact. The PFD-recorded indicated airspeed at the point the aircraft stalled (approximately 46 kts for the first stall, and approximately 47 kts for the second stall), although slightly above the POH stall speed for wings level and zero flaps, is consistent with the aircraft performing stalls with the flaps retracted.

The PFD data that was recorded for date, time, vertical speed, and pressure altitude, was compared to data from ATC and the Tablet Computer Navigation application, and was found to be consistent with this data, and was therefore considered reliable. The Investigation analysed the PFD user-accessible data with the assistance of the UK AAIB, and the OEM of the PFD. The OEM had access to PFD diagnostic data, in particular the gyro-rate data. From this, the Investigation is satisfied that the PFD-recorded data accurately reflects the flight path and aircraft attitude for the accident flight, up until the point where the aircraft rolled through 180° following the second stall exercise. After this point, aircraft attitude data became invalid due to the dynamic nature of the aircraft upset, which the UK AAIB noted '*would be in excess of the capability of the ADAHRS to accurately resolve the motion of the aircraft*'.

Aircraft position data (as recorded by the PFD), and therefore the aircraft ground track and groundspeed, as indicated by the white ground tack shown in **Figure No. 5**, **Section 1.11.3.1**, also became invalid which was likely due to shielding of the GPS antenna. However, engine RPM, indicated airspeed, vertical acceleration, pressure altitude and vertical speed, continued to be recorded with values that were regarded as valid.

The FAA '*Airplane Flying Handbook, Chapter 5*' describes a spin as a manoeuvre that is in equilibrium, with the angular rotation rate, airspeed, and vertical speed all stabilised. In a spiral dive the airplane will not be in equilibrium, but instead will have a rapidly increasing airspeed, and the *g*-load (Z-axis or vertical acceleration) can rapidly increase as a result. After the point that the aircraft rolled left through 180°, the recorded data shows an increasing airspeed, Z-axis acceleration, and descent rate. This is consistent with the aircraft entering a spiral dive.

Furthermore, the OEM of the PFD informed the Investigation that analysis of the recorded diagnostic gyro-rate data, when taken in conjunction with the user-accessible data, indicate that the aircraft most likely entered a spiral dive after it rolled left through 180°.

The data indicates that the spiral dive continued for approximately three rotations, during which Z-axis acceleration increased, peaking at +5 *g.* Following the +5 *g* peak, there is a noticeable change to a number of the recorded parameters:

- There is a marked reduction in vertical acceleration to between +2.0 and +1.5 *g.*
- There is a marked reduction in indicated airspeed.
- There is a reduction in Vertical speed.

The marked changes in the three parameters above would be consistent with an aircraft entering a spin, including a flat spin.

Furthermore, a review of the diagnostic data, by the OEM for the PFD, showed that, following the +5 g peak in Z-axis acceleration, there was a marked change to the Gyro-Rotation Rate. The OEM informed the Investigation that at this point the rotation rate about the Z-axis (yaw rate) exceeded the limit of the sensor, and that this would indicate that the aircraft was rotating counter-clockwise about the Z-axis, at more than -180° per second, which '*would correspond to the aircraft entering a flat spin with a high rate of anticlockwise rotation*'.

The data suggests that coincident with the +5 *g* peak in Z-axis acceleration, the aircraft may have experienced an accelerated stall. CASA AC 61-16 v 1.0, '*Spin avoidance and stall recovery training*', points out that some light sports aircraft may demonstrate stall characteristics that could result in entry to an unrecoverable spin, particularly in accelerated stalls.

2.2 Control of the Aircraft

The recorded data indicates that during both stall exercises the aircraft manoeuvring was very similar in each case, prior to the point when it rolled through 180° during the attempted recovery from the second stall exercise and departed from controlled flight.

As flight control inputs were not recorded, it was not possible for the Investigation to conclusively determine what flight control inputs were made, or which pilot was handling the aircraft during any stage of the accident flight. Whilst information provided to the Investigation by the syndicate members suggests that it was usual for a syndicate member to operate as the handling pilot, there remains the possibility that the Right Seat Pilot may have handled the aircraft, either to demonstrate manoeuvres such as slow flight and stalling, or to attempt to recover the aircraft.

The data indicates that, during each of the two stalls, the right wing dropped. This was followed by a left roll during the stall recovery. The Aircraft/Kit Manufacturer has stated that the left roll exhibited by the accident aircraft during both stall recoveries, in response to the right wing-drop, was '*possible only by using also opposite ailerons*'. In general, if left aileron is used, in an attempt to correct a right wing-drop at the stall, it is likely that the roll to the right would be exacerbated. In the case of the subject aircraft this was not the case, and the aircraft rolled to the left following the right wing-drop.

2.3 Wreckage and Impact Analysis

The Investigation found a portion of a propeller and the right elevator horn embedded in the soil at the accident site. In addition, there were witness marks in the soil from the nose-wheel and left main wheel. The Investigation overlaid a plan view of the subject aircraft onto a plot of the witness marks, including the portion of propeller blade and elevator balance horn, that were measured at the accident site (**Figure No. 12**).

This aligned very closely with the witness marks and showed that the aircraft initially impacted the ground on a magnetic heading of 033°. This indicates that the aircraft impacted the ground with a significant counter-clockwise rotational motion about the normal (Z) axis, before bouncing and coming to rest on a heading of 320° (**Figure No. 13**).

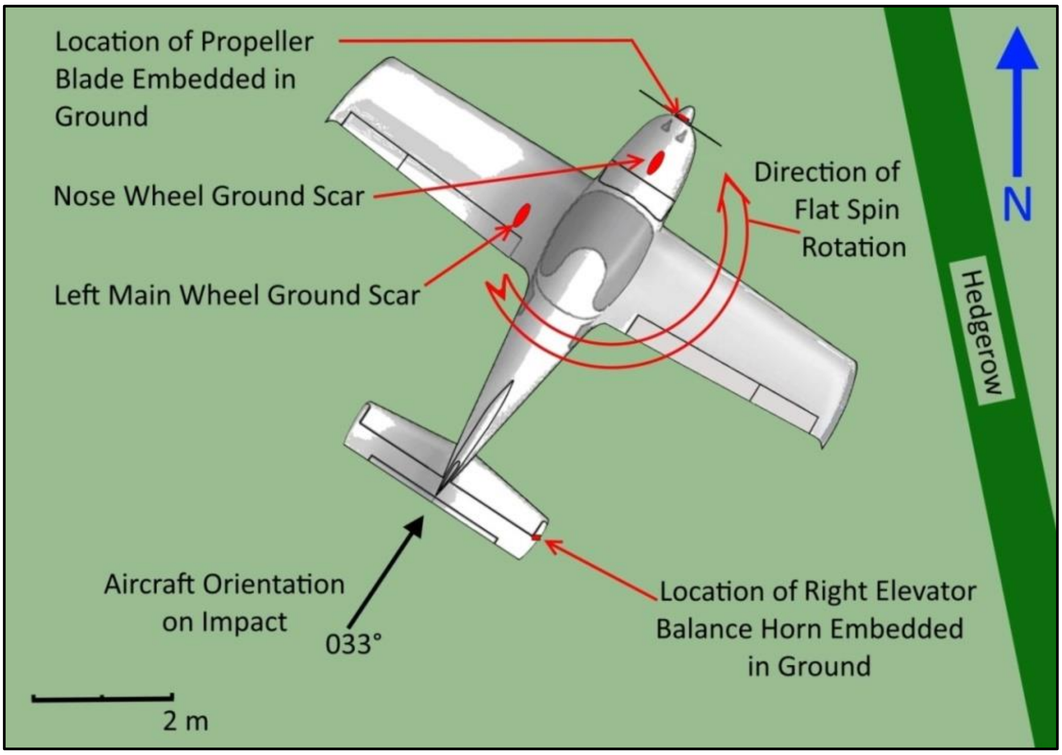


Figure No. 12: Orientation of Aircraft at Initial Impact

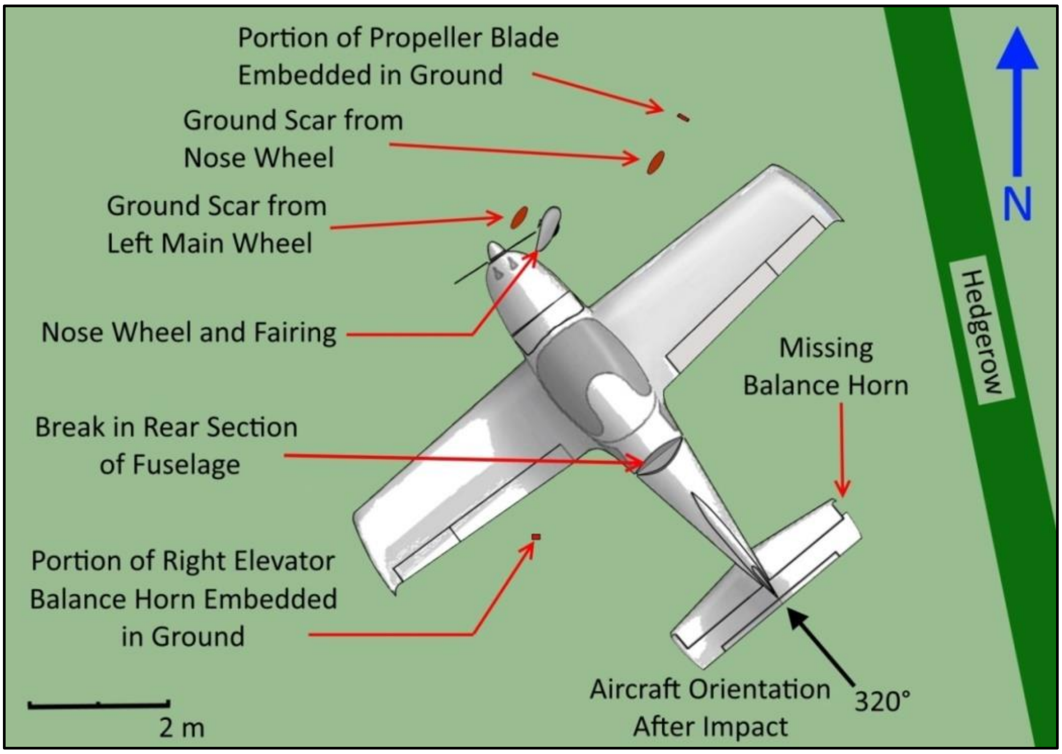


Figure No. 13: Final Orientation of Aircraft

The lack of damage to the nearby foliage, the vertical compression of the wing and fuselage structures, the manner in which the tail partially separated from the aft fuselage, and the distortion of the engine mounting and tail fin, also indicate that the aircraft impacted whilst in a counter-clockwise-rotating flat spin.

The underside of the nose section of the aircraft sustained more compression damage than the tail section, and the left main-gear leg sustained more damage than the right. This would indicate that the aircraft, whilst in a flat spin, had a slight nose-down and slight left wing down attitude at impact.

The aircraft structure and all components were present at the accident site. During examination of the aircraft wreckage, the Investigation found no evidence that the aircraft sustained any damage or failure, prior to impact, that may have been the result of the aircraft being subjected to the high *g* loads prior to impact. This evidence, and the wing load testing data (see **Section 1.6.1**), which stated that the wings could sustain +6.85 *g*, indicates that the aircraft did not likely sustain any structural failure prior to impact.

The Investigation examined the canopy and the cockpit sidewall. There was no damage to the underside of the canopy frame. The nature of the damage to the canopy structure close to the canopy's left hinge, the gas springs, and the latch mechanisms, indicated that the canopy was closed and latched at the time of aircraft impact. Furthermore, evidence provided by a SAR crew member who first attended the accident site, confirmed that the canopy was found in the closed and latched position.

2.4 The Flight

2.4.1 The Earlier Manoeuvres

There was no record in the Left Seat Pilot's flying logbooks, or the separate notes of his recent flights that he had practiced stalling in the subject aircraft, prior to the accident flight. Therefore, he would likely have been unfamiliar with the pre-stall characteristics of the aircraft, such as pre-stall buffet.

The data shows that during an approximate three minute period commencing at time 18:12:30, approximately six minutes prior to the two stall exercises being performed, the aircraft was maintaining a constant track of 153.5° (+/- 2.5°). On this track the aircraft descended twice from an altitude of approximately 3,300 ft to approximately 2,900 ft. The recorded data shows changes to engine power, airspeed and aircraft pitch attitude, and that the aircraft maintained a wings-level attitude, with no noticeable wing drop. The data also indicates that these manoeuvres were performed following a period of straight flight, i.e. the manoeuvres were not preceded by any turns.

This indicates that it was is possible that, prior to stalling the aircraft, a slow flight exercise was being performed in order that the Left Seat Pilot could experience the aircraft's handling characteristics leading up to a stall, including pre-stall buffet. A further indication that a slow flight exercise was being performed is that no clearing turns were carried out, prior to these earlier manoeuvres.

The recorded data indicates that, following what appears to be a slow flight exercise, the aircraft carried out what the Investigation considered to be two clearing turns, before proceeding with the stall exercises.

2.4.2 The Two Stalls

2.4.2.1 General

A review of the user-accessible recorded aircraft attitude data, i.e. aircraft pitch and roll, was carried out in conjunction with the recorded diagnostic roll-rate data. This showed that the attitude data recorded for the first stall exercise and recovery, and the initial part of the second stall exercise, prior to loss of control, were consistent and therefore reflected the motion of the aircraft.

Nothing in the recorded data indicated that unapproved manoeuvres were being deliberately performed. The manoeuvres recorded after each stall would indicate an unexpected upset, followed by attempts to recover the aircraft.

2.4.2.2 Right Wing-Drop and Canopy Latching

The recorded data shows that during both stall exercises there was a marked right wing-drop to approximately 30°. The Aircraft/Kit Manufacturer's stall test report (**Section 1.18.6**) states that during the stall test there was '*usually slight right wing drop*'. The syndicate members informed the Investigation that the aircraft would always drop a wing during a stall. They stated that it could be either wing, but often the right wing, and that the wing-drop was in the region of 10-15°.

The UK LAA TADS notes that a marked wing-drop during a stall may be connected to the adjustment of the canopy latch mechanism and the wing lower gap seals. The syndicate members informed the Investigation that they would occasionally experience a noticeable draught from the right side of the canopy. A draught could be caused by a canopy that is not seated correctly. Both the canopy latches and wing gap seals were damaged during the impact, to the extent that it was not possible to verify their adjustment pre-accident, and whether this could have contributed to the marked wing-drop. However, it should be noted that the canopy was found to be in the latched closed position by members of the emergency services who were first at the scene.

The UK LAA's note on a wing-drop that occurs in connection with canopy adjustment is located in a section on '*Special Flight Testing Issues*'. Therefore, owners and operators of the aircraft may not associate a wing-drop that has subsequently developed, post flight-testing, with a canopy that is not seating correctly.

Safety Action Taken by the UK LAA

During the course of the Investigation, the UK LAA advised the Investigation that '*The UK Light Aircraft Association has amended the TADS (Type Acceptance Data Sheet – issue 4B dated 13.8.21) for the Bristell NG5 to include text giving guidance for owners and operators regarding the possibility that a wing drop at the stall may indicate the need for adjustments to the wing gap seals or canopy*.' Therefore, the Investigation makes no Safety Recommendation in this regard.

2.4.2.3 Application of Engine Power

During both stall exercises, as the right wing dropped, engine power was applied, and the aircraft pitched up, rolled and yawed to the left. The left roll continued until the aircraft had rolled to approximate 103° left wing down in the case of the first stall exercise, and approximate 93° left wing down in the case of the second stall exercise.

In each case, the left roll was initially arrested, and the aircraft began a right roll. In the case of the first stall exercise the aircraft was recovered to wings level.

In the case of the second stall exercise, as the aircraft was rolling right, back towards wings level, a rapid left roll recommenced, and this left roll continued through 180°. This appears to have coincided with a brief application of engine power. This is discussed further in **Section 2.7** and **Section 2.8**.

2.4.3 The Spiral Dive

Following the rapid left roll through 180°, the aircraft attitude and position data, as recorded in the user-accessible data, became unreliable as aircraft rotation rates may have been in excess of the capability of the ADAHRS to accurately resolve the motion of the aircraft. It is therefore not possible to say with absolute certainty what the motion of the aircraft was following its roll through 180°. However, the user-accessible data for airspeed, vertical acceleration, and vertical speed, taken in conjunction with gyro roll-rate data, would suggest that the aircraft entered a spiral dive, during an attempt to recover from the left wing rotation.

Regarding the aircraft's behaviour during spin testing, the Manufacturer's test report frequently referred to the aircraft entering a spiral descent, rather than a true spin. The test report also states, '*During first 2 turns, there is practically no difference between the left and right spin. After 3 turn, the plane goes into a very steep negative spiral, therefore spin with more than 1 turn should be avoided*', and also '*the aircraft mostly entered into a spiral rather than a true spin*'.

The Investigation also notes that CASA AC 61-16 v 1.0. '*Spin avoidance and stall recovery training*' states:

> *'It is common for light aircraft to exhibit spiral characteristics; the wings unstalling at some point after entering the spin and the aircraft accelerating into a spiral dive with rapidly increasing airspeed'.*

2.4.4 The Flat Spin

During the spiral dive, with increasing airspeed, the aircraft sustained increasing *g* loading, which peaked at +5 *g*. The data indicates that at +5 *g* the aircraft likely experienced an accelerated stall. Evidence at the accident site indicates that the aircraft impacted the ground in a counter-clockwise rotating flat spin and therefore the aircraft entered a flat spin prior to impact.

