Air Accident Investigation Unit Ireland

FORMAL REPORT

ACCIDENT
Laser Z200, PH-LSR
Abbeyshrule, Co. Longford
20 March 2016

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

Foreword

This safety investigation is exclusively of a technical nature and the Final Report reflects the determination of the AAIU regarding the circumstances of this occurrence and its probable 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 460 of 2009, the Chief Inspector of Air Accidents, on 20 March 2016, appointed Mr Kevin O'Ceallaigh as the Investigator-in-Charge to carry out an Investigation into this Accident and prepare a Report.

Aircraft Type and Registration:	Laser Z200, PH-LSR	
No. and Type of Engines:	1 x Lycoming AEIO-360-A1E	
Aircraft Serial Number:	PFA 123-12682	
Year of Manufacture:	1996	
Date and Time (UTC)[4]:	20 March 2016 @ 17.45 hrs	
Location:	Abbeyshrule, Co. Longford, Ireland	
Type of Operation:	General Aviation	
Persons on Board:	Crew - 1	Passengers - 0
Injuries:	Crew - 1 (Fatal)	Passengers - 0
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot Licence issued by the UK[5] CAA[6]	
Commander's Details:	Male, aged 47 years	
Commander's Flying Experience:	447 hours, of which 45 minutes were on type	
Notification Source:	Telephone call from an eyewitness	
Information Source:	AAIU Field Investigation	

[4] **UTC**: Co-ordinated Universal Time. All timings in this report are quoted in UTC (equivalent to local time).
[5] **UK:** United Kingdom.
[6] **CAA:** Civil Aviation Authority

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SYNOPSIS

The Pilot was conducting a flight in the vicinity of Abbeyshrule Airfield (EIAB) in Co. Longford. This was his second flight in the Laser Z200 single-seat, aerobatic aircraft which had been delivered to him at EIAB seven days prior to the accident. The flight consisted of circuits of the airfield incorporating a number of landings, take-offs, and aerobatic manoeuvres. While flying on the downwind segment of the final circuit, the Pilot initiated a sequence of aerobatic rolling manoeuvres at a circuit height of approximately 800 ft. Eyewitnesses observed the aircraft entering a steep nose-down flight path. During the attempted recovery, the aircraft appeared to stall and enter the initial stage of a spin. It impacted with terrain in an agricultural field adjacent to the runway, fatally injuring the Pilot. The aircraft was destroyed and there was no fire.

NOTIFICATION

The AAIU was notified within 15 minutes of the accident by a member of a local flying club at EIAB who had witnessed the event and contacted an Inspector of Air Accidents directly by phone. The AAIU Inspector on Call was also notified by Air Traffic Services (ATS) in Shannon.

1. FACTUAL INFORMATION

1.1 History of the Flight / Occurrence

1.1.1 General

On the day of the accident the Pilot had travelled by air to Inishmore Airfield (EIIM) on the Aran Islands, off the west coast of Ireland, with some friends and members of a local flying club. They travelled in two groups: one group in a Cessna 182S and the other group in a Samba XXL aircraft. The Pilot flew the Cessna 182S to the Aran Islands. They departed EIIM around 16.00 hrs to return to EIAB, with the Pilot as a rear-seat passenger.

After landing at EIAB the Pilot told his friends in the Cessna 182S that he was going to take his recently purchased aircraft, a Laser Z200, for a local flight. He was subsequently observed preparing it for departure. During the pre-flight inspection, the Pilot secured two *GoPro Hero* video cameras to the aircraft: The first on the engine cowling in front of the cockpit facing rearwards, and the second on the left wingtip facing towards the cockpit. The Pilot then boarded the aircraft and closed the canopy.

The Pilot started the engine, taxied the aircraft to the threshold of Runway (RWY) 10, completed an engine run, and then departed in an easterly direction. The aircraft climbed in this direction for a short period of time before it turned to fly back towards EIAB and align with the approach path for RWY 28. The aircraft was seen to descend towards the runway and complete six rapid banking manoeuvres to the left and right, which is commonly referred to as a '*wing-waggle*', and is often used as a method of acknowledging people watching from the ground.

Following this initial manoeuvre, the aircraft performed a further five left-hand circuits[7], to RWY 28. During three of the circuits the aircraft conducted a touch and go[8] on RWY 28; one of these three circuits also included the completion of three aileron rolls[9] during the downwind leg. The other circuits were both completed without attempting a touch and go. These circuits included aerobatic and inverted manoeuvres overhead the aerodrome. Eyewitness told the Investigation that in their opinion the entire flight, including these manoeuvres, was conducted at a height of approximately 800 ft AAL[10].