Whilst a test pilot may be able to recover an aircraft from a flat spin under flight-test conditions, this may not always be achievable in a normal general aviation environment. The Investigation found that the CG of the subject aircraft was beyond the aft limit (**Section 2.5**). A CG that is beyond the aft limit would make entry into a flat spin easier and make recovery more difficult. The following points are taken from a review of literature on spinning, (**Section 1.16.1**):

- A rearward CG is likely to increase angle of attack, deepen the stall, and flatten the spin. This may also render the spin unrecoverable.
- Some light sport aircraft may demonstrate stall characteristics in which a wing drop can rapidly and unpredictably result in an unrecoverable spin entry.
- The CG of an aircraft influences its stall and spin behaviour. In addition, flatter spin attitudes are promoted with an aft CG, and non-recoverable spins become more likely.
- Stability, stalling characteristics, and spin recovery are all affected by the CG position. In spins at aft CG locations, the pitch attitude in a stabilised spin is more level. This produces increased angle of attack on the horizontal tail and may make the elevators ineffective in spin recoveries.
- An aft CG is conducive to easy spin entries. The nose-down pitching moment is less, and it is far easier to obtain a complete stalling angle of attack. Not only does this aft weight tend to raise the nose and flatten the spin, but the damping arm is shorter and the amount of fuselage surface available for damping is less.
- CS-VLA 221 (a) (3) states that: '*It must be impossible to obtain uncontrollable spins with any use of the controls*'.

2.5 Aircraft Weight and Balance

2.5.1 Introduction

Weight and Balance documentation for the accident aircraft stated that the aft limit for CG was 35% MAC.

The Investigation calculated the weight of the aircraft at take-off as 570.5 kg. This is below the maximum take-off weight of 600 kg.

At the time of the accident, the syndicate pilots had been using a moment arm of 0.6 m (600 mm) aft of datum for a pilot and passenger, when determining the weight and balance of the subject aircraft. This was the figure contained in the POH supplied with the aircraft. The other syndicate members informed the Investigation that each of them had carried out weight and balance calculations using the aircraft POH weight and balance tables, and they believed the aircraft would be within weight and balance limits when loaded as per the guidance in the POH.

Calculations performed by the Investigation that were based on the aircraft dimensions and centre of mass positions, and also aircraft weighing carried out on behalf of the Investigation in the UK, both showed that the moment arm for persons seated in the subject aircraft type, as published in the POH, and the UK LAA weight and balance documentation, was incorrect.

Due to the nature of the weighing method, and the slight variations between aircraft (including aircraft seating), the results showed a range of values. Following a review of the results of the weight and balance measurements carried out in the UK, the UK LAA determined that an appropriate value for the moment arm for a pilot and passenger, in the UK version of the aircraft type, should be set at 750 mm aft of the original datum (wing rib number four), i.e. an addition of 150 mm to the moment arm originally specified in the POH.

The examination of the moment arm error by the Investigation has shown that, for this aircraft, a small change in the location of a variable load, such as a pilot or passenger, has a significant effect on the aircraft's CG. In the case of the subject aircraft, as loaded at the time of the accident, every 10 mm rearward shift in moment arm of the persons on board, resulted in the aircraft CG moving rearward by just under a quarter of a percent MAC. The Investigation therefore considers that an error of 150 mm in pilot and passenger moment arm is significant in nature, with likely adverse effects on aircraft handling characteristics under certain circumstances. The Investigation's determination of the subject aircraft pilot and passenger moment arm was calculated to be 768 mm aft of the original datum (see **Section 1.6.10.3**).

2.5.2 Action Taken by the UK LAA

Following the decision of the UK LAA to adopt a revised moment arm of 750 mm aft of datum, for persons seated in the UK variant of the Bristell NG5, the UK LAA immediately took the following action:

- The issuing of an Airworthiness Information Leaflet, (LAA/MOD/385/011 Issue 1, see **Appendix D**), issued on 17 July 2020, and an Airworthiness Alert, (LAA/AWA/20/18, see **Appendix E**), issued on 20 July 2020, advising owners and pilots of NG5 aircraft of the change in the pilot and passenger moment arm measurement to be used in pre-flight CG calculations.
- The UK LAA advised the UK CAA of the issues concerning CG calculation on the aircraft type.

2.5.3 Action Taken by the Aircraft/Kit Manufacturer

The finding, by the Investigation, of the erroneous moment arm for pilot and passenger in the Bristell NG5 aircraft was sent to the Aircraft/Kit Manufacturer. The Aircraft/Kit Manufacturer agreed with the moment arm value for pilot and passenger that had been adopted by the UK LAA. The Aircraft/Kit Manufacturer subsequently issued a Safety Alert, '*Bulletin Number: ALL-SA-0-0-0-0001-2020*', issued 7 August 2020 (which was re-classified to a Safety Directive at the request of the FAA) to all users of variants of the Bristell NG5, and Bristell LSA, informing them of the changes to the Weight and Balance sections of the relevant POH/AOI.

The amended weight and balance information contained in the Safety Alert Bulletin used a value of 750 mm aft of (the original) datum for the moment arm for persons seated in the short-wing version of the aircraft. This was the value determined by the Aircraft/Kit Manufacturer as stated to the Investigation in an email dated 18 August 2020 (see **Section 1.6.10.8**).

However, the Investigation subsequently established that the weighing exercise carried out by the Aircraft/Kit Manufacturer included a significant number of values greater than 750 mm aft of datum. In addition, the weighing exercise did not state the dimensions of the seat cushion material in the aircraft used for the weighing exercise. The Investigation therefore makes the following Safety Recommendation to the Aircraft/Kit Manufacturer:

BRM Aero should review the Weight and Balance documentation for all NG5 variants to take account of all values obtained during its weighing of the aircraft, including those values that were greater than 750 mm aft of the wing rib 4 datum for the moment arm for persons seated in the NG5 aircraft. The effects of seat cushion thickness should be included in the review. The review should be monitored by the Czech LAA, and amendments arising from the review circulated to all owners/operators of the NG5 variants (**IRLD2022001**).

The Investigation notes that relatively small changes to the location of variable loads can have a large effect on the CG for light aircraft, and that even a small variation in seat position and seat cushioning material may affect the position of the seated person within the cockpit, and therefore the effective moment arm of that person.

The Investigation believes that the method used by the Aircraft/Kit Manufacturer, as outlined in **Section 1.6.10.6**, for finding the pilot and passenger moment arm, whereby persons climb into the aircraft and then scale readings are taken, can lead to a large spread of results, and therefore make it difficult to accurately determine the moment arm for persons seated in the aircraft.

The physical characteristics of the aircraft seating, including seat dimensions, seat-back recline angle, and seat cushion material, are fixed within the aircraft at time of construction. Therefore, knowing the aircraft seat characteristics, and using available anthropometric data, it should be possible to determine a suitable moment arm for persons seated in an aircraft. In addition, the Investigation found that small changes in aircraft tilt angle during the weighing process, will affect the CM location, and therefore the effective moment arm, of a seated person.

The Investigation therefore makes the following Safety Recommendation to the Aircraft/Kit Manufacturer:

BRM Aero should review its procedures for the determination of the moment arm for a seated pilot and passenger in each of its aircraft variants, with a view to changing the method to one using available anthropometric data and aircraft seat location and dimensions, taking into account all possible seating configurations, including but not limited to, seat-back recline angle, and seat cushion material (**IRLD2022002**).

2.5.4 Accident Aircraft Centre of Gravity

2.5.4.1 Centre of Gravity as Determined by the Investigation

The Aircraft/Kit Manufacturer stated that the aft CG limit for the aircraft is 35% MAC.

Using the accident aircraft seat characteristics, as provided by the Aircraft/Kit Manufacturer and measured by the Investigation, and using available anthropometric data, the Investigation found that, in the case of the accident aircraft, the moment arm for the pilot and passenger was 0.768 m (768 mm) aft of datum (wing rib number four). Using this figure, the CG of the aircraft at the commencement of the flight was 35.6% MAC. As fuel was used during flight, the CG would have moved further aft to 35.9% MAC. In addition, under high +*g* loading, when the aircraft occupants might have been pushed further into their seats, it is possible that the effective CG of the aircraft may have moved further aft.

The above calculations are made using a moment arm for items stowed behind the cockpit seats of 2.0 m, i.e. the moment arm given in the POH for the subject aircraft. The Investigation notes, however, that some versions of the POH contain a value for the moment arm for items stowed behind the cockpit seats of 1.4 m aft of the original datum. Using a value of 1.4 m, the calculated CG for the aircraft, at the time of the accident would be 35.7% MAC, which would still have been outside the aft limit CG limit.

2.5.4.2 Centre of Gravity using 750 mm Moment Arm

During the course of the Investigation, the UK LAA and the Aircraft/Kit Manufacturer adopted a figure of 750 mm aft of the original datum position (wing rib number four), as the moment arm for persons seated in the subject aircraft. Using this value, and the actual weights of the pilots and other variable loads on the accident aircraft, the calculated CG for the aircraft, at the time of the accident would be 35.5% MAC, which would still have been outside the CG limits (see **Appendix H**).

2.5.4.3 Centre of Gravity using new MAC

The Aircraft/Kit Manufacturer had provided the Investigation with the original aerodynamic data titled '*BASIC AERODYNAMIC CALCULATION OF BRISTELL UL HD*' dated 25 June 2011, for the short wing variant. This gave the length of the MAC of the short wing as 1.367 m, located 2.0705 m outboard of the aircraft Plane of Symmetry (**Section 1.6.1**).

During the course of the Investigation, the Aircraft/Kit Manufacturer provided new aerodynamic data relating to the MAC, in a document dated 9 August 2021. The new data suggested that the MAC was now 1.3745 m in length, and located 1.854 m outboard of the aircraft Plane of Symmetry (**Section 1.6.1**)**.** This new information stated that it was also for the short wing.

Both the original and 'new' aerodynamic data indicated that the sweep-back angle of the leading edge of the outer portion of the short wing was approximately 1.745°. Consequently, as the 'new' MAC is situated 216.5 mm inboard of the original MAC (2.0705 m minus 1.854 m), it follows that the leading edge of the 'new' MAC is 6.6 mm ahead of the leading edge of the original MAC, due to the sweep-back angle of the wing (**Figure No. 14**).

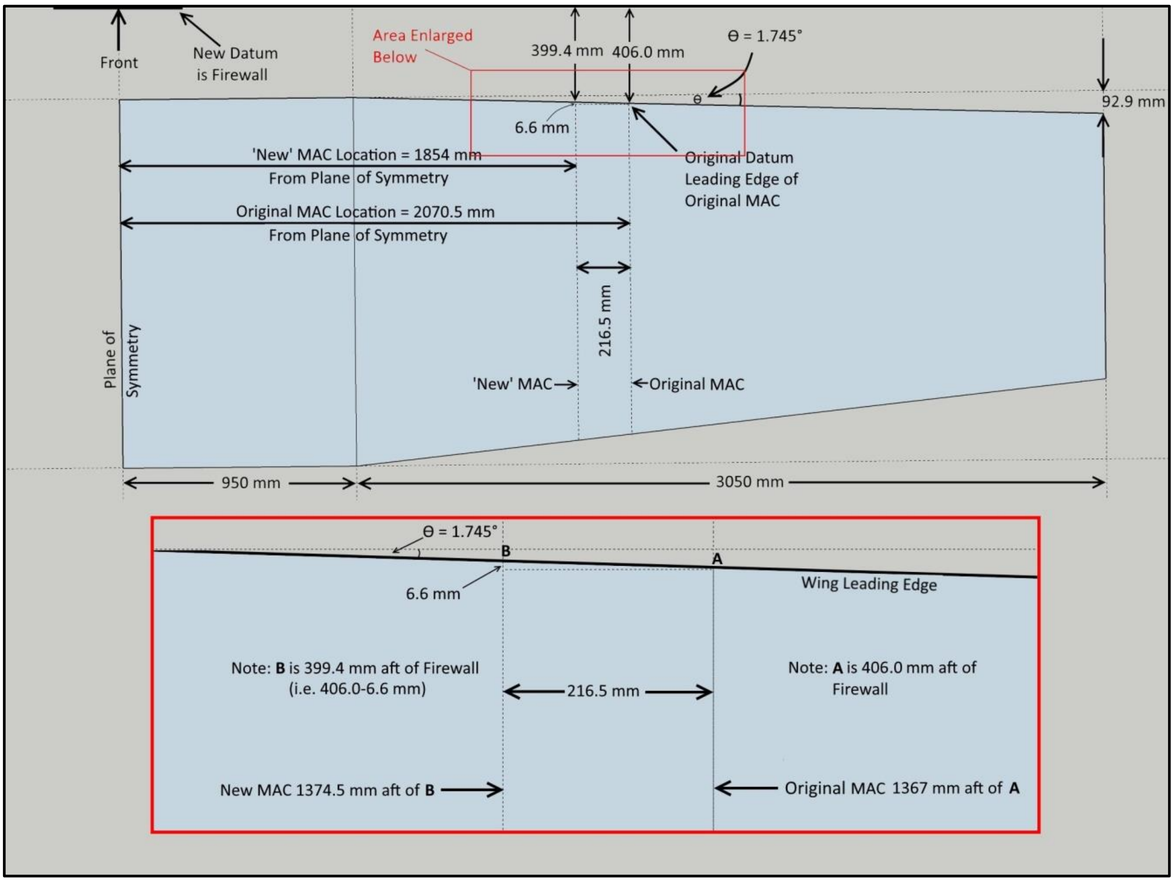


Figure No. 14: Diagram showing how wing sweep angle affects distance of MAC from Firewall Datum as calculated from the data in **Section 1.6.1**

Information from the Aircraft/Kit Manufacturer showed that the new datum (aircraft firewall) is situated 406 mm ahead of the original datum (old MAC leading edge position). From this it follows that the 'new' MAC lies 399.4 mm aft of the new datum (i.e. 406 mm minus 6.6 mm). The Investigation notes that the Aircraft/Kit Manufacturer issued an amended Weight and Balance document for the short wing variant (BRSW-AOI-AU_Ra, dated August 2020), which stated that the 'new' MAC for the short wing, of 1.3745 m lay 406.1 mm aft of the new Firewall datum. From the information above, the Investigation believes that the location of the MAC relative to datum is incorrect in the amended Weight and Balance documentation issued by the Aircraft/Kit Manufacturer in August 2020, and that the Weight and Balance document should show the 'new' MAC as lying 399.4 mm aft of the Firewall. The Investigation therefore makes the following Safety Recommendation to the Aircraft/Kit Manufacturer:

BRM Aero should consider issuing a revised Weight and Balance document for the Short Wing variant of the NG5, highlighting the correct location of the Mean Aerodynamic Chord with respect to the Firewall datum (**IRLD2022003**).

Using this corrected value for the location of the 'new' MAC of 399.4 mm aft of Firewall, and the 'new' MAC of 1.3745 m, the Investigation calculated the effect on the CG of the aircraft. This showed that the CG was 36.2% MAC as compared to 35.9% MAC when using the original MAC length of 1.367 m and location of 2.0705 m outboard of aircraft Plane of Symmetry, i.e. the CG is further aft than originally determined.

As the Investigation was dealing primarily with the Short Wing variant of the NG5, it did not obtain aerodynamic data for the Long Wing variant. Therefore, the Investigation did not determine if the revised Weight and Balance document (BRLW-AOI-AU_Ra, Dated August 2020), contained an error in relation to the location of the MAC for the Long Wing. However, given the finding of an error in this respect with the Short Wing, the Investigation makes the following Safety Recommendation to the Aircraft/Kit Manufacturer:

> BRM Aero should review the Weight and Balance document for the Long Wing variant of the NG5, to ensure that the correct location of the Mean Aerodynamic Chord with respect to the Firewall datum is stated in the appropriate Weight and Balance document, and that this is issued to owners/operators of the Long Wing variant of the NG5 (**IRLD2022004**).

2.5.4.4 Effect of Centre of Gravity on the Occurrence

A review of literature on stalling and spinning indicates that the further aft an aircraft's CG is, the less its longitudinal stability, the stronger the pro-spin forces and moments are, and the more sensitive the aircraft will be to elevator inputs. In an aircraft with an extremely aft CG, very light back elevator control forces may lead to inadvertent stall entries and if a spin is entered, the balance of forces on the aircraft may result in a flat spin. In addition, an increase in airspeed will generally cause an aircraft to pitch up, and this will be more noticeable the further aft the aircraft's CG.

In '*Flying Qualities and Flight Testing of the Airplane*', 1996, Stinton, notes that an aircraft's neutral point is affected by power application, and that for a propeller driven aircraft with a tractor propeller (i.e. a propeller located at the front of the aircraft), the application of engine power at low airspeeds has the effect of shifting the neutral point forward, bringing it closer to the CG. This could further reduce an aircraft's longitudinal stability and affect an aircraft's handling characteristics.

The Investigation also notes the following text from two Safety Investigation reports.

In a Final Report, issued by the Portuguese GPIAAF, into an accident involving a BRM Aero S.R.O., model Bristell UL, Registration CS-USX (**Section 1.18.4.4**), it was noted that:

> *'The aircraft aerodynamic characteristics, which probably do not comply with the certification requirements (ASTM), namely the static margin and the ability for spin recover*[y]*, suggests that pilots should adopt a conservative and cautious attitude during flight manoeuvres'*

An investigation by the Australian ATSB into an accident involving a BRM Aero S.R.O, Bristell S-LSA aircraft, Registration VH-YVX (**Section 1.18.4.3**), noted that:

> *'The aircraft experienced an accelerated aerodynamic stall and entered into an upright, fully-developed spin.* […]*, recovery from a fully-developed spin may not have been possible in the aircraft type'.*

The Aircraft/Kit Manufacturer's spin test report on a variant of the aircraft type noted that '*The short wing version of the aircraft was chosen for the* [additional] *tests as previous tests had determined that this version was the worst configuration for the spin recovery*'. As stated in **Section 1.6.1**, the accident aircraft was fitted with the short wing. In the case of the accident flight, unknown to the pilots, the CG was beyond the aft CG limit prescribed for the aircraft, and that this likely had an adverse effect on the handling characteristics of the aircraft during the attempted stall recovery, and subsequent aircraft upset. The aircraft then entered a flat spin, from which recovery may not have been possible. A CG being beyond the aft limit would militate against recovery.

2.5.4.5 Aircraft/Kit Manufacturer's Revised Weight and Balance Document

The Investigation recognises the fact that the Aircraft/Kit Manufacturer has issued an amendment to Part 6 of the aircraft AOI/POH, copies of which are included as **Appendix F** for a Long Wing variant, and **Appendix G**, for a Short Wing variant. Both of these amendments contain a '*Sample Pilot Calculation*' table for the CG of the aircraft, which concludes with the statement, '*Sample aircraft is within limits*'.