The aircraft commenced a seventh circuit by turning left onto an easterly downwind leg, and subsequently turned westwards again to align with RWY 28 while maintaining circuit height. It completed a series of three aileron rolls to the left overhead the airfield in a westerly direction. The second and third aileron rolls were commenced approximately 1-2 seconds after the completion of the previous manoeuvre. As the third aileron roll was completed, the aircraft immediately started a steep left turn onto a downwind leg for an eighth circuit.

As the aircraft passed abeam the aerodrome in an easterly direction it conducted more rolling manoeuvres. A witness reported seeing the aircraft descending rapidly towards the ground during these manoeuvres and that it impacted terrain in a steep nose-down attitude. The Pilot was fatally injured. There was no fire. The aircraft was destroyed. The elapsed time from take-off until the end of the flight was estimated to be approximately 13 mins[11] 48 secs[12].

A detailed description of each circuit, based on *GoPro* video camera footage and eyewitness statements, is contained in **1.11.3.3 Detailed Flight Description** of this report.

1.1.2 Witness Statements

A number of witnesses to the accident flight were interviewed by the Investigation. The respective location of each eyewitness is shown in **Figure No. 1.**

1.1.2.1 Eyewitness 1 and 2

Eyewitness 1 and 2 had travelled to EIIM earlier in the day in the Samba XXL. The eyewitnesses said that they were 10 minutes behind the Cessna on the return flight from EIIM and that by the time that they had arrived back at EIAB, the Pilot had already taken the Laser Z200 out of the hangar and told them that "*he was going to do a few circuits*".

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[7] **Circuit:** A pattern flown by aircraft based on the runway in use, usually rectangular in shape and designed to maintain a safe and orderly flow of traffic at an aerodrome. It usually consists of a number of stages; take-off, climb out, crosswind leg, downwind leg, base leg, final approach and landing.
[8] **Touch and go:** The aircraft lands on a runway and, without coming to a stop, accelerates and takes-off again. This manoeuvre permits more practice take-offs and landings within a given period of time.
[9] **Aileron Roll:** An aerobatic manoeuvre in which the aircraft rotates through 360 degrees about its longitudinal axis until it reaches its original orientation.
[10] **AAL:** Above Aerodrome Level
[11] **Mins:** Minutes
[12] **Secs:** Seconds

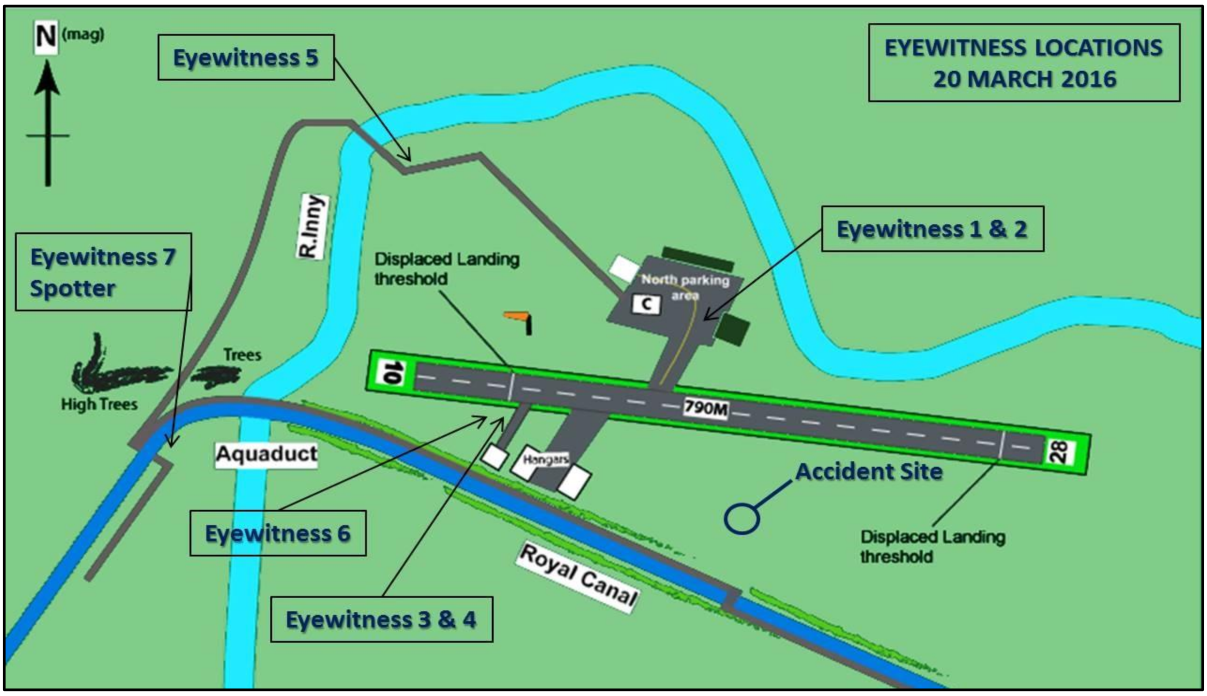

Figure No. 1: Eyewitness locations 20 March 2016 (Adapted from EIAB website)