The Investigation notes that the revised Weight and Balance document issued by the Aircraft/Kit Manufacturer, for the Short Wing (BRSW-AOI-AU_Ra), contains a value for the location of the MAC that appears to be incorrect (**Section 2.5.4.3**). Therefore the Investigation believes that the current issue of '*BRSW-AOI-AU_Ra*' may result in operators of the aircraft not making correct Weight and Balance and Aircraft CG calculations.

The Investigation also reviewed the '*Sample Pilot Calculation*' tables contained in the amendments issued for both the '*Long-Wing*' and '*Short-Wing*' variants, and notes the following:

- The table for the Long Wing variant, as currently published in '*BRLW-AOI-AU_Ra*', contains an anomaly relating to the numerical value of the load contained in the aircraft wing lockers. The anomaly has been highlighted (by a red box), in **Appendix F**.

- Whilst the published table for the Short Wing variant shows the aircraft as within limits, as soon as fuel is used, the aircraft CG will begin to move aft, and will immediately go beyond the aft limit.

- In addition, as noted above in **Section 2.5.4.3**, the location of the MAC, as currently published in '*BRSW-AOI-AU_Ra*', appears to be incorrect, and when the corrected MAC location is used for the CG calculation, the CG for the Short Wing '*Sample Aircraft*' would be outside limits.

The errors in document '*BRSW-AOI-AU_Ra*' are highlighted (circled red) in **Appendix G**.

Both tables in the amended Weight and Balance document state that the '*sample aircraft is within limits*'. Whilst this statement is correct for the '*sample aircraft*' loaded as per the table, it does not account for changes in CG due to fuel-burn. This could be misleading to operators of the aircraft. The Investigation notes that past versions of the POH contained a chart showing maximum combined pilot and passenger weights for various fuel and baggage configurations. The revised Part 6 issued by the Aircraft/Kit Manufacturer does not appear to contain such a chart.

The Investigation therefore makes the following Safety Recommendation to the Aircraft/Kit Manufacturer:

> BRM Aero should issue an amendment for the Weight and Balance section of the POH/AOI for all NG5 variants, using accurate moment arm values, showing the maximum pilot and passenger weights allowed, with respect to differing fuel and baggage loads. The table should include the amount of fuel that can be used before the aircraft CG moves outside the aft limit (**IRLD2022005**).

2.5.5 Stowage of Luggage in the Fuselage

As outlined earlier, the Investigation notes that some versions of the POH show the moment arm for luggage stowed in the fuselage (i.e. the area behind the cockpit seats), as 2.0 m aft of the datum point at wing rib number four. The amended AOI (POH) Weight and Balance documents issued by the Aircraft/Kit Manufacturer gives a value for the moment arm for luggage stowed in the fuselage as 1,806 mm (1.806 m) aft of the fire-wall datum. This is equivalent to 1,400 mm (1.4 m) aft of the wing rib number four datum on the short-wing variant of the aircraft. This value suggests that the luggage should be placed directly behind the cockpit seats, and not on the parcel shelf which is further aft, against the rear bulkhead.

The CG issues identified by the Investigation highlight how sensitive the subject aircraft type is to small changes in the location of variable loads, and how they can significantly and adversely affect the aircraft's CG. An item placed on the parcel shelf would have a much greater moment arm, and consequently a larger effect on the aircraft CG than the same item placed directly behind the cockpit seats.

Safety Action Taken by the Aircraft/Kit Manufacturer

The Investigation acknowledges the statement from the Aircraft/Kit Manufacturer that it '*will create warning label to be installed on the parcel shelf prohibiting stowage of items in this area*'.

However, the Investigation considers that a revision to the POH in this regard is also warranted and therefore makes the following Safety Recommendation to the Aircraft/Kit Manufacturer:

> BRM Aero should issue an amendment to the aircraft AOI/POH stating that stowage of items on the parcel shelf is prohibited (**IRLD2022006**).

2.6 Engine Stoppage

During the flight, the recorded engine data is consistent with normal engine operation up to the time that the recorded vertical acceleration indicated the aircraft experienced +5 *g*, when the engine RPM is recorded as reducing to zero, indicating that the engine had stopped.

The engine installed on the subject aircraft was not configured for aerobatic flight or high-g manoeuvres, and the OEM for the aircraft engine informed the Investigation that the engine could cut out due to an excessively rich fuel-air mixture being delivered by the carburettors, as a result of '*prolonged (approximately 7.5 seconds) centrifugal forces*'. Prior to the engine stoppage, the aircraft had experienced a period of high vertical acceleration in excess of +2.0 *g* for approximately 8 seconds. This would cause the carburettor floats to sink in the fuel bowl, adversely affecting engine operation. The Investigation considers that the engine stoppage was likely as a result of the high *g* forces experienced, and therefore did not contribute to the loss of control of the aircraft.

Recorded engine RPM data and aircraft battery voltage data show that at time 18:21:28.37, and at recorded pressure altitude of 1,737 ft, an attempt was made to restart the engine, which was unsuccessful.

2.7 Human Factors

83

2.7.1 Response to the Wing-Drop

As noted earlier, it is not possible to state with certainty which pilot may have been handling the aircraft during, or following the stall exercises. However, during both stall exercises, there was a marked right wing-drop. In both cases, as the wing dropped, there was an application of engine power. This may have been a startle response to the wing-drop by the handling pilot, or alternatively, it may have been the handling pilot's usual stall recovery technique. The Investigation notes that a number of documents on the subject of Stall Recovery Technique provide advice to pilots to apply full engine power during stall recovery.

The Aircraft/Kit Manufacturer's stall test report states that the tests '*clearly demonstrated, that the wing level stall characteristics of Bristell even after exceeding of CG aft limit up to 2% of MAC, are absolutely satisfactory*'. The Aircraft/Kit Manufacturer informed the Investigation that it is of the opinion that the left roll observed in the data for the accident aircraft to correct the right wing-drop during the two stall exercises, was as a consequence of using left aileron during the stall recovery. However, as noted in the Aircraft/Kit Manufacturer's stall test report, there were a number of times during the test when the aircraft did exhibit a tendency to roll left during engine power application. Also, as was found during the NG5 accident that occurred at Clyde North, Victoria, Australia, in August 2017 (see **Section 1.18.4.2**), the use of opposite aileron to pick up a dropping wing during a stall, can cause the aircraft to enter a spin in the direction of the dropping wing. Therefore, the Investigation is of the opinion that it was unlikely that left aileron was used to correct the dropping right wing in the case of the accident aircraft. However, control inputs were not recorded, and it is possible that other flight control inputs may have been made.

2.7.2 Brief Application of Engine Power Following Second Stall

Following the second stall exercise and application of engine power, the aircraft once again rolled left in excess of 90° left wing down. Following this, the data indicates that engine power was reduced, and the aircraft began to roll right, back towards wings level. The data then indicates that at this time the aircraft recommenced a rapid left roll, which was coincident with a momentary reapplication of engine power. This reapplication of engine power may have been the handling pilot's response to experiencing a second large left roll during the attempted recovery from the second stall exercise.

Notwithstanding the reason for the reapplication of engine power, the recommencement of the left roll continued, and the aircraft rolled through 180°.

2.7.3 Pilot Disorientation

The Gyro roll-rate data indicates that, as the aircraft rolled through 180°, it entered a spiral dive. In the Aircraft/Kit Manufacturer's spin test report carried out on the aircraft type, the word '*spiral*' is often placed after the word '*spin*' and at one point the report states '*the aircraft mostly entered into a spiral rather than a true spin.'*

In a spiral dive, the aircraft wings are not usually stalled, and therefore recovery from such a manoeuvre may be possible, provided the pilot is aware of what is happening, and is aware of the orientation of the aircraft when control inputs are made.

Pilot disorientation can be defined as the conflict between visual, vestibular and proprioceptive inputs to the brain which prevent making sense of which way is up. It may occur during an aircraft upset, and Stowel notes that remaining oriented when an aircraft is rotating can '*be difficult at best, impossible at worst*.'

Following the sudden left roll through 180°, the rotation rate of the aircraft in all three axes was considerable, and to such a degree, that the pilots may have become disorientated. Recovery from the spiral dive may have been compromised due to disorientation. Due to the subject aircraft having a CG beyond the aft limit, the aircraft may have been more sensitive to elevator control inputs. This, and pilot disorientation, may have contributed to the high Z-axis *g* loads recorded.

2.8 Aircraft Response to Engine Power

Due to a CG that was outside the aft limit, the aircraft may have displayed an increased tendency to pitch up following increases in engine power and increases in airspeed. Following the increase in engine power to a high power setting during stall recovery in both stall exercises, the aircraft pitched up and rolled to the left. The roll to the left was likely exacerbated by effects of propeller rotation including propeller torque effect (**Section 1.16.6)**.

Furthermore, the author of a flight test report on the aircraft type stated that '*the right rudder authority became increasingly limited with full power if the airspeed was allowed to bleed back towards the stalling speed.*' And that they '*would have liked to have seen a bit more right rudder authority available, either perhaps from a bigger rudder* […] *so as to counteract the left turning tendency under full power*'.

Irrespective of the possible reasons for the engine power being applied when it was, during the stall recovery, the aircraft appears to display a tendency to pitch up and roll left, when high engine power is applied at low airspeeds. This was also displayed during the Aircraft/Kit Manufacturer's stall testing. In addition, the stall test results note that, '*Yellow highlighted are the stalls, which may lead to a critical stall behaviour when there are no pilot inputs at all (fully released controls)*'. These were instances where full engine power was applied during stall recovery. As no detailed description of the '*critical stall behaviour*' was contained in the Aircraft/Kit Manufacturer's stall test report, the Investigation was unable to establish the exact nature of the '*critical stall behaviour*', or determine if any particular piloting techniques may be required to ensure consistent safe recoveries from stalls, especially with respect to the application of high engine power at low airspeeds.

A review of the POH supplied with the subject aircraft, and a number of POHs for other NG5 variants, found that they did not contain text that might draw an operator's attention to the handling characteristics associated with application of engine power at low airspeed.

The Investigation considers that there may be an added safety benefit if greater awareness of this tendency was made available to pilots and operators of the aircraft. Therefore, the Investigation makes the following Safety Recommendation to the Aircraft/Kit Manufacturer:

> BRM Aero should consider placing appropriate text in the POH/AOI for the NG5, informing operators of the possible hazards associated with the application of high engine power at low airspeeds (**IRLD2022007**).

2.8.1 Safety Action Taken by the UK CAA and UK LAA

The UK CAA's CAP 659 document includes a requirement that all newly registered aircraft are to have a Flight Manual, which is sometimes referred to as the Pilot's Operating Handbook.

The UK Civil Aviation Authority informed the Investigation that the UK LAA had agreed that the UK version of the Bristell NG5 POH would be updated to warn UK pilot's operating this aircraft type of the hazards associated with applying high engine power at low airspeeds. The UK CAA confirmed to the Investigation, on 17 August 2021, that this action has been taken. Consequently this Final Report contains no Safety Recommendation to the UK CAA or UK LAA in this regard.

2.9 Aircraft Spin Testing

During recovery from the second stall exercise the aircraft entered a flat spin from which a successful recovery was not achieved. With regard to spin testing carried out on NG5 aircraft, the Investigation notes the following:

- The spin testing matrix of the short wing, fixed gear, variant was reduced, '*on the basis of previously proven spin characteristics on all versions of BRISTELL aircraft tested to date*'.

- The Aircraft/Kit Manufacturer has stated that: '*Initially spin testing of the short wing NG5 was not carried out as our engineering evaluation determined to our satisfaction that the long wing testing would adequately cover the short wing version*'.

- Ballast was used variously during the spin tests, to simulate the additional weight of occupants. The spin test report states the ballast was located under the aircraft seats.

- The aircraft used in testing had a ballistic recovery parachute system fitted. On the NG5 this is usually fitted in a forward baggage locker space.

- The UK LAA required that the variant built from a kit in the UK, such as the subject aircraft, was to be fitted with a larger span horizontal tailplane. It is not clear from the spin test report that testing was carried out on a version with a short wing, and a larger tailplane.

A review of literature on spinning suggests that it would not be appropriate to assume that, a given aircraft, when fitted with a different wing, would retain the original spin characteristics, and that a full spin test program would be required. In addition the spin test report states that '*The short wing version of the aircraft was chosen for the* [additional] *tests as previous tests had determined that this version was the worst configuration for the spin recovery*'.

Regarding the use of ballast, examination of the seating in the subject aircraft indicates that the only suitable location for such ballast would be in the cavity under the seats that is close to the wing main spar. The moment arm for ballast in this location would be less than that for persons seated in the aircraft, and therefore would not replicate the weight distribution of two adults.

The Aircraft/Kit Manufacturer subsequently informed the Investigation of the presence of an anti-spin recovery system fitted under the tail of the aircraft used for spin testing. The Aircraft/Kit Manufacturer considered that the installation of this system under the tail of the test aircraft, in addition to the ballistic recovery system, '*covered that mass configuration* [of the accident aircraft] *in full*'.

However, the Investigation is of the opinion that the installation of a ballistic recovery parachute system in the forward locker, and an anti-spin system under the tail of the aircraft, would alter both the weight and balance, and the inertial characteristics of the aircraft. As such, the test aircraft would not accurately represent the mass distribution of the production aircraft.

Therefore, the Investigation makes the following Safety Recommendation to the Aircraft/Kit Manufacturer:

BRM Aero should conduct and document further spin testing of each NG5 aircraft variant, separately, and in a manner that accurately represents the mass distribution of variable loads, including two occupants, and each wing and tail combination used in both production and kit aircraft (**IRLD2022008**).

2.10 Aircraft/Kit Manufacturer's Stall Test Report

Subsequent to the accident, the Aircraft/Kit Manufacturer stated that it had carried out a stall test flight using a Bristell UL HD aircraft. The test was undertaken by two test pilots. The stall test report is included as **Appendix N**. Whilst the aircraft used for the stall test was dimensionally similar to the subject aircraft, it did have some differences, including an additional fuselage fillet structure under the rear empennage beneath the tail, a different propeller fitted, and a Ballistic recovery system fitted. It is therefore possible that the stall test may not have been representative of the subject aircraft at the time of the accident.

The test flight was carried out on 28 July 2021. The Aircraft/Kit Manufacturer stated that the flight tests:

> '*clearly demonstrated, that the wing level stall characteristics of Bristell even after exceeding of CG aft limit up to 2% of MAC, are absolutely satisfactory. The aeroplane is controllable up to a stall, which is shown itself by nose pitch down and usually slight right wing drop. The aeroplane has no tendency to enter into a spin. Exceeding of CG aft limit up to 37% MAC does not lead to uncontrollable wing level stall characteristics*'.

The Investigation notes and acknowledges the stall test report which the Aircraft/Kit Manufacturer provided regarding testing of the aircraft's stall characteristics. Whilst the Aircraft/Kit Manufacturer's stall test report concludes that the '*stall characteristics of Bristell even after exceeding of CG aft limit up to 2% of MAC, are absolutely satisfactory',* the stall test report does not show what caused the accident aircraft to pitch up, and roll to the left during stall recovery, as the test report stated they '*were not able to introduce situation similar to the accident.*'

The Aircraft/Kit Manufacturer informed the Investigation that their stall test report showed that the left roll exhibited by the accident aircraft during stall recovery was '*possible only by using also opposite ailerons*'. However, the Aircraft/Kit Manufacturer's stall test report does indicate that during a stall where '*aileron counter steering*', i.e. opposite aileron, is used, the wing-drop continues and is not corrected. In addition, the stall test report showed that, in a number of instances during the test, the aircraft rolled to the left during the application of engine power. The stall test result also notes that, '*Yellow highlighted are the stalls, which may lead to a critical stall behaviour when there are no pilot inputs at all (fully released controls)*'. These were instances where full engine power was applied during stall recovery. As no detailed description of the '*critical stall behaviour*' was contained in the Aircraft/Kit Manufacturer's stall test report, the Investigation was unable to establish the exact nature of the '*critical stall behaviour*', or determine if any particular piloting techniques may be required to ensure consistent safe recoveries from stalls, especially with respect to the application of high engine power at low airspeeds. See also **Section 2.8.**

2.11 Maintenance

Up to the date of the accident, the aircraft had completed a total flight time of 48 hours 35 minutes. Prior to the aircraft's delivery to Ireland, it had undergone an annual inspection, which included inspections of the engine and propeller.

These inspections had been carried out, under the auspices of the UK LAA, at a recorded flight time of 20 hours 35 minutes. The aircraft passed the inspections with no findings, and were '*carried out as per the Bristell Manual*. Following its delivery to Ireland the aircraft had completed a further flight time of 22 hours 35 minutes, prior to the accident.

Examination of the aircraft, engine and propeller by the Investigation, did not show any pre-existing fault that may have contributed to the accident.

2.11.1 Nose-wheel Steering Cable

The Investigation examined the flexible telescopic control cable that linked the rudder pedals to the nose landing gear. The control cable was found undamaged and able to move freely within the sheath. Further examination of the control cable indicated that it was capable of functioning normally during the flight, and would not have contributed to the accident.

2.12 Meteorology

Meteorological conditions at the time of the accident were regarded as benign, and were considered not to have contributed to the cause of the accident.

2.13 Regulatory Framework

At the time of the accident, the aircraft was categorised as an EASA Annex 1 aircraft as it was an amateur built aircraft. As the aircraft was registered in the UK, the aircraft, and its documentation, were subject to the national aviation regulations of the UK. The UK Civil Aviation Authority published a document; '*CAP 659, Amateur Built Aircraft, A Guide to Approval, Construction and Operation of Amateur Built Aircraft*' describing the applicable requirements.

The aircraft kit was purchased in the UK and constructed under the auspices of the UK LAA, using the UK CAA's 51% rule, as set out in CAP 659. As part of its approval processes for the aircraft kit, the UK LAA issued a Type Acceptance Data Sheet (TADS) for the aircraft type, and a UK LAA Certificate of Design for the subject aircraft. In addition, prior to approving the aircraft type, the UK LAA had visited the Aircraft/Kit Manufacturer's facilities, and test flown an example of the aircraft. A UK Permit-to-Fly for the subject aircraft itself was issued by the UK CAA, upon recommendation from the UK LAA.