Both of these eyewitnesses told the Investigation that during the Pilot's previous flight on 17 March 2016, they were sufficiently concerned for the Pilot's ability to control the aircraft that they manned the airport fire tender as a precaution. However, having seen the first two touch and go landings of the 20 March 2016 flight they considered that, in their opinion, "*He had the hang of it now…we don't have to worry about him now*". They said that the Pilot conducted some circuits and manoeuvres overhead the airfield. Eyewitness 1 said that he had looked away as the aircraft rolled out on downwind. When he looked up again, as the aircraft passed the hangar, it appeared to Eyewitness 1 that the Pilot had "*put the nose down"* and he didn't understand why the Pilot would do that at such a low altitude. He observed the aircraft descend vertically into the field. Eyewitness 2 did not observe the descent but heard the sound of the aircraft impacting the ground. They both then got into a car and went to the accident site to provide assistance. Both eyewitnesses estimated that the circuits and manoeuvres were all conducted at, or close to, the standard circuit height for EIAB of 800 ft AAL.

1.1.2.2 Eyewitness 3 and 4

Eyewitness 3 and 4 said that they had travelled with the Pilot to EIIM in the Cessna 182S earlier on the day of the accident. On return to EIAB the Pilot told them that he was "*going to take the Laser out for a spin*". They observed the first touch and go circuits and then they saw the aircraft "*do some flips*" and they said that they were "*worried for him as he hadn't had the airplane for long*". Eyewitness 4 said that he took his eye off the aircraft, and when he heard a change in the sound in the engine, he looked up again. They then both saw the aircraft descending vertically toward the ground. They lost sight of the aircraft as the hangar obscured their view. Neither eyewitness reported hearing any unusual engine sounds prior to impact. Eyewitness 3 said that the aircraft was also turning as it descended.

Both eyewitnesses observed the rolling manoeuvres and considered that they were conducted at circuit height. Eyewitness 3 said that when the aircraft exited the final manoeuvre, it looked lower than circuit height. Eyewitness 3 told the Investigation that the Pilot had said that he was confident of his ability to conduct aerobatics in the aircraft. After the aircraft impacted the ground, they went towards the accident site to provide assistance.

1.1.2.3 Eyewitness 5

Eyewitness 5 was walking with her young son and saw the aircraft conducting aerobatics and thought that there may have been a show going on so she walked towards the airfield. As she crossed over a bridge near the aerodrome car park, she saw the aircraft coming towards her and noted that it appeared to be very low. She thought that it was landing but it then "*went way up in the sky again*" before turning over her head. She said that the aircraft then turned again and she noticed in particular that it was pointing "*dead-straight nose down*" and that it "*nose-dived*" into the ground. She heard the sound of the impact which she described as a "*puff*" or muffled sound rather than an explosion.

1.1.2.4 Eyewitness 6

Eyewitness 6 was a friend of the Pilot and had previously flown with him in the Cessna 182S and a Slingsby aircraft. He provided the Investigation with video and audio of the final 30 seconds of the flight that was recorded on his mobile phone. He said that the Pilot had conducted some touch and go circuits and a couple of rolls over the airfield and on the downwind leg. He said that the aircraft was pitching down as it entered a roll. He said that the roll aggravated the pitch-down, and as the aircraft came out of a roll, it was inverted and "*pitching down a bit*". He said that the Pilot rolled the aircraft upright but that "*the aircraft didn't seem right, that it felt a little bit sloppy, and he entered a dive*".

The eyewitness thought that the Pilot had then attempted to recover the aircraft. He thought that the Pilot had recovered at approximately 200 ft and that he was relieved to see it, but then "*the wing suddenly flipped*" and the aircraft descended rapidly in a "*severe dive*" with a roll to the left until impacting the ground. Eyewitness 6 said that he then called the emergency services on his phone. The witness was of the opinion that the Pilot had possibly passed out during the recovery or had experienced an accelerated stall or exceeded the angle of attack. He stated that there was no change in engine sound prior to the aircraft impacting the ground. He said that the Pilot had previously told him that he wanted to step up from the Slingsby to something a bit more advanced.

1.1.2.5 Eyewitness 7

Eyewitness 7 observed the flight. He regularly acted as a spotter to provide advice to pilots on the content and technique being used during their aerobatic displays. He had attended training courses and seminars in the UK for this purpose. As a result he had spent a lot of time observing and judging the conduct of aerobatics. He had a direct view of the flight of PH-LSR until just prior to the moment of impact.