The aircraft documentation supplied with the subject aircraft when purchased by the syndicate, included both UK LAA-issued documentation, and a POH. The UK LAA informed the Investigation that the POH was not a document controlled by the UK LAA. CAP 659 includes a requirement that all newly registered aircraft are to have a Flight Manual, which is sometimes referred to as the Pilot's Operating Handbook.

The syndicate was in possession of a POH which had been supplied with the aircraft. It carried the logo of both the Aircraft Manufacturer and its agent, and the members of the syndicate believed it to be a valid aircraft document. Statements to the Investigation from owners of this aircraft type suggest that both the POH and UK LAA Weight and Balance documents were regarded as trusted documents.

The Investigation notes that CAP 659 states that the UK LAA is approved by the UK CAA to investigate the designs of certain classes of aircraft intended for amateur construction and recommend to the UK CAA when the designs should be approved. While the UK LAA accepted documentation provided by a manufacturer as accurate, the Investigation established that the weight and balance information provided by the Aircraft/Kit Manufacturer at the time of the accident was not accurate.

2.13.1 Safety Action Taken by the UK CAA

During the course of the Investigation, the UK Civil Aviation Authority informed the Investigation that it had identified weight & balance and POH data as focus areas for future oversight activities.

In addition, the UK CAA confirmed to the Investigation that a comprehensive review of CAP 659 (Amateur-Built Aircraft) is due to take place and will include an update to Section 11 (Flight Manual) to clarify the guidance on flight manuals/POH and to make clear that any conditions and limitations associated with the *'Permit to Fly'* override the manufacturer's data.

As a result of this Safety Action, no Safety Recommendation to the UK CAA is required in this regard.

2.13.2 NG5 Type Certification in the Czech Republic

In the Czech Republic, certification for the aircraft type was carried out by the LAA-CR, which is approved by the Ministry of Transport of the Czech Republic to do so.

Documentation received from the LAA-CR indicated that, during an aircraft certification process, the Chief Technical Inspector convenes a meeting with the Technical Board that submits the certification documentation for an aircraft type. This board, which usually consists of an aircraft manufacturer's employees, votes and makes recommendations to the Chief Technical Inspector for the issuing of a Type Certificate. The Investigation notes that certification was issued in 2007, for a very similar aircraft type, the Roko Aero NG4, which included a weight and balance document that was in many respects the same as that approved for the subject aircraft type, i.e. the Bristell NG5. The NG4 weight and balance documentation used the same value for the moment arm for a pilot and passenger, as that used in the NG5 weight and balance documentation, i.e. 600 mm. The similarity between the NG4 and NG5 is such that the Aircraft/Kit Manufacturer has stated that '*the NG4 is aerodynamically virtually identical to the NG5*'.

It should also be noted that the POHs for NG5 and NG4 aircraft give a moment arm for the wing locker storage as 630 mm aft of the original wing rib four datum, yet the original moment arm for a person seated in either the NG5, or NG4 aircraft was 600 mm. This would imply that a pilot and passenger would be seated **forward** of the mid-section of the wing lockers, which is not the case in either the NG5 or NG4.

As this same error has been in existence since 2007, the Investigation is of the opinion that the LAA-CR type certification process may not be sufficiently robust to trap any errors occurring during the design phase, or in the preparation of documentation, for light aircraft such as the subject aircraft type. The Investigation therefore makes the following Safety Recommendation to the Ministry of Transport of the Czech Republic:

> The Ministry of Transport of the Czech Republic should review the Type Certification procedures of the Czech Light Aircraft Association and ensure that a robust process is in place with respect to the examination and acceptance of documentation provided by an aircraft manufacturer in support of their design (**IRLD2022009**).

2.13.3 Weight and Balance of NG4

The Investigation notes and welcomes the response of EASA regarding contacting affected owners/operators of NG4 aircraft on EASA permits, to advise them of the revised weight and balance moment arms to be used for CG calculations. The Investigation believes that a similar global action is warranted and necessary for all NG4 aircraft. As the NG4 design and production originally was located in the Czech Republic, and that the aircraft manufacturer of the NG4 may no longer be in existence, the Investigation accordingly makes the following Safety Recommendation to the Ministry of Transport of the Czech Republic:

> The Ministry of Transport of the Czech Republic should ensure through appropriate means that owners/operators of NG4 aircraft, globally, are advised of the revised weight and balance documentation, including any changes to moment arms, to be used for aircraft weight and balance calculation (**IRLD2022010**).

2.14 Survivability

Neither pilot survived the accident. The aircraft's rate of descent recorded at impact was approximately 4,500 feet per minute, which is equivalent to approximately 82 kilometres per hour. On impact, the Z-axis accelerometer recorded +9.9 *g*. The OEM for the PFD informed the Investigation that any vertical acceleration value above +10 *g* would be recorded as +9.9 *g*. Whilst the aircraft structure would have absorbed some of the impact forces, it is likely that the vertical deceleration forces experienced were significantly higher than the +9.9 *g* recorded in the data.

2.14.1 Left Seat Pilot Seat Restraint Harness

During examination of the aircraft at the accident site, the Investigation noted that the Left Seat Pilot's four-point restraint harness was not fastened. The shoulder straps were found resting in the rear baggage area, behind the Pilot's seat, and the two lap straps were found on the seat base, underneath the Left Seat Pilot. The emergency services that attended the aircraft prior to the arrival of the AAIU also noted that the Left Seat Pilot's restraint harness was found not fastened.

Examination of the latching mechanism for the harness indicated that it was capable of functioning normally and did not show evidence of having been released due to impact forces. The autopsy report for the Left Seat Pilot stated that '*the pattern of injury suggests that the deceased was not strapped in at the time of impact*'. It is therefore considered unlikely that the Left Seat Pilot's restraint harness was released post-impact.

The syndicate members noted that the Right Seat Pilot emphasised the importance of performing HASEL checks prior to stalling, part of which involved ensuring that seat harnesses were secure. The data indicates that clearing turns were performed prior to the stall exercises. These are consistent with HASEL checks being performed. The Investigation is therefore of the opinion that the Left Seat Pilot would not have commenced the flight with his seat harness undone and that the Right Seat pilot would have checked that both harnesses were secure as part of the HASEL checks performed prior to stalling.

The recorded data shows that an attempt to start the engine was made during the flat spin phase of the descent, which was unsuccessful. It was likely performed to try to recover the aircraft, and would have been a conscious, deliberate action requiring coordination to reach the start switch, which was located such that only the Left Seat Pilot could carry this out in flight. It would also require coordinating control of the aircraft with the Right Seat Pilot. It is possible that the Left Seat Pilot unfastened his restraint harness in order to reach forward and turn the start switch.

It is also possible that the Left Seat Pilot may have undone his restraint harness and moved forward in an attempt to bring the CG forward, and break out of the flat spin.

The manner in which the lap straps of the seat harnesses were anchored would mean that a pilot sitting unrestrained would either be sitting on the cam-lock mechanism affixed to the lap strap, or the lap strap with the cam-lock would be draped across the central armrest, and on the lap of the opposite pilot.

The Investigation believes that the Left Seat Pilot would not have commenced, or continued a flight with the discomfort of a large cam-lock mechanism, when unfastened, and resting on the seat base under the Left Seat Pilot. Nor is it likely that the Right Seat Pilot would have commenced, or continued a flight with the large cam-lock mechanism, unfastened, and resting across the central armrest.

Following impact with the ground, the aircraft bounced before coming to rest in its final post-impact position. During the accident sequence it is likely the lap straps would have gone under the now unrestrained Left Seat Pilot.

3. CONCLUSIONS

3.1 Findings

General

1. The Left Seat Pilot was licensed to carry out the flight.

2. The Left Seat Pilot was accompanied by an experienced and licensed pilot/instructor, who was seated in the right seat of the aircraft.

3. The other syndicate pilots informed the Investigation that the Right Seat Pilot flew with them in order to assist them in becoming familiar with the aircraft.

4. Nothing in the recorded data indicated that unapproved manoeuvres were being deliberately performed. The manoeuvres recorded after each stall would indicate an unexpected upset, followed by attempts to recover the aircraft.

5. The aircraft had recently undergone an annual maintenance inspection, which was '*carried out as per the Bristell Manual*'. The Investigation found no mechanical issues that might have contributed to the accident.

6. Meteorological conditions at the time of the accident were benign and were unlikely to have contributed to the accident.

7. Statements from the syndicate members indicate that the Left Seat Pilot intended to carry out a general handling flight in the local area which would likely have included practising stalls.

8. There was no record in the Left Seat Pilot's flying logbooks, or the separate notes of his recent flights that he had practiced stalling in the subject aircraft.

9. The POH for NG4 and NG5 aircraft stated that the moment arm for persons seated in the aircraft was 600 mm aft of datum. The Investigation found that this information was incorrect.

10. The POH, and associated Weight and Balance documentation, for the subject aircraft also stated that the moment arm for persons seated in the aircraft was 600 mm aft of datum. As a result, weight and balance calculations carried out using the information in the subject aircraft POH would have given an incorrect CG position for the aircraft.

11. The Investigation determined that the actual moment arm for the pilots seated in the subject aircraft was 768 mm aft of datum.

12. Using a moment arm of 768 mm aft of datum, the Investigation determined that the accident aircraft CG was outside the published aft CG limit at the time of the accident. This may have caused the aircraft to be less longitudinally stable and more sensitive to pitch inputs from the elevator or engine power increases.

13. In July 2020, the UK LAA issued two documents, Airworthiness Information Leaflet, LAA/MOD/385/011 Issue 1, and Airworthiness Alert, LAA/AWA/20/18, in which the moment arm for a pilot or passenger was stated as 750 mm aft of datum.

14. In August 2020, the Aircraft/Kit Manufacturer issued an amendment to the Aircraft Operating Instructions for the Long Wing aircraft, titled BRLW-AOI-AU_Ra, which contained an error in one of the tables.

15. In August 2020, the Aircraft/Kit Manufacturer issued an amendment to the Aircraft Operating Instructions for the Short Wing aircraft, titled '*BRSW-AOI-AU_Ra*', which stated that the MAC for the Short Wing aircraft lay 406.1 mm aft of the new datum. This value was found to be incorrect.

16. Using the Aircraft/Kit Manufacturer's revised moment arm and datum point for a pilot and passenger, and the actual weights of the pilots and other variable loads on the accident aircraft, the calculated CG for the aircraft, at the time of the accident, would have been outside the published aft CG limit.

17. The Aircraft/Kit Manufacturer's weighing exercise gave a range of values for the moment arm of persons seated in the aircraft, some of which were greater than 750 mm aft of (the original) datum.

18. Data obtained from the Primary Flight Display indicates that two stall exercises were performed. The aircraft recovered following the first stall exercise. However, the aircraft departed from controlled flight following the second stall exercise

19. Recorded engine data indicates that the aircraft engine was operating normally up to the time that the aircraft experienced high *g* forces, following attempted recovery from the second stall exercise, during which the engine stopped.

20. The Aircraft/Kit Manufacturer's spin testing did not encompass all configurations or weight distribution of the aircraft type, whether factory or kit-built.

21. The aircraft used for spin testing was fitted with a ballistic recovery parachute system and an anti-spin system. This would alter the weight/mass distribution, the inertial characteristics, and CG of the test aircraft in comparison to NG5 aircraft not fitted with such systems.

22. During the first stall exercise, there was a marked right wing-drop.

23. During the stall recovery, engine RPM was increased, and as the right wing-drop reached approximately +30°, the aircraft began pitching up, rolling and yawing to the left.

24. The application of full engine power as part of a stall recovery is consistent with advice contained in General Aviation training and safety literature.

25. Following the first stall exercise, the maximum left roll angle reached was approximately -103° left wing down. The aircraft began to roll back to the right and was recovered to wings level, as it descended to 2,500 ft altitude.

26. The aircraft was then climbed to 3,276 ft and proceeded to carry out a second stall exercise.

27. During the second stall exercise, there was a right wing-drop.

28. During the stall recovery, engine RPM was increased, and as the right wing-drop reached approximately +30°, the aircraft began pitching up, rolling and yawing to the left.

29. Following the second stall exercise, the maximum left roll angle reached was approximately -93° left wing down.

30. Engine power was reduced, and a right roll commenced.

31. At the time the right roll was commencing, there was a momentary increase in engine power to approximately 3,100 RPM.

32. The right roll stopped and the aircraft suddenly entered a rapid left roll, which continued through 180°.

33. The recorded data showed that the aircraft then entered a rotating descent with increasing airspeed and vertical acceleration, indicating that the aircraft had entered a spiral dive.

34. In consideration of the dynamics involved, it is possible that the pilots became disorientated during the spiral dive and this may have compromised their ability to recover the aircraft.

35. During the third rotation of the spiral dive, the recorded vertical acceleration peaked at +5 *g* and the aircraft likely experienced an accelerated stall, following which it entered a flat spin.

36. It is probable that the prolonged high *g* loads experienced by the aircraft resulted in an excessively rich fuel-air mixture being delivered to the engine, causing it to stop.

37. During the flat spin there was an attempt to restart the aircraft's engine, by the Left Seat Pilot. This was unsuccessful.

38. The flat spin continued until impact.

39. The syndicate members informed the Investigation that the Right Seat Pilot emphasised the importance of performing HASEL checks prior to stalling, part of which involved ensuring that seat harnesses were secure.

40. The Left Seat Pilot, who was found with his restraint harness undone, likely undid his harness during the latter stages of the descent prior to impact in an attempt to restart the engine and/or to move the aircraft CG forward.

41. Both pilots sustained fatal injuries due to the deceleration forces experienced on impact.

3.2 Probable Cause

The aircraft entered a flat spin following a departure from controlled flight during an attempted stall recovery.

3.3 Contributory Cause(s)

1. The subject aircraft's CG was beyond the aft CG Limit, making the aircraft more susceptible to entry into a flat spin, and more difficult to recover from such a spin.

2. Reduced longitudinal stability due to the aircraft's CG being beyond the published aft limit.

3. Incorrect Weight and Balance information published in the POH led the pilots to believe the aircraft would be within the required CG limits during the flight.

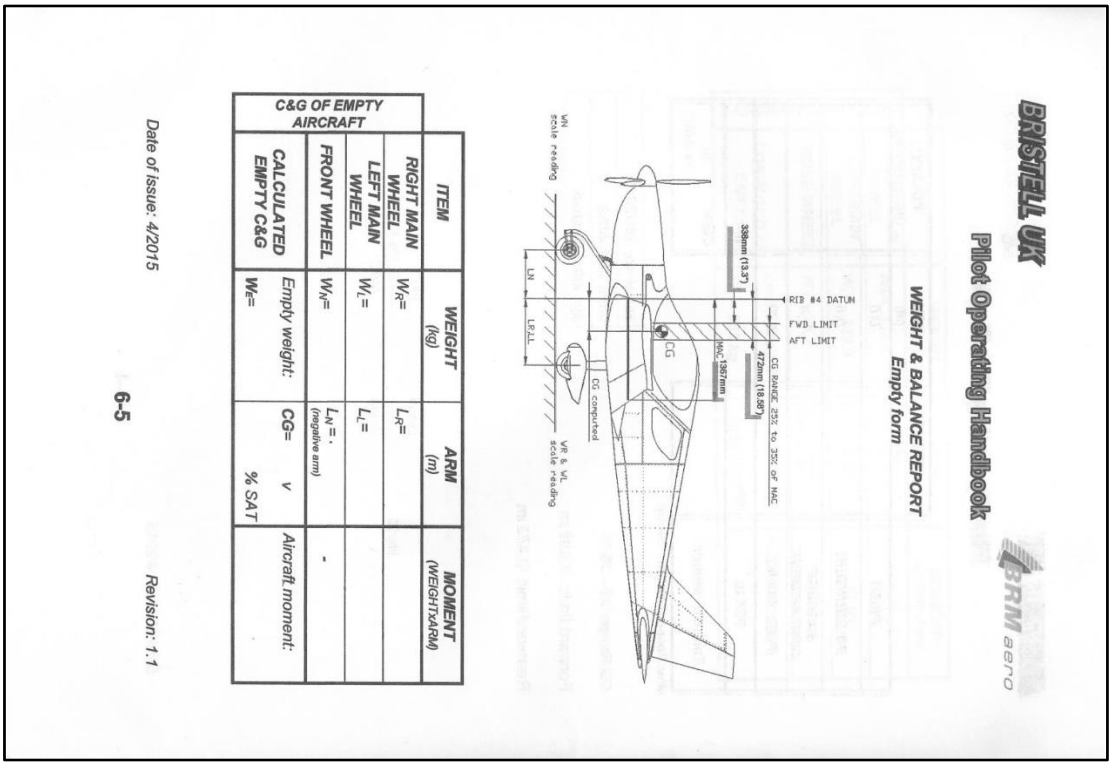
4. Reaction of the aircraft to the application of engine power during attempted stall recovery.

4. SAFETY RECOMMENDATIONS

No.	It is Recommended that:	Recommendation Ref.
1.	BRM Aero should review the Weight and Balance documentation for all NG5 variants to take account of all values obtained during its weighing of the aircraft, including those values that were greater than 750 mm aft of the wing rib 4 datum for the moment arm for persons seated in the NG5 aircraft. The effects of seat cushion thickness should be included in the review. The review should be monitored by the Czech LAA, and amendments arising from the review circulated to all owners/operators of the NG5 variants.	IRLD2022001
2.	BRM Aero should review its procedures for the determination of the moment arm for a seated pilot and passenger in each of its aircraft variants, with a view to changing the method to one using available anthropometric data and aircraft seat location and dimensions, taking into account all possible seating configurations, including but not limited to, seat-back recline angle, and seat cushion material.	IRLD2022002
3.	BRM Aero should consider issuing a revised Weight and Balance document for the Short Wing variant of the NG5, highlighting the correct location of the Mean Aerodynamic Chord with respect to the Firewall datum.	IRLD2022003
4.	BRM Aero should review the Weight and Balance document for the Long Wing variant of the NG5, to ensure that the correct location of the Mean Aerodynamic Chord with respect to the Firewall datum is stated in the appropriate Weight and Balance document, and that this is issued to owners/operators of the Long Wing variant of the NG5.	IRLD2022004
5.	BRM Aero should issue an amendment for the Weight and Balance section of the POH/AOI for all NG5 variants, using accurate moment arm values, showing the maximum pilot and passenger weights allowed, with respect to differing fuel and baggage loads. The table should include the amount of fuel that can be used before the aircraft CG moves outside the aft limit.	IRLD2022005

No.	It is Recommended that:	Recommendation Ref.
6.	BRM Aero should issue an amendment to the aircraft AOI/POH stating that stowage of items on the parcel shelf is prohibited.	IRLD2022006
7.	BRM Aero should consider placing appropriate text in the POH/AOI for the NG5, informing operators of the possible hazards associated with the application of high engine power at low airspeeds.	IRLD2022007
8.	BRM Aero should conduct and document further spin testing of each NG5 aircraft variant, separately, and in a manner that accurately represents the mass distribution of variable loads, including two occupants, and each wing and tail combination used in both production and kit aircraft.	IRLD2022008
9.	The Ministry of Transport of the Czech Republic should review the Type Certification procedures of the Czech Light Aircraft Association and ensure that a robust process is in place with respect to the examination and acceptance of documentation provided by an aircraft manufacturer in support of their design.	IRLD2022009
10.	The Ministry of Transport of the Czech Republic should ensure through appropriate means that owners/operators of NG4 aircraft, globally, are advised of the revised weight and balance documentation, including any changes to moment arms, to be used for aircraft weight and balance calculation.	IRLD2022010
	View Safety Recommendations for Report 2022-006	

Appendix A – Weight and Balance section of POH



BRISTELL UK

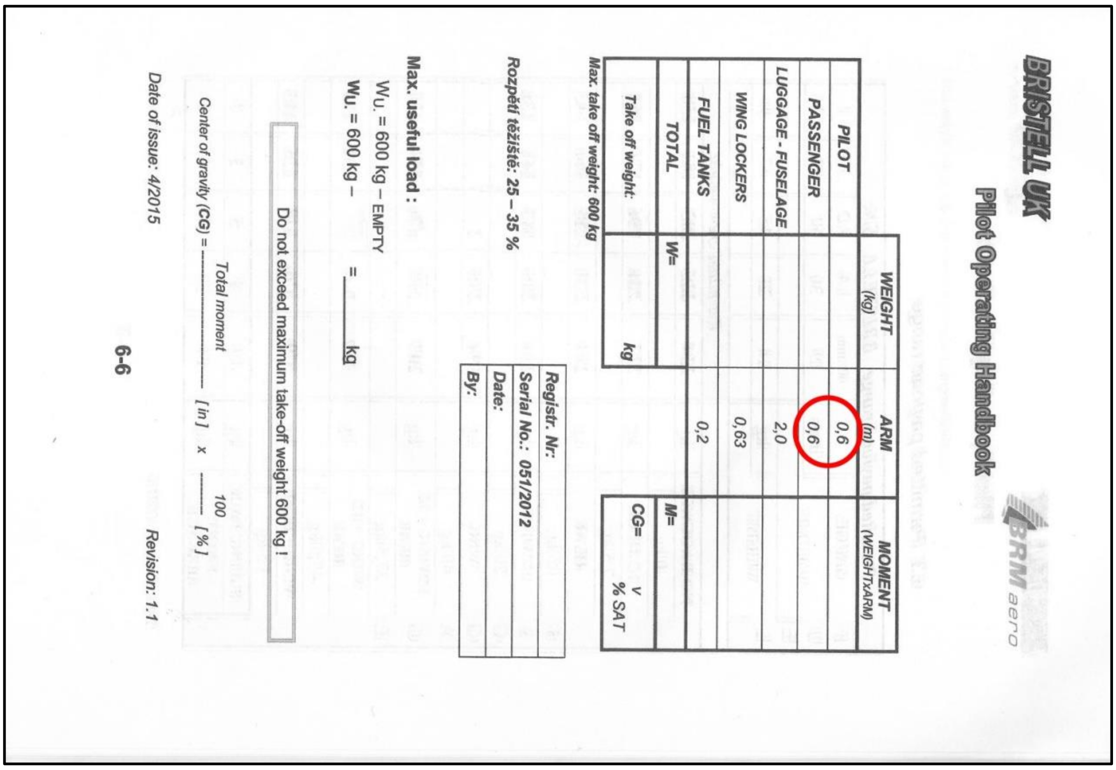
Pilot Operating Handbook

WEIGHT & BALANCE REPORT
Empty form

BRM aero

C&G OF EMPTY AIRCRAFT			
ITEM	WEIGHT (kg)	ARM (m)	MOMENT (WEIGHTxARM)
RIGHT MAIN WHEEL	W_R=	L_R=	
LEFT MAIN WHEEL	W_L=	L_L=	
FRONT WHEEL	W_N=	L_N= - (negative arm)	-
CALCULATED EMPTY C&G	Empty weight: W_E=	CG= v % SAT	Aircraft moment:

Date of issue: 4/2015 6-5 Revision: 1.1



BRISTELL UK

Pilot Operating Handbook

BRM aero

	WEIGHT (kg)	ARM (m)	MOMENT (WEIGHTxARM)
PILOT		0,6	
PASSENGER		0,6	
LUGGAGE - FUSELAGE		2,0	
WING LOCKERS		0,63	
FUEL TANKS		0,2	
TOTAL	W=		M=
Take off weight:	kg		CG= v % SAT

Max. take off weight: 600 kg

Rozpětí těžiště: 25 – 35 %

Registr. Nr:
Serial No.: 051/2012
Date:
By:

Max. useful load :

W_U = 600 kg – EMPTY

W_U = 600 kg – ____ = ____ kg

Do not exceed maximum take-off weight 600 kg !

Center of gravity (CG) = Total moment / ------ [in] x 100 / ------ [%]

Date of issue: 4/2015 6-6 Revision: 1.1

Two pages from subject aircraft Weight and Balance section of POH.
Note: Erroneous Pilot/Passenger Moment Arm Highlighted in Red

Back to Section 1.6.10.2

Appendix B – Weight and Balance Calculation for Accident Aircraft

Aircraft Empty Weight CG

Item	Weight (kg)	Arm (m)	Moment (kg.m)
Right Wheel	123.000	0.719	88.437
Left Wheel	125.000	0.719	89.875
Nose Wheel	80.000	-0.750	-60.000
Totals	328.000		118.312
Aircraft Empty CG =		0.361	
	MAC (m) = 1.367		
A/C Empty CG % MAC =		26.4	

Aircraft Laden CG

		Item	Weight (kg)	Arm (m)	Moment (kg.m)
		A/C Empty	328.000	0.361	118.312
		Pilot	97.300	0.768	74.726
		Passenger	89.100	0.768	68.429
		Baggage (Fuselage)	3.000	2.000	6.000
		Baggage (Wing)	1.950	0.630	1.229
		Zero Fuel totals	519.350		268.696
			ZFW CG (m)	0.517	
		ZFW CG % MAC =		37.8	
Fuel quantity (ltr)	65.5	Fuel Weight (kg)	47.160	0.200	9.432
		Total A/C Wt (kg)	566.510		278.128
			Laden CG (m)	0.491	
		A/C Laden CG % MAC =		35.9	

Aircraft Weight and Balance at time of accident using Calculated Moment Arm for person seated on compressed cushion

Back to Section 1.6.10.4

Back to Section 1.6.10.5

Appendix C – Method for Calculating Aircraft Moment Arms by Weighing

Test 1.

1. Measure the distance from Datum to Nose Wheel, Left and Right Main Wheels. This will be L_N, L_L, L_R. (Note, $L_L = L_R$)
2. Place aircraft on scales (any fuel amount), without crew.
3. Measure weight on wheels as follows W_{N1} W_{L1} W_{R1}.

Test 2.

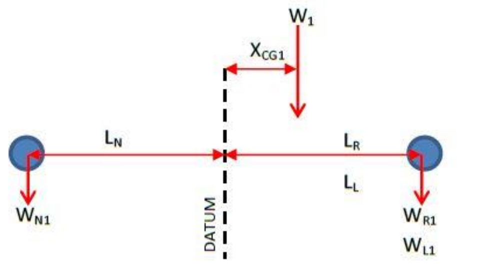
1. Add a crew member, with aircraft on scales.
2. Measure weight on wheels as follows W_{N2} W_{L2} W_{R2}

Test 3.

3. Add a second crew member, with aircraft on scales.
4. Measure weight on wheels as follows W_{N3} W_{L3} W_{R3}

Analysis.

Test 1.



If $L_L \neq L_R$ then use average of $L_L + L_R$

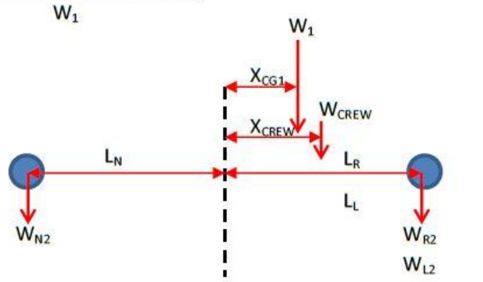
1. $W_1 = W_{N1} + W_{L1} + W_{R1}$
2. $\Sigma M = (-L_N \times W_{N1} + L_L \times W_{L1} + L_R \times W_{R1}) - X_{CG1} \times W_1 = 0$ therefore

$$X_{CG1} = \frac{-L_N \times W_{N1} + L_R \times (W_{L1} + W_{R1})}{W_1}$$

X_{CG1} = Distance of CG from Datum without Crew onboard

X_{CREW} = Distance of Crew Moment Arm from Datum

Test 2 (and 3).



1. $W_2 = W_{N2} + W_{L2} + W_{R2}$ therefore $W_{CREW} = W_2 - W_1$
2. $\Sigma M = (-L_N \times W_{N2} + L_L \times W_{L2} + L_R \times W_{R2}) - (X_{CG1} \times W_1) - (X_{CREW} \times W_{CREW}) = 0$ therefore

$$X_{CREW} = \frac{-L_N \times W_{N2} + L_R \times (W_{L2} + W_{R2}) - X_{CG1} \times W_1}{W_{CREW}}$$

Formulae for iterative method for calculating aircraft Moment Arms

Back to Section 1.6.10.6

Appendix D – UK LAA Airworthiness Information Leaflet

MOD/385/011 issue 1

Classification: **A**

LAA Approval

Date: 17.07.20

Airworthiness Information Leaflet

Bristell NG5

Change in the Pilot and Passenger Moment Arm measurement to be Used in Pre-flight Centre of Gravity Calculations

Light Aircraft Association

Applicability: All Bristell NG5 aircraft operating under the LAA Permit to Fly scheme, including those flying on test.

Background: During a recent weight and balance check carried out on a Bristell NG5 aircraft at the LAA's Turweston HQ, it was found that the pilot and passenger moment arm, as measured from the aircraft's datum, was different than that defined in the Pilot's Operating Handbook (POH). The POH defines this moment as 600mm aft of the datum where the true figure appears to lie between 700 and 750 mm aft of the datum.

The consequence of this further rearward location of the pilot and passenger is that the loaded centre of gravity of the aircraft will be further aft than previously calculated; pilots using the 600 mm pilot moment arm in their pre-flight centre of gravity calculations might therefore inadvertently fly the aircraft with the centre of gravity outside of the aft cg limit.

The possibility that an aircraft could be flown beyond its rearward limit is, naturally, increased when flown two-up. Flying an aircraft beyond the aft cg limit can be extremely dangerous for a number of reasons, in particular, there is an increased risk of degraded flight handling characteristics and a possible departure from controlled flight.

This Airworthiness Information Leaflet (AIL) requires, with immediate effect, the pilot to use a revised pilot moment arm for the pilot and passenger in their pre-flight centre of gravity calculations, as defined below.

Compliance by: Before flight.

Actions Required:

1. It is already a requirement that, before a flight may commence, the pilot ensures that the aircraft will remain within its centre of gravity limits in all phases of the proposed flight. This AIL requires a pilot to use a revised moment arm of 750 mm aft of the datum in carrying out centre of gravity calculations, which may result in a reduction in the weight of crew that can be carried in the aircraft. Do not fly the aircraft, or to allow it to be flown, without first ensuring that it will remain within the permitted loaded centre of gravity range as stated on the Permit to Fly operating limitations document, when the loaded centre of gravity is calculated using the revised moment arm.
2. Annotate the aircraft's Weight and Balance Schedule clearly, in the sections relating to variable load items and sample loading cases, with an indelible pen:

   'Warning – for pilot and passenger moment arm figure refer to LAA/MOD/385 011 Issue 1'.
3. On receipt of this AIL, email engineering@laa.uk.com letting us know that you have read and understood its requirements.

Certification: It remains the pilot's responsibility to ensure that an aircraft remains within its permitted centre of gravity range during all stages of flight. Before further flight, after the date of this AIL, ensure that the requirements of the AIL have been complied with and that an entry is made in the aircraft's airframe log book confirming this.

LAA Airworthiness Information Leaflet Classifications
Classification A – Considered Mandatory by the LAA Classification B – Recommended by the LAA Classification C – Material published for information and/or guidance

Page 1 of 1

The technical content of this document is approved under the authority of UK CAA organisation approval reference: DAI/1172/48

Light Aircraft Association, Turweston Aerodrome, Nr. Brackley, Northamptonshire, England NN13 5YD
www.laa.uk.com Telephone +44 (0)1280 846786

Back to Section 1.6.10.7
Back to Section 2.5.2

Appendix E – UK LAA Airworthiness Alert

Light Aircraft Association

AIRWORTHINESS ALERT

LAA/AWA/20/18
20th July 2020

Bristell NG-5 Aircraft

Change in the Pilot and Passenger Moment Arm measurement to be Used in Pre-flight Centre of Gravity Calculations

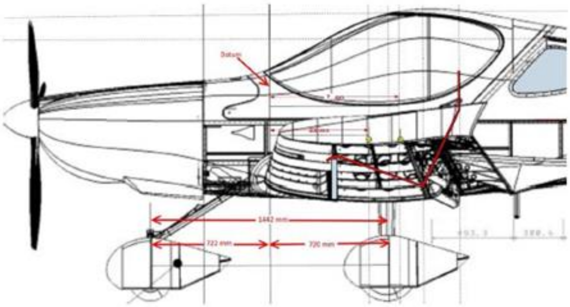
During a recent weight and balance check carried out on a Bristell NG5 aircraft at the LAA's Turweston HQ, it was found that the pilot and passenger moment arm, as measured from the aircraft's datum, was different than that defined in the Pilot's Operating Handbook (POH). The POH defines this moment as 600mm aft of the datum where the true figure appears to lie between 700 and 750 mm aft of the datum.

The consequence of this further rearward location of the pilot and passenger is that the loaded centre of gravity of the aircraft will be further aft than previously calculated. Pilots using the 600 mm pilot moment arm in their pre-flight centre of gravity calculations might therefore inadvertently fly the aircraft with the centre of gravity outside of the aft cg limit.

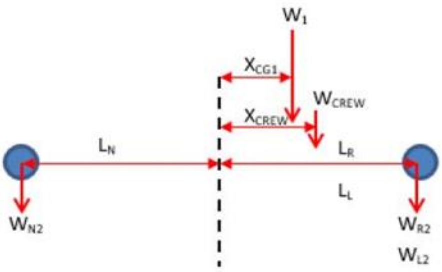
The possibility that an aircraft could be flown beyond its rearward limit is, naturally, increased when flown two-up. Flying an aircraft beyond the aft cg limit can be extremely dangerous for a number of reasons; in particular, there is an increased risk of degraded flight handling characteristics and a possible departure from controlled flight.

Whilst further investigations are being carried out to determine a more accurate moment arm for the pilot and passenger, and until further notice, a pilot moment arm of 750 mm aft of the datum must be used in all pre-fight centre of gravity calculations.

The Airworthiness Information Leaflet (AIL) (LAA/MOD/385/011 Issue 1) mandating this change may be downloaded HERE.



As part of their training, all pilots learn how to carry out a weight and balance calculation to ensure that the aircraft's centre of gravity will remain within tested limits during all phases of the flight; this assessment must be carried out before every flight. Naturally, to establish the accurate centre of gravity of a loaded aircraft, the moment arms, as measured from a pre-determined datum, must be accurately defined.



Small variations in moment arms can add up to quite large variations in centre of gravity position, that's why every aircraft must be both weighed and measured during an aircraft's empty centre of gravity determination. Because of normal morphological differences between people, the pilot's and passenger's moment arms can be tricky to calculate, the worst case pilot and passenger moment arms must therefore take account of body shapes and sizes.

Page 1 of 1

Back to Section 1.6.10.7 Back to Section 2.5.2

Appendix F – Amended Aircraft Operating Instructions (Long Wing)

BRISTELL S-LSA

BRMAERO Wings with heart

Aircraft Operating Instructions

Explanation

This revision of the original Aircraft Operating and Maintenance Manual is related to Section 6. Weight and Balance.
Pages in this document shall replace the appropriate pages in the original Aircraft Operating Instructions (AOI).

List of Revision effective pages:

Section	Page	Rev.	Date of Issue
	1		08/2020
2	2-9	Ra	08/2020
6	6-1	Ra	08/2020
	6-4	Ra	08/2020
	6-5	Ra	08/2020
	6-6	Ra	08/2020
	6-7	Ra	08/2020
	6-8	Ra	08/2020

Date of Issue: 08/2020 *Revision: Ra*
Document No.: BRLW-AOI-AU_Ra **1**

2.6 *Miscellaneous Instrument Marking*

There is not any miscellaneous instrument marking.

2.7 *Weight*

Empty weight (standard equipment)	325	kg	715	lb

> ***NOTE***
>
> Actual empty weight is shown in SECTION 6

Max. take-off weight	600	kg	1320	lb
Max landing weight	600	kg	1320	lb
Weight of fuel (120 l, 16 US gal)	87	kg	209	lb

Maximum baggage weight:

Baggage compartment behind seats	15	kg	33	lb
Wing lockers (optional)	20	kg	44	lb each
Front locker (optional)	10	kg	22	lb

2.8 *Center of gravity*

Operating C.G. range	25	to 35 %	of MAC	
MAC	1349.7	mm	53.138	in

Datum: Firewall

2.9 *Approved maneuvers*

Airplane Category: LSA

The BRISTELL S-LSA is approved for normal and below listed maneuvers:

- Steep turns not exceeding 60° bank
- Lazy eights
- Chandelles
- Stalls (except whip stalls)

> **WARNING**
>
> Aerobatics and intentional spins are prohibited!

BRISTELL S-LSA BRMAERO

Aircraft Operating Instructions

SECTION 6

6 WEIGHT AND BALANCE

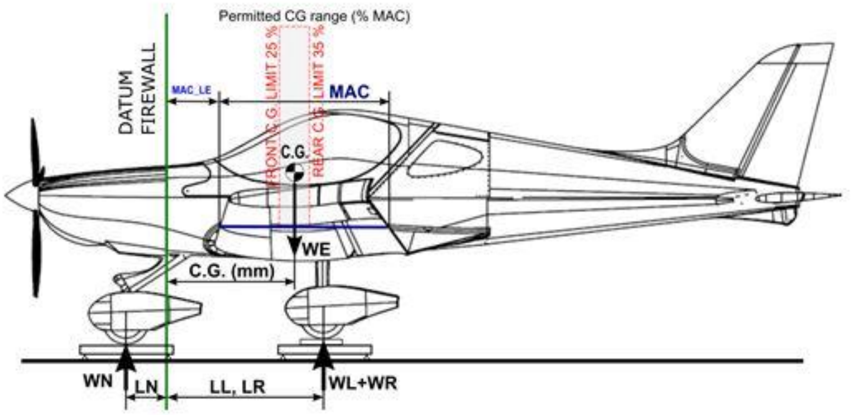
105

Date of Issue: 08/2020 *Revision: Ra*
Document No.: BRLW-AOI-AU_Ra **6-1**

6.2 *Weight and Balance Record*

6.2.1 Weight and Balance Report

6.2.1.1 Empty Aircraft Weight and CG



MAC_LE (mm): 412,6
MAC (mm): 1349,7

	ITEM	WEIGHT (kg)	ARM (mm)	MOMENT = WEIGHT x ARM (kg.mm)
EMPTY AIRCRAFT WEIGHT AND CG	RIGHT MAIN WHEEL	WR=	LR= 1108	MR=
	LEFT MAIN WHEEL	WL=	LL= 1108	ML=
	NOSE WHEEL	WN=	LN= -369	MN=
	EMPTY AIRCRAFT	EMPTY WEIGHT (kg) WE=	CG (mm) = CG (%MAC) =	EMPTY ACFT TOTAL MOMENT (kg.mm) MT=

$$CG\ (mm) = \frac{Total\ Moment}{Total\ Weight}$$

$$CG\ (\%MAC) = (CG\ (mm) - 412.6) \times \frac{100}{MAC}$$

Serial No.:	
Date:	
By:	

BRISTELL S-LSA BRMAERO Wings with heart

Aircraft Operating Instructions

6.3 Empty weight & balance data

Date	Empty Weight (kg)	Empty CG (mm)	Empty Moment (kg-mm)	Authorised Person
On delivery				*Factory*

NOTES: 1. *Empty weight includes unusable fuel (1 litre), full oil & coolant.*

2. *If the aircraft weight is altered this empty weight and empty centre of gravity position must be updated by an authorised person.*

3. ***The pilot must always use the latest data in the above table.***

Date of Issue: 08/2020 *Revision: Ra*

Document No.: BRLW-AOI-AU_Ra 6-5

6.4 Calculation of Weight & CG Position for Flight

6.4.1 Fuel Weight Table

The following fuel weights are based on a fuel specific gravity of 0.72 kg/litre.

Useable Fuel (Litres)	Weight (kg)
10	7.2
20	14.4
30	21.6
40	28.8
50	36
60	43.2

Useable Fuel (Litres)	Weight (kg)
70	50.4
80	57.6
90	64.8
100	72
110	79.2
119	85.7

108

Sample Pilot Calculation

1. Obtain the Empty Weight data for the aircraft from the paragraph 6.3 and enter it in the table below.
   Example *- Empty Weight 366 kg, Arm to the firewall 762,56 mm, Moment 279098,1 kg mm*
2. Enter weights of occupants, fuel and baggage in the table.
   NOTE: *Fuel weight for a given quantity can be determined using the data in para 6.4.1 above.*
3. Multiply weights by the corresponding arms to give the moments.
4. Total up the weights and moments. Divide total moment by total weight to give arm.
   i.e. Arm = Total Moment ÷ Total Weight
5. Provided the take-off weight does not exceed 600 kg, and the moment arm is within the range of 750 mm to 885 mm, the aircraft is within limits.

BRISTELL S-LSA BRMAERO Wings with heart

Aircraft Operating Instructions

--- SAMPLE ONLY ---

Item	Weight (kg)	Arm (mm)	Moment (kg mm)
Empty (para 6.3)	366	762,56	279098,1
Pilot	90	1156	104040
RH seat	90	1156	104040
Fuel (Max 89 kg)	24	606	14544
Baggage – behind seats (Max 15 kg)	0	1806	0
Baggage – wing lockers (Max 20 kg each)	18	1036	29008
Baggage – Front (optional) (Max 10 kg)	0	106	0
TOTALS	**588**	**885**	**530730,1**

--- Sample Aircraft Is Within Limits ---

109

Anomolies in Table:

- Product of 18 and 1036 is 18,648 not 29,008
- Quotient of 530,730.1 ÷ 588 is 902.6 not 885
- The Totals for Weight and Moment above would result in the Sample Aircraft being Outside Limits
- If the correct value for the Product of 18 and 1036 is used, this would show the Sample Aircraft in Limits

Date of Issue: 08/2020 *Revision: Ra*
Document No.: BRLW-AOI-AU_Ra **6-7**

6.4.3 Pilot Calculations

(Copy this page and do your calculations using this table).

Item	Weight (kg)	Arm (mm)	Moment (kg mm)
Empty (para 6.3)		762,56	
Pilot		1156	
RH seat		1156	
Fuel (Max 89 kg)		606	
Baggage – behind seats (Max 15 kg)		1806	
Baggage – wing lockers (Max 20 kg each)		1036	
Baggage – Front (optional) (Max 10 kg)		106	
TOTALS			

Provided the calculated take-off weight does not exceed 600 kg, and the arm is within the range of 750 mm to 885 mm, the aircraft is within limits.

WARNING

EXCEEDING MTOW MAY LEAD TO DETERIORATION OF SAFETY OF FLIGHT!

Back to Section 1.6.10.8 Back to Section 2.5.4.5

Appendix G – Amended Aircraft Operating Instructions (Short Wing)

BRISTELL S-LSA

BRMAERO Wings with heart

Aircraft Operating Instructions

Explanation

This revision of the original Aircraft Operating and Maintenance Manual is related to Section 6. Weight and Balance.
Pages in this document shall replace the appropriate pages in the original Aircraft Operating Instructions (AOI).

List of Revision effective pages:

Section	Page	Rev.	Date of Issue
	1		08/2020
2	2-9	Ra	08/2020
6	6-1	Ra	08/2020
	6-4	Ra	08/2020
	6-5	Ra	08/2020
	6-6	Ra	08/2020
	6-7	Ra	08/2020
	6-8	Ra	08/2020

Date of Issue: 08/2020 *Revision: Ra*
Document No.: BRSW-AOI-AU_Ra **1**

2.6 Miscellaneous Instrument Marking

There is not any miscellaneous instrument marking.

2.7 Weight

Empty weight (standard equipment)	325	kg	715	lb

> **NOTE**
>
> Actual empty weight is shown in SECTION 6

Max. take-off weight	600	kg	1320	lb
Max landing weight	600	kg	1320	lb
Weight of fuel (120 l, 16 US gal)	87	kg	209	lb

Maximum baggage weight:

Baggage compartment behind seats	15	kg	33	lb
Wing lockers (optional)	20	kg	44	lb each
Front locker (optional)	10	kg	22	lb

2.8 Center of gravity

Operating C.G. range	25	to 35 %	of MAC	
MAC	1374.5	mm	54.114	in

Datum: Firewall

2.9 Approved maneuvers

Airplane Category: LSA

The BRISTELL S-LSA is approved for normal and below listed maneuvers:

- Steep turns not exceeding 60° bank
- Lazy eights
- Chandelles
- Stalls (except whip stalls)

> **WARNING**
>
> Aerobatics and intentional spins are prohibited!

BRISTELL S-LSA BRMAERO Wings with heart

Aircraft Operating Instructions

SECTION 6

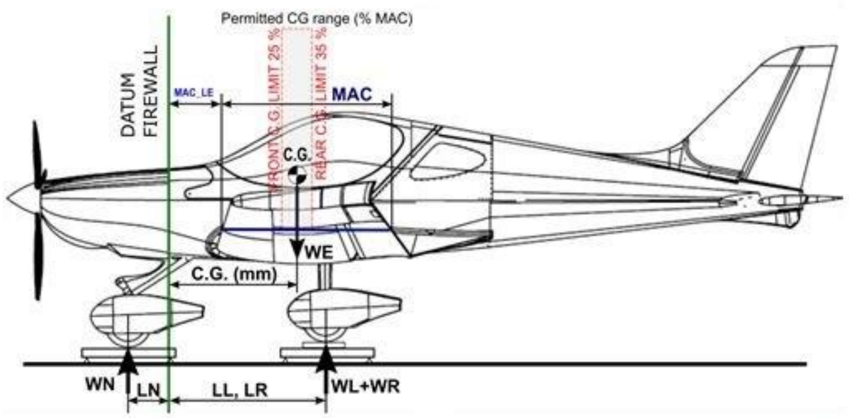
BRISTELL S-LSA

Aircraft Operating Instructions

6.2 *Weight and Balance Record*

6.2.1 Weight and Balance Report

6.2.1.1 Empty Aircraft Weight and CG



MAC_LE (mm): 406,1
MAC (mm): 1374,5

	ITEM	WEIGHT (kg)	ARM (mm)	MOMENT = WEIGHT x ARM (kg.mm)
EMPTY AIRCRAFT WEIGHT AND CG	RIGHT MAIN WHEEL	WR=	LR= 1108	MR=
	LEFT MAIN WHEEL	WL=	LL= 1108	ML=
	NOSE WHEEL	WN=	LN= -369	MN=
	EMPTY AIRCRAFT	EMPTY WEIGHT (kg) WE=	CG (mm) = CG (%MAC) =	EMPTY ACFT TOTAL MOMENT (kg.mm) MT=

$$CG(mm) = \frac{\text{Total Moment}}{\text{Total Weight}}$$

$$CG\ (\%MAC) = (CG\ (mm) - 406) \times \frac{100}{MAC}$$

Serial No.:	
Date:	
By:	

Incorrect value for MAC_LE Highlighted with ◯

BRISTELL S-LSA BRMAERO Wings with heart

Aircraft Operating Instructions

6.3 Empty weight & balance data

Date	Empty Weight (kg)	Empty CG (mm)	Empty Moment (kg-mm)	Authorised Person
On delivery				*Factory*

NOTES: 1. *Empty weight includes unusable fuel (1 litre), full oil & coolant.*

2. *If the aircraft weight is altered this empty weight and empty centre of gravity position must be updated by an authorised person.*

3. ***The pilot must always use the latest data in the above table.***

115

Date of Issue: 08/2020 *Revision: Ra*

Document No.: BRSW-AOI-AU_Ra 6-5

BRISTELL S-LSA

BRM AERO
Wings with heart

Aircraft Operating Instructions

6.4 Calculation of Weight & CG Position for Flight

6.4.1 Fuel Weight Table

The following fuel weights are based on a fuel specific gravity of 0.72 kg/litre.

Useable Fuel (Litres)	Weight (kg)
10	7.2
20	14.4
30	21.6
40	28.8
50	36
60	43.2

Useable Fuel (Litres)	Weight (kg)
70	50.4
80	57.6
90	64.8
100	72
110	79.2
119	85.7

Sample Pilot Calculation

1. Obtain the Empty Weight data for the aircraft from the paragraph 6.3 and enter it in the table below.
   Example *- Empty Weight 366 kg, Arm to the firewall 762,56 mm, Moment 279098,1 kg mm*
2. Enter weights of occupants, fuel and baggage in the table.
   NOTE: *Fuel weight for a given quantity can be determined using the data in para 6.4.1 above.*
3. Multiply weights by the corresponding arms to give the moments.
4. Total up the weights and moments. Divide total moment by total weight to give arm.
   i.e. Arm = Total Moment ÷ Total Weight
5. Provided the take-off weight does not exceed 600 kg, and the moment arm is within the range of 750 mm to 887,5 mm, the aircraft is within limits.

Incorrect CG Range, based on Incorrect MAC_LE on Page 6-4

BRISTELL S-LSA BRMAERO Wings with heart

Aircraft Operating Instructions

--- SAMPLE ONLY ---

Item	Weight (kg)	Arm (mm)	Moment (kg mm)
Empty (para 6.3)	366	762,56	279098,1
Pilot	90	1156	104040
RH seat	90	1156	104040
Fuel (Max 89 kg)	24	606	14544
Baggage – behind seats (Max 15 kg)	0	1806	0
Baggage – wing lockers (Max 20 kg each)	28	1036	29008
Baggage – Front (optional) (Max 10 kg)	0	106	0
TOTALS	**598**	**887,5**	**530730,1**

117

--- Sample Aircraft Is Within Limits ---

Sample Aircraft is Outside Limits if Correct MAC_LE is used

Date of Issue: 08/2020 *Revision: Ra*
Document No.: BRSW-AOI-AU_Ra **6-7**

BRISTELL S-LSA

BRMAERO Wings with heart

Aircraft Operating Instructions

6.4.3 Pilot Calculations

(Copy this page and do your calculations using this table).

Item	Weight (kg)	Arm (mm)	Moment (kg mm)
Empty (para 6.3)		762,56	
Pilot		1156	
RH seat		1156	
Fuel (Max 89 kg)		606	
Baggage – behind seats (Max 15 kg)		1806	
Baggage – wing lockers (Max 20 kg each)		1036	
Baggage – Front (optional) (Max 10 kg)		106	
TOTALS			

Provided the calculated take-off weight does not exceed 600 kg. and the arm is within the range of 750 mm to 887.5 mm the aircraft is within limits.

WARNING
EXCEEDING MTOW MAY LEAD TO DETERIORATION OF SAFETY OF FLIGHT!

Incorrect CG Range, based on Incorrect MAC_LE on Page 6-4

Date of Issue: 08/2020 *Revision: Ra*

Document No.: BRSW-AOI-AU_Ra **6-8**

Back to Section 1.6.10.8
Back to Section 2.5.4.5 Back to Section 1.16.2.2

Appendix H – Weight and Balance Calculation using Manufacturer's Amended Moment Arm.

Aircraft Empty Weight CG

Item	Weight (kg)	Arm (m)	Moment (kg.m)
Right Wheel	123.000	0.719	88.437
Left Wheel	125.000	0.719	89.875
Nose Wheel	80.000	-0.750	-60.000
Totals	328.000		118.312
Aircraft Empty CG =		0.361	
	MAC (m) = 1.367		
A/C Empty CG % MAC =		26.4	

Aircraft Laden CG

		Item	Weight (kg)	Arm (m)	Moment (kg.m)
		A/C Empty	328.000	0.361	118.312
		Pilot	97.300	0.750	72.975
		Passenger	89.100	0.750	66.825
		Baggage (Fuselage)	3.000	2.000	6.000
		Baggage (Wing)	1.950	0.630	1.229
		Zero Fuel totals	519.350		265.341
			ZFW CG (m)	0.511	
		ZFW CG % MAC =		37.4	
Fuel quantity (ltr)	65.5	Fuel Weight (kg)	47.160	0.200	9.432
		Total A/C Wt (kg)	566.510		274.773
			Laden CG (m)	0.485	
		A/C Laden CG % MAC =		35.5	

Aircraft Weight and Balance at time of accident using Manufacturer's Amended Moment Arm.

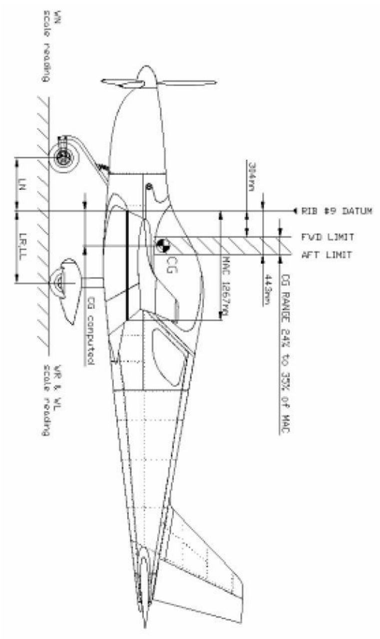
Back to Section 1.6.10.4

Back to Section 1.6.10.8

Back to Section 2.5.4.2

Appendix I – NG4 Weight and Balance section

Empty Weight C.G. Check



AIRCRAFT EMPTY CG			
ITEM	WEIGHT (kg)	ARM (m)	MOMENT (WEIGHTxARM)
RIGHT MAIN WHEEL	W_R= 120,6	L_R= 0,79	95,274
LEFT MAIN WHEEL	W_L= 124,4	L_L= 0,79	98,276
NOSE WHEEL	W_N= 103	L_N = - 0,785 (negative arm)	- 80,855
COMPUTED CG EMPTY	Empty Weight: W_E= 348 kg	CG= 0,323 m 25,5 % MAC	Aircraft moment: 112695

Date of Issue: 04/2008 6-4 Revision: 1.0

	WEIGHT (kg)	ARM (m)	MOMENT (WEIGHTxARM)
PILOT		0,6	
PASSENGER		0,6	
BAGGAGE COMPARTMENT - A		1,4	
BAGGAGE COMPARTMENT - B		2,0	
WING LOCKERS		0,65	
FUEL TANKS		0,20	
TOTAL	W=		M=
Take-Off Weight:			CG= in % MAC

Serial No: 001/2008
Date: 2008-04-26
By: [redacted]

Max.Take-off Weight: 600 kg

CG Range: 24 – 35 %

Maximum useful weight:

W_{USEFUL} = 600 kg W_{EMPTY}

W_{USEFUL} = 600 kg – 348 kg = 252 kg

This useful weight must be never exceded!

Center of Gravity (CG) = $\frac{\text{Total Moment}}{\text{Total Weight}}$ [in] x $\frac{100}{\text{MAC}}$ [%]

Date of Issue: 04/2008 6-5 Revision: 1.0

Two pages from NG4 Weight and Balance.
Note: Erroneous Pilot/Passenger Moment Arm Highlighted in Red

Back to Section 1.16.2

Appendix J – CASA Safety Notice

Australian Government
Civil Aviation Safety Authority

SAFETY NOTICE

19 FEBRUARY 2020

SAFETY NOTICE

Pilots and operators of Bristell light sport aircraft (LSA) are strongly advised to avoid conducting any manoeuvre that may lead to an aerodynamic stall of the aircraft - either intentionally or unintentionally. This includes any flight training for stalls.

The manufacturer has previously declared to CASA that the Bristell LSA meets the applicable certification requirements for LSA.

Recent information received by CASA from the aircraft manufacturer shows that the aircraft may not meet the LSA standards as it does not appear to have been adequately tested (as required by the certification standards) for its ability to recover from spins.

Worldwide, a number of Bristell aircraft have been involved in fatal accidents following unrecovered spins.

Further investigation and discussion with the manufacturer is ongoing and an update will be provided as new information becomes available.

SAFETY ISSUES

Light Sport Aircraft are required to meet a range of international standards for certification. The manufacturer has declared that the aircraft meets the standards published by ASTM International. The standard (ASTM Standard F2245, section 4.5.9) specifies the spinning performance requirements, including the ability to recover from a spin.

CASA has been engaging with the aircraft manufacturer, BRM Aero which is based in the Czech Republic, seeking to confirm that the four variants presently operating in Australia meet the standard. We are concerned that contrary to the formal declarations made by the manufacturer, the aircraft may not have been adequately tested for compliance with the ASTM standard for spin recovery.

There have been several fatal accidents worldwide (including in Australia) where Bristell aircraft have entered a spin (including during stall flight training) and failed to recover.

BACKGROUND

Manufacturers of LSA (either registered with CASA or otherwise) are able to certify or make a self-declaration, that the aircraft meets accepted standards, such as the ASTM standards when making application to CASA for a special certificate of airworthiness (COA) as an LSA.

This scheme, which has been adopted internationally, lowers manufacturer compliance costs, reduces the time to bring a design to market, and enables a more timely response to design and technology change. It is less rigorous than schemes which require a manufacturer to hold a production certificate issued by a National Aviation Authority such as CASA, EASA, or the FAA.

BRM Aero has previously declared that the Bristell variants meet these standards, however, subsequent to investigations which followed a number of fatal accidents involving these aircraft the manufacturer has been unable to provide satisfactory evidence that the design is compliant with the requirements of the ASTM standards applicable to light sport aircraft.

FURTHER INFORMATION

CASA continues to engage with BRM Aero in relation to this issue and is considering a range of proportionate safety related actions designed to mitigate the identified safety risks and will provide more information as it becomes available.

If you have any urgent questions, please contact: sport@casa.gov.au

Back to Section 1.18.5

Appendix K – CASA Safety Advisory Notice July 2020

Australian Government
Civil Aviation Safety Authority

SAFETY ADVISORY NOTICE

01-2020 Issue 2 – 28 July 2020

Bristell Light Sport Aircraft Self-Certified by BRM Aero Ltd

This Safety Advisory Notice is **an advisory document** that provides information and makes recommendations to aviation industry participants about identified risks to aviation safety. The notice seeks to ensure aviation participants are reasonably informed.

1. Update to Safety Notice dated 19 February 2020

On 19 February 2020 CASA issued a safety notice to pilots and operators of Bristell Light Sport Aircraft (LSA). The safety notice advised that further information would be provided as it became available.

This updated safety notice provides further information and should be read in conjunction with the safety notice of 19 February 2020. The information contained in the safety notice of 19 February 2020 remains applicable and a copy is available for viewing on CASA's website. (https://www.casa.gov.au/sites/default/files/safety_notice_-_bristell_lsa_-_20_feb_2020_-_accessible.pdf).

On 28 July 2020 CASA issued operational limitations under regulation 262APA(4) of the *Civil Aviation Regulations 1988* (CAR 1988) in relation to particular activities associated with any **flying training operation** performed by BRM Aero Ltd, NG4 and NG5 LSA operating with a Special Certificate of Airworthiness.

The **operating limitations** that apply to **flying training operations** are described below.

1. *A pilot in command of or student under instruction in, a BRM Aero Light Sport Aircraft (including the NG4, NG5 and TDO design variants) engaged in a flight training operation, is prohibited from conducting an intentional stall of the aircraft, or from performing any flight training activities that could reasonably lead to an unintended stall (for example, performance limit turns which occur at high angle of bank, high angles of attack and low airspeed).*

2. *A copy of these operating limitations must be attached to the Special Certificate of Airworthiness, be carried at all times in the aircraft and be readily accessible.*

Notes:

1. The operational limitations remain in effect until such time as written notice from the Civil Aviation Safety Authority is issued advising to the contrary.

2. Nothing in these operating limitations are intended to prevent the conduct of a normal landing.

3. A flight training operation includes any training operation, regardless of whether that operation is administered by a Sport Aviation Body (SAB), an Approved Self-administering Organisation (ASAO) under CASR Part 149, or an operator who holds a CASR Part 141 or CASR Part 142 certificate authorising the operation.

Page 1 of 2

Australian Government
Civil Aviation Safety Authority

The purpose of this update is to sufficiently inform aviation participants who conduct recreational and private operations in the affected aircraft, of the potential risks performing certain activities, so they are able to make informed decisions.

2. Safety Issues

Several fatal accidents have occurred worldwide (including in Australia) where Bristell aircraft appear to have entered a 'flat' spin (including during stall flight training) and failed to recover.

CASA has previously sought confirmation from the manufacturer as to compliance with the ASTM LSA standards and, in particular, spin compliance flight testing. At the present time, CASA has not received sufficient assurance as to the extent of such testing, including testing covering each design variant.

CASA also holds concerns as to the reliability of some of the information already provided.

3. Further Information

There are four known and different design variants of the affected aircraft. These include a long-wing variant (9.1m wingspan), short-wing variant (8.1m wingspan), a TDO tailwheel long-wing variant and the NG4. In regards to the NG4 variant, only those aircraft certified by BRM Aero Ltd on CASA Form 681 are affected.

CASA has sought from the manufacturer independent flight testing certification for each of the four design variants.

CASA has engaged with other national aviation regulators in relation to Bristell LSA currently operating within their national fleets. It should also be noted that the Australian circumstances for operations differ from other jurisdictions, most notably due to Bristell LSA being used for flight training in Australia.

CASA has provided a copy of the operational limitations and a statement of reasons explaining why they have been imposed to all Registered Operators of the affected aircraft as it is required to do so by regulation 262APA(5) of the CAR 1988

CASA is satisfied that by reason of the safety notice issued on 19 February 2020 and this update, that pilots performing recreational and private activities are sufficiently on notice of CASA's concerns, in particular, as to the spin recovery characteristics of the aircraft.

4. Recommendations

CASA recommends in accordance with the original Safety Notice that private and recreational pilots not intentionally stall the aircraft or perform any manoeuvres that could reasonably lead to an unintended stall. CASA also recommends that all pilots should inform any passenger of the details of this notice before commencement of a flight.

5. Enquiries

Enquiries with regard to the content of this safety notice should be made via the direct link email address: sport@casa.gov.au

Page 2 of 2

Back to Section 1.18.5

Appendix L – CASA Safety Advisory Notice June 2021

Australian Government
Civil Aviation Safety Authority

SAFETY ADVISORY NOTICE

01-2021 Issue 3 – 21 June 2021

Bristell Light Sport Aircraft Self-Certified by BRM Aero Ltd

This Safety Advisory Notice is **an advisory document** that provides information and makes recommendations to aviation industry participants about identified potential risks to aviation safety. The notice seeks to ensure aviation participants are reasonably informed.

1. Update to Safety Notice dated 28 July 2020

On 21 June 2021, CASA revoked the regulation 262APA(4) operating limitations following receipt of new compliance information from BRM Aero Ltd and fundamental corrections having been made to the Aircraft Operating Instructions (AOI).

On 9 March 2021, BRM Aero Ltd provided to CASA further information as to compliance of Bristell LSA with ASTM 4.5.9 spin requirements by two specialist organisations as to spin compliance and the scope of the LSA self-certification scheme. In addition, CASA had information that BRM Aero Ltd had recently made and distributed to aircraft owners, important corrections to the centre of gravity calculations for the affected aircraft. The corrections were required to be incorporated into the AOI.

CASA is reasonably satisfied that the corrections made to the AOI have adequately mitigated the safety related concerns held by CASA, such that all participants are meaningfully aware of these corrections and importantly, how they change the loading requirements of the aircraft. Provided operators of the aircraft only operate the aircraft in compliance with the corrected AOI data, CASA considers that the potential for inadvertent operation of the aircraft at or outside the centre of gravity limits is substantially reduced.

2. Further Information

On 5 August 2020 CASA were advised by the Irish Aircraft Accident Investigation Unit (AAIU) that during their investigation into a fatal accident involving a Bristell NG5, which occurred on 13 June 2019, the AAIU discovered that the moment arm specified in the aircraft operating instructions extant at the time of the accident was incorrect. This information was provided to BRM Aero Ltd on 25 June 2020.

The AAIU in consultation with, and with the cooperation of, the UK Light Aircraft Association (LAA) identified that the pilot and passenger moment arm for the aircraft was closer to 750 mm as opposed to the 600mm published in the AOI for the Bristell NG5. A safety notice was issued by the UK LAA on 20 July 2020 and updated on 24 November 2020. A copy of that safety notice can be accessed at: Bristell WB issues.pdf (lightaircraftassociation.co.uk)

On 7 August 2020 BRM Aero Ltd issued a Safety Directive for all NG5 variants. When issuing this Safety Directive, BRM Aero Ltd took the opportunity to also change the datum associated with the calculations, moving the datum from the leading edge of the mean aerodynamic chord to the face of the firewall. As a result of this change, not only the arm for the pilot and passenger was changed but all the relevant moment arms were changed to reflect the change in datum.

Australian Government
Civil Aviation Safety Authority

On 15 June 2021, the AAIU issued a second interim statement regarding the fatal accident of 13 June 2019 which provides information as to discrepancies in the pilot and passenger weights and balance arms as contained in the Aircraft Operating Instructions at the time of the accident. A copy of the second interim statement can be accessed at: http://www.aaiu.ie/node/1525

3. Recommendations

a) CASA recommends that pilots and operators of the affected aircraft ensure they are familiar with the effect of the revised AOI corrections, as there may now be a significant change to the way the aircraft is permitted to be loaded and there may now be restrictions upon operating the aircraft in certain configurations.

b) Pilots and operators should pay particular attention to the corrected arm associated with the pilot and passenger row. The correction to the AOI has adjusted the arm for the pilot and passenger significantly further rearward.

c) Pilots and operators should pay particular attention to the aft movement of the centre of gravity with fuel burn. Dependant on the empty weight and empty CoG of each aircraft, the corrected arm and the effect of an aft moving CoG with fuel burn, may significantly change the revised permitted loading of the aircraft, when compared to previous loading of the aircraft.

d) Pilots should check that the loading of the aircraft is within the published limits, both at the proposed take-off weight and also at a zero-fuel or minimum fuel weight.

4. The Light Sport Aircraft Regulatory Scheme

Manufacturers of LSA (whether registered with CASA or otherwise) are able to certify or make a self-declaration, that the aircraft meets accepted published standards, such as the ASTM standards when making application to CASA for a Special Certificate of Airworthiness (SCoA) as an LSA.

This scheme, which has been adopted by the FAA, NZ CAA and CASA, lowers manufacturer compliance costs, reduces the time to bring a design to market, and enables a timelier response to design and technology change. It is less rigorous than schemes which require a manufacturer to hold a production certificate issued by a National Aviation Authority such as CASA, EASA, or the FAA It is important to understand that the self-certification of these aircraft is not verified by any NAA as would be the case for a manufacturer who holds a production certificate.

Based upon a review of self-certification practices by LSA manufacturers, CASA is changing the process to obtain the first-of-model (within Australia) SCoA for an LSA. In all such cases, CASA is to be notified of any SCoA applications before assessment and CASA will have the option of conducting the assessment directly. CASA may also specifically approve an Authorised Person on a case-by-case basis, based on risk and other relevant factors.

5. Enquiries

Enquiries regarding this safety advisory notice can be made to sport@casa.gov.au

Page 2 of 2

Back to Section 1.6.16
Back to Section 1.18.5.1

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Back to Section 1.16

Appendix N – Manufacturer's Stall Test Report

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REPORT NO.:
ULHD-REP-2-13-1-EN-0003_2021

REPORT ON
WING LEVEL STALL CHARACTERISTICS OF BRISTELL BEHIND CG AFT LIMIT

127 **Annotation:**
This report describes flight tests to determine wing level stall characteristics of Bristell aircraft (wing span 8.13 m), when operated 1-2 % of MAC behind CG aft limit 35 % MAC.
The tests were done due to findings at investigation of BRISTELL, G-OJCS accident in Belan, Co. Kildare, Ireland, 13 June 2019.

Elaborated by: [redacted]
BRM Aero, Certification manager

Approved by: [redacted]
Test pilot, LAA CZ

[redacted]
BRM B23 Test pilot

Doc.No.:	ULHD-REP-2-13-1-EN-0003_2021	Date of issue:	Revision No.:	Date of Rev:	Page: 1
File name:	*ULHD-REP-2-13-1-EN-0003_2021*	30.7.2021	-	-	Pages: 11

Report No.: ULHD-REP-2-13-1-EN-0003_2021	REPORT ON WING LEVEL STALL CHARACTERISTICS OF BRISTELL BEHIND CG AFT LIMIT	BRM AERO

Table of Content

Report No.: ULHD-REP-2-13-1-EN-0003_2021	REPORT ON WING LEVEL STALL CHARACTERISTICS OF BRISTELL BEHIND CG AFT LIMIT	BRM AERO

1 Introduction

It was found during investigation of probable causes of Bristell G-OJCS accident in Belan, Co. Kildare, Ireland, 13 June 2019 (stall practising, subsequently transition into a deep spiral and then into a flat spin) , that it was exceeded Center of Gravity (CG) aft limit 35 %of MAC, which may have a degrading effect on the stall characteristics.

Therefore, BRM Aero decided to conduct flight tests of a serially produced aircraft (the crashed aircraft was built from a kit) to investigate in detail the stall characteristics when the CG aft limit is exceeded 1 to 2 % of MAC (at the time of the accident the CG as presented in the investigation report was approximately 35.9 %MAC).

This report describes these flight tests.

2 Test Objective

Testing of wing level stall characteristics of Bristell NG5 (wing span 8.13 m) at 1 to 2 % behind the CG aft limit (35 %MAC).

3 Date of the test

28.7.2021

4 Test site

Kunovice airport (LKKU), Czech Republic

IATA: UHE · ICAO: LKKU

Summary	
Airport type	Public
Serves	Uherské Hradiště
Location	Kunovice
Elevation AMSL	581 ft / 177 m
Coordinates	49°01′46″N 17°26′23″E

Runways			
Direction	Length		Surface
	ft	m	
02L/20R	4,856	1,480	Grass
02C/20C	6,562	2,000	Concrete
02R/20L	5,545	1,690	Grass

5 Certification basis

[1] Bekanntmachung von Lufttüchtigkeitsforderungen für aerodynamisch gesteuerte Ultraleichtflugzeuge *LTF-UL vom 15.01.2019 – new German UL airworthiness requirements

[2] UL 2 – Part I., Airworthiness Requirements UL – Aircraft Three Axes Standard Control Ultra Light Aircraft, First edition 2019 – new Czech UL airworthiness requirements

Doc.No.:	ULHD-REP-2-13-1-EN-0003_2021	Date of issue:	Revision No.:	Date of Rev:	Page: 3
File name:	*ULHD-REP-2-13-1-EN-0003_2021*	30.7.2021	-	-	Pages: 11

6 Certification bases applicable requirements

German:

LTF-UL 201 Überziehverhalten bei waagerecht gehaltenen Tragflügeln

Das Überziehverhalten muss für die vordere und hintere Grenze der Schwerpunktlage und die in **LTF-UL 25** festgelegten Höchst- und Mindestmassen untersucht werden.

1. Überziehversuche müssen durchgeführt werden, indem die Geschwindigkeit ausgehend vom horizontalen Geradeausflug je Sekunde um etwa 2 km/h vermindert wird, bis entweder der überzogene Flugzustand erreicht ist, er sich durch ein nicht unmittelbar steuerbares Abkippen nach vorn über einen Flügel anzeigt, oder bis die Höhensteuerung zum Anschlag kommt. Bis zum Erreichen des überzogenen Zustandes muss es möglich sein, durch Betätigung der Steuerung Rollen und Gieren im Sinne des entsprechenden Steuerausschlages zu erzeugen und zu korrigieren.
2. Bei der Wiederherstellung des normalen Flugzustandes muss es unter normaler Verwendung der Steuerung möglich sein, mehr als 20° Querneigung zu verhindern. Das Flugzeug darf dabei keine nichtbeherrschbare Neigung zum Trudeln aufweisen.
3. Der Höhenverlust vom Beginn des überzogenen Flugzustandes bis zur Wiederherstellung des Horizontalfluges und die maximale Längsneigung nach dem Abkippen gegenüber dem Horizont müssen unter Anwendung üblicher Verfahren ermittelt werden.

Erläuterungen:
Der beim Überziehen auftretende Höhenverlust ist der Unterschied zwischen der Höhe, in der der überzogene Flugzustand eintritt und der Höhe, in der der Horizontalflug wieder erreicht ist.

4. Der Nachweis der Erfüllung der Forderungen der Absätze 1. bis 3. dieses Abschnittes muss unter folgenden Bedingungen erbracht werden.
   a. Flügelklappen in jeder Stellung
   b. Fahrwerk eingefahren und ausgefahren
   c. Flugzeug auf **1,4 V_{S1}** ausgetrimmt (falls mit Trimmung versehen)
   d. Motorleistung: Leerlauf und höchste Dauerleistung.

Czech:

UL 2 § 201 Wings level stall characteristics

The stall characteristics for the extreme forward and rear location of the centre of gravity and the maximum and minimum weight according to UL 2 § 25 have to be tested.

Stall tests have to be performed as follows:

1) Starting from level flight by reducing the speed by approximately 2km/h per second until a stall occurs, which is manifested by an uncontrollable downward pitching movement of the aeroplane (might be accompanied by a roll movement), or until the pitch control reaches the back stop. It must be possible to produce and correct roll and yaw by use of the coresponding controls, until the aeroplane stalls.

2) During the recovery part of the manoeuvre, it must be possible to prevent more than 20° of bank, by the normal use of controls. The aeroplane must not exhibit a tendency towards uncontrollable spins.

3) The loss of altitude must be determined from the beginning of the stall until regaining level flight by applying normal procedures.

Note:
The loss of altitude encountered in the stall is the change in altitude between the altitude at which the aeroplane pitches and the altitude at which horizontal flight is regained.

4) Compliance with the requirements of the 1) to 3) must be shown under the following conditions:
   a) wing flaps at all positions,
   b) landing gear retracted and extended.
   c) aeroplane speed set for 1,4 V_{S1} (trimmed if applicable),
   d) engine power setting:
      i) idle, and
      ii) 75% of max continuous power,
      iii) in case 75% of maximum continuous power causes the pitch over 30° then the engine power setting can be further reduced no less than 50% of maximum continuous power.

130

Report No.: ULHD-REP-2-13-1-EN-0003_2021	REPORT ON WING LEVEL STALL CHARACTERISTICS OF BRISTELL BEHIND CG AFT LIMIT	BRM AERO

7 Tested aircraft

- Aircraft type/model: BRISTELL UL HD (BRISTELL LSA-K acc.to the Czech TC ULL 06/2019 and German Kennblatt 66253)
- Acft Serial number: 581/2021
- Registration: OK-QUU 06

- Engine type/model: ROTAX 912 ULS 2
- Engine S/N: 9574918

- Propeller type/model: DUC SWIRL-3
- S/N: Not recorded
- 3 blade, composite, on-ground adjustable

- AEPS (parachute) : MAGNUM 501
- S/N: 501-20/11-4098

8 Weight and Balance

See 15.1Appendix 1 Weight and Balance of Bristell aircraft, S/N: 581/2021.
A/ at the take-off
TOW: 589 kg
CG: 36.1 %MAC
- Empty weight of the aircraft weighed
- Laden aircraft weighed

Note: CG aft limit: 35 %MAC

Doc.No.:	ULHD-REP-2-13-1-EN-0003_2021	Date of issue:	Revision No.:	Date of Rev:	Page: 5
File name:	ULHD-REP-2-13-1-EN-0003_2021	30.7.2021	-	-	Pages: 11

B/ at landing:
Weight: 564 kg
CG: 37 %MAC
- Remaining fuel after flight drained off and weighed.

9 Test crew

Pilot: [redacted] Czech LAA test pilot
Co-pilot: [redacted] BRM B23 test pilot

10 Test equipment

On-board avionics/instruments installed in tested Bristell:

- KANARDIA ASI –airspeed indicator
- KANARDIA ALT – altimeter
- KANARDIA HORIS - artificial horizon
- KANARDIA VSI – vertical speed indicator
- WINTER slip/skid indicator.

Further Inertial Measurement Unit Xsens Mti-20-2A8G4 was attached on the wing-centre section and connected to a notebook with software for data downloading. The unit allows measurement of accelerations and angular speeds within 3 axes.
The data from this unit can be exported to txt files for further evaluation in e.g. MS Excel.
The source data and txt files are archived by BRM Flight Test Dpt.

There was also used GARMIN VIRB camera mounted in the cockpit (on the tip-up canopy) using a suction –cup holder. The camera recorded instrument panel and view outside the aircraft. The pilot's comments for particular stalls were recorded as well, using audio cable connected to Garmin camera. The MP4 video/audio files are archived by BRM Flight Test Dpt.

Report No.: ULHD-REP-2-13-1-EN-0003_2021	REPORT ON WING LEVEL STALL CHARACTERISTICS OF BRISTELL BEHIND CG AFT LIMIT	BRMAERO

11 Test program and methodology:

The programs and methodologies approved and used by the LAA Czech Republic were used:

- 05_UL 2 § 201 Chování při přetažení v přímém letu (Wing level stall characteristics).

This methodology is used by the Czech LAA test pilots to check UL/LSA flight characteristics (wing level stalls) .

Wing level stalls at idle for all positions of the wing flaps, various recovery techniques, even improper.

12 Test course

Flight testing was performed on 28.7.2021on Kunovice airport (LKKU).

Meteorological conditions: QNH: 1014 Hpa, QMU: +28°C, CAVOK, wind calm, no thermal turbulence.

The stalls at idle for all positions of the wing flaps (retracted, take-off, landing) were tested at first phase. All stalls were recovered by standard use of the controls i.e. control stick forward, nose dropped below the horizon and descent flight was recovered, using first the rudder to correct roll and then even ailerons.

During second phase of testing the full throttle was applied for all these configurations – always after the nose dropped below the horizon.

Next phase of testing was focused on stall recovery for all flaps positions (retracted, take-off, landing) according to the following points:

1) Full throttle applied when the nose was above or at the horizon
2) Corrections of the roll by using the ailerons, without input into the rudder
3) Stall entry into right, left roll and skid, full throttle applied– nose above or at the horizon
4) Full throttle applied at horizontal flight, at speed of about 1.1 Vs1
5) Stalls and stalls recovery at full power
6) Stalls and stalls recovery for various positions of the trim (neutral, tail heavy)
7) Stall from steep left turn

It was always possible easily and safely recover tested aeroplane during all these regimes by standard use of the controls.

The test pilots were not able to introduce situation similar to the accident.

13 Data evaluation

Excel table elaborated to summarize all tested stall configurations, pilot comments etc. – see **15.2 Appendix 2 Summary of performed stalls, pilot comments**

MP4 Video files from GARMIN VIRB camera – VLC Multimedia Player

The MP4 video/audio files are archived by BRM Flight Test Dpt.

Txt files from Mti-20-2A8G4 unit - Microsoft EXCEL.

The source data and txt files are archived by BRM Flight Test Dpt.

Doc.No.:	ULHD-REP-2-13-1-EN-0003_2021	Date of issue:	Revision No.:	Date of Rev:	Page: 7
File name:	ULHD-REP-2-13-1-EN-0003_2021	30.7.2021	-	-	Pages: 11

Report No.: ULHD-REP-2-13-1-EN-0003_2021	REPORT ON WING LEVEL STALL CHARACTERISTICS OF BRISTELL BEHIND CG AFT LIMIT	BRM AERO

14 Conclusion

The flight tests performed on 28.7.2021 have clearly demonstrated, that the wing level stall characteristics of Bristell even after exceeding of CG aft limit up to 2% of MAC , are absolutely satisfactory.
The aeroplane is controllable up to a stall, which is shown itself by nose pitch down and usually slight right wing drop. The aeroplane has no tendency to enter into a spin.
Exceeding of CG aft limit up to 37 %MAC does not lead to uncontrollable wing level stall characteristics.

The test pilots were not able to introduce situation similar to the accident.

Kunovice, 30.7.2021

[redacted]
Test pilot, LAA CZ

[redacted]
BRM B23 Test pilot

15 Appendices

16.1 Appendix 1 Weight and Balance of Bristell aircraft, S/N: 581/2021

16.2 Appendix 2 Summary of performed stalls, pilot comments

Report No.: ULHD-REP-2-13-1-EN-0003_2021	REPORT ON WING LEVEL STALL CHARACTERISTICS OF BRISTELL BEHIND CG AFT LIMIT	BRM AERO

15.1 *Appendix 1 Weight and Balance of Bristell aircraft, S/N: 581/2021*

The tables hereinafter provide information on weight and balance of Bristell aircraft, S/N: 581/2021, used for the flight tests on 28.7.2021, to thoroughly check wing level stall characteristics, due to accident of Bristell NG5, G-OJCS, Belan, Co. Kildare, 13 June 2019.

As may be seen from the tables below, the testing of stalls was done within the CG range from 36.1 to 37 % MAC, i.e. up to 2 % behind the CG aft limit 35 %MAC, and within the weight range from 589 kg to 564 kg.

1. Empty Aircraft Weight and CG

MAC_LE (mm): 406,1
Registration: OK-QUU 06 MAC (mm): 1374,5

EMPTY AIRCRAFT WEIGHT AND CG	ITEM	WEIGHT (kg)	ARM (mm)	MOMENT = WEIGHT x ARM (kg.mm)
	RIGHT MAIN WHEEL	WR= 135,0	LR= 1108	MR= 149526,0
	LEFT MAIN WHEEL	WL= 137,0	LL= 1108	ML= 151741,2
	NOSE WHEEL	WN= 75,0	LN= -369	MN= -27705,0
	EMPTY AIRCRAFT	EMPTY WEIGHT (kg) WE= 347,0	CG (mm) = 788,36 CG (%MAC) = 27,8	EMPTY ACFT TOTAL MOMENT (kg.mm) MT= 273562,20

CG (mm)= TOTAL MOMENT / TOTAL WEIGHT
CG (%MAC)= (CG (mm) - MAC_LE) X 100 / MAC

Serial No.: 581/2021
Date: 28.7.2021
By: [redacted]

2. Loaded Aircraft Weight and CG **A/TAKEOFF**

LOADED AIRCRAFT WEIGHT AND CG	ITEM	WEIGHT (kg)	ARM (mm)	MOMENT = WEIGHT x ARM (kg.mm)
	EMPTY AIRCRAFT	347,0	788,36	273562,2
	PILOT: Rakušan	95	1156,0	109820,0
	PASSENGER: Mitáš + Notebook	107	1156,0	123692,0
	BAGGAGE - BEHIND SEATS	0	1806,0	0,0
55	FUEL TANKS	39,6	606,0	23997,6
	LOADED AIRCRAFT	TAKEOFF WEIGHT (kg) TOW= 589	CENTER OF GRAVITY CG (mm)= 902,26 CG (%MAC) = 36,1	LOADED ACFT TOTAL MOMENT (kg.mm) MT= 531072

Max.Takeoff Weight: 600 kg
CG Range: 25 35
Front C.G. limit (behind Datum): 750 mm
Aft C.G. limit (behind Datum): 887 mm

CG (mm)= TOTAL MOMENT / TOTAL WEIGHT
CG (%MAC)= (CG (mm) - MAC_LE) X 100 / MAC

Serial No.: 581/2021
Date: 28.7.2021
By: [redacted]

3. Loaded Aircraft Weight and CG **B/LANDING**

LOADED AIRCRAFT WEIGHT AND CG	ITEM	WEIGHT (kg)	ARM (mm)	MOMENT = WEIGHT x ARM (kg.mm)
	EMPTY AIRCRAFT	347,0	788,36	273562,2
	PILOT: Rakušan	95	1156,0	109820,0
	PASSENGER: Mitáš + Notebook	107	1156,0	123692,0
	BAGGAGE - BEHIND SEATS	0	1806,0	0,0
21	FUEL TANKS	15,12	606,0	9162,7
	LOADED AIRCRAFT	TAKEOFF WEIGHT (kg) TOW= 564	CENTER OF GRAVITY CG (mm)= 915,12 CG (%MAC) = 37,0	LOADED ACFT TOTAL MOMENT (kg.mm) MT= 516237

Max.Takeoff Weight: 600 kg
CG Range: 25 35
Front C.G. limit (behind Datum): 750 mm
Aft C.G. limit (behind Datum): 887 mm

CG (mm)= TOTAL MOMENT / TOTAL WEIGHT
CG (%MAC)= (CG (mm) - MAC_LE) X 100 / MAC

Serial No.: 581/2021
Date: 28.7.2021
By: [redacted]

Doc.No.:	ULHD-REP-2-13-1-EN-0003_2021	Date of issue:	Revision No.:	Date of Rev:	Page: 9
File name:	*ULHD-REP-2-13-1-EN-0003_2021*	30.7.2021	-	-	Pages: 11

Report No.: ULHD-REP-2-13-1-EN-0003_2021	REPORT ON WING LEVEL STALL CHARACTERISTICS OF BRISTELL BEHIND CG AFT LIMIT	BRMAERO Wings with heart

15.2 Appendix 2 Summary of performed stalls, pilot comments

Issue	Video file	Time on video	Power	Flaps [°]	Trim	Pilot technique	Pilot comment	Loss of control?	Risk of spin?
1	20210728_Stall 1	5:50	idle	0	neutral	Standard methodology by elevator pushing without power		No	No
2	20210728_Stall 1	6:15	idle	0	neutral	Standard methodology by elevator pushing without power		No	No
3	20210728_Stall 1	9:15	idle	10	neutral	Standard methodology by elevator pushing without power	Right wing drops down	No	No
4	20210728_Stall 1	9:55	idle	10	neutral	Standard methodology by elevator pushing without power	Right wing drops down	No	No
5	20210728_Stall 1	13:20	idle	30	neutral	Standard methodology by elevator pushing without power		No	No
6	20210728_Stall 1	13:40	idle	30	neutral	Standard methodology by elevator pushing without power	Right wing drops down	No	No
7	20210728_Stall 1	14:00	idle	30	neutral	Standard methodology by elevator pushing without power	Left wing slightly drops down	No	No
8	20210728_Stall 1	14:20	idle	30	neutral	Standard methodology by elevator pushing without power	Does not stall, keeps turning to the left	No	No
9	20210728_Stall 1	17:30	idle	0	neutral	Standard methodology by elevator pushing down, power on when aircraft pitches down		No	No
10	20210728_Stall 1	17:45	idle	0	neutral	Standard methodology by elevator pushing down, power on when aircraft pitches down		No	No
11	20210728_Stall 1	18:50	idle	10	neutral	Standard methodology by elevator pushing down, power on when aircraft pitches down		No	No
12	20210728_Stall 1	19:18	idle	10	neutral	Standard methodology by elevator pushing down, power on when aircraft pitches down		No	No
13	20210728_Stall 1	21:43	idle	30	neutral	Standard methodology by elevator pushing down, power on when aircraft pitches down	Right wing drops down	No	No
14	20210728_Stall 1	22:08	idle	30	neutral	Standard methodology by elevator pushing down, power on when aircraft pitches down	Right wing drops down	No	No
15	20210728_Stall 1	22:25	idle	30	neutral	Standard methodology by elevator pushing down, power on when aircraft pitches down	Right wing drops down	No	No
16	20210728_Stall 2	0:15	idle	0	neutral	Stall input - skid. 25% of right pedal deflection, during stall - left aileron counter steering	Right wing drops down	No	No
17	20210728_Stall 2	6:35	idle	0	neutral	Stall input - skid. 25% of left pedal deflection, during stall - right aileron counter steering	Stalls wings levelled	No	No
18	20210728_Stall 2	7:10	idle	0	neutral	Stall input - skid. 25% of left pedal deflection, during stall - right aileron counter steering	Left wing drops down	No	No
19	20210728_Stall 2	9:00	idle	0	neutral	Standard methdology by elevator pushing down, recovery to horizontal position, in horizont full power	Left wing drops down	No	No
20	20210728_Stall 2	9:30	idle	0	neutral	Standard methdology by elevator pushing down, recovery to horizontal position, in horizont full power (when full power - hands off the steering)	After recovery, nose pitches down	No	No
21	20210728_Stall 2	11:55	idle	0	120	Standard methdology by elevator pushing down, recovery to horizontal position, in horizont full power (when full power - hands off the steering)	After recovery, nose pitches up	No	No
22	20210728_Stall 2	12:30	idle	10	neutral	Standard methdology by elevator pushing down, recovery to horizontal position, in horizont full power (when full power - hands off the steering)	After full power, aircraft slightly banks left	No	No
23	20210728_Stall 2	15:00	idle	10	110	Standard methdology by elevator pushing down, recovery to horizontal position, in horizont full power (when full power - hands off the steering)	After recovery, nose strongly pitches up	No	No
24	20210728_Stall 2	15:55	idle	30	neutral	Standard methdology by elevator pushing down, recovery to horizontal position, in horizont full power (when full power - hands off the steering)	Right wing drops down	No	No
25	20210728_Stall 2	16:35	idle	30	100	Standard methdology by elevator pushing down, recovery to horizontal position, in horizont full power (when full power - hands off the steering)	Right wing drops down, after recovery, nose strongly pitches up	No	No
26	20210728_Stall 2	0,840277778	tactical	0	90	Above stall speed full throttle, hands off	Does not stall, banks slightly to left side	No	No
27	20210728_Stall 2	20:50	tactical	0	90	During stall full throttle, hands off	When hands off, goes to the left spiral	No	No
28	20210728_Stall 2	22:35	idle	0	neutral	Stall, after nose goes to horizont, full throttle - hands off	After full throttle banks 30° to the left descending turn (not a spiral)	No	No
29	20210728_Stall 2	23:40	climb	0	neutral	During climb, 85-90 IAS, cycling deflections with pedals	No affect, aircraft yaws	No	No
30	20210728_Stall 3	2:00	idle	0	neutral	Standard stall, recovery by ailerons, after stall full throttle	Right wing drops down	No	No
31	20210728_Stall 3	3:05	climb	0	neutral	On 90 IAS during climb full power, hands off	Banks to the left	No	No
32	20210728_Stall 3	6:05	idle	0	85	On stall speed full throttle, hands off	Banks to the left, goes to the right	No	No
33	20210728_Stall 3	7:00	idle	0	85	On stall speed full throttle, hands off	Stalls drops right wing down	No	No
34	20210728_Stall 3	7:30	idle	0	85	On stall speed full throttle, hands off	Pitches up, goes to the right descending turn	No	No
35	20210728_Stall 3	10:50	idle	0	neutral	On stall speed full throttle, hands off	Pitches down	No	No

NOTE: Yellow highlighted are the stalls, which may lead to a critical stall behaviour when there are no pilot inputs at all (fully released controls).

Doc.No.:	ULHD-REP-2-13-1-EN-0003_2021	Date of issue:	Revision No.:	Date of Rev:	Page: 11
File name:	*ULHD-REP-2-13-1-EN-0003_2021*	30.7.2021	-	-	Pages: 11

Back to Section 1.18.6
Back to Section 2.10

- 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.

Produced by the Air Accident Investigation Unit

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