He said that he saw the aerobatic manoeuvres of the aircraft. He considered that during the initial aileron rolls being conducted by the Pilot, that there had been no pitch-up of the nose prior to entry into each roll and no use of rudder during the roll to maintain altitude. He said that in his opinion the aircraft had lost approximately 300 ft of altitude during each roll and had a tendency to yaw off the Pilot's display axis[13] during the roll. The second sequence of rolls used the same technique and lost the same amount of altitude. He said that on the final turn onto the downwind leg, the Pilot used an excessive amount of rudder, resulting in the aircraft being closer to the runway than previous circuits and that he estimated the speed to be approximately 100 kts but definitely not more than 120 kts. The first roll, in the opinion of this eyewitness, "*wallowed and was draggy*" but that the Pilot continued into the second roll. He believed that the Pilot had become disorientated during the first roll and that the aircraft was in a nose-low attitude while inverted. He said that the Pilot attempted to pull through the vertical manoeuvre to recover rather than rolling the wings level first. The eyewitness said that it seemed to him that the wing had stalled just prior to the final roll to the left and descent to impact. It was his opinion that the aircraft appeared to be mechanically sound, and that the engine was functioning normally without any indication of malfunction.

1.1.2.6 Witness 8

Witness 8 was a qualified pilot with competition aerobatic experience. Although he did not witness the occurrence, he had previously flown with the Pilot. He told the Investigation that on a number of occasions he had watched the Pilot conduct aerobatic manoeuvres; both from the ground and when in an aircraft cockpit with the Pilot. It was his view that the Pilot used an incorrect technique to complete aileron rolls. He said that he had advised the Pilot to try to obtain some instruction or advice prior to conducting aerobatics, but that the Pilot did not agree with this opinion. He noted in particular that the Pilot did not use elevator while inverted and did not use rudder appropriately during the roll. This resulted in a nose-low pitch attitude on completion of the roll with a consequent loss of approximately 300-500 ft of altitude per roll.

1.2 Injuries to Persons

The Pilot was fatally injured in the accident.

Injuries	Crew	Passengers	Others
Fatal	1	-	-
Serious	-	-	-
Minor /None	-	-	

Table No. 1: Injuries to persons

1.3 Damage to Aircraft

The aircraft was destroyed.

[13] **Display Axis:** An imaginary line on the ground, preferably aligned with a linear terrain feature, that the pilot uses as a directional reference during a flying display.

1.4 Other Damage

There was ground scarring and fuel spillage as a result of the impact.

1.5 Personnel Information

1.5.1 General

The Pilot was a male aged 47 years. He owned a UK-registered Slingsby T67 Firefly (Serial no. 2256) aircraft which was stored in a hangar at EIAB. This aircraft was first registered to the Pilot on 30 November 2015. The Pilot had previously owned another Slingsby T67 Firefly (Serial no. 2247), the ownership of which was transferred on 8 June 2015 to an individual in the Czech Republic.

The Pilot held a European Union Private Pilot's Licence for aeroplanes (PPL (A)) which was issued on 29 September 2011 by the UK CAA. The Irish Aviation Authority (IAA) informed the Investigation that the Pilot had previously been issued with a PPL (A) by the IAA on 14 January 2011 which he subsequently transferred to the UK CAA. The Pilot's Class Rating for Single-Engine Piston landplanes (SEP Land) was revalidated on 7 February 2015 and was valid until 28 February 2017.

The IAA and the UK CAA informed the Investigation that the Laser Z200 was subject to Dutch national licensing requirements as it was an '*Annex II*' aircraft. This term refers, *inter alia*, to aircraft that are categorised under *Annex II of Regulation (EC) 216/2008* as "*aircraft of which at least 51 % is built by an amateur, or a non-profit making association of amateurs, for their own purposes and without any commercial objective"*. On this basis, licensing requirements for '*Annex II*' aircraft are the responsibility of the National Authority of the State of Registration. The CAA of the Netherlands (CAA NL) informed the Investigation that it is their policy that any EU person that possesses an EU PPL (A) with a SEP (Land) rating is allowed to fly an EU registered SEP aircraft.

The Pilot held a valid European Union Class 2 Medical Certificate issued on 6 October 2015 by an IAA approved Aeromedical Examiner (AME) which was valid until 6 October 2017. The Certificate was issued without limitation.

Personal Details:	Male, aged 47 years
Licence:	Private Pilot Licence issued by the UK CAA
Last Periodic Check:	7 February 2015
Medical Certificate:	Class 2 valid until 6 October 2017

Table No. 2: Personal details

The Investigation noted that the Pilot was in possession of a Display Authorisation (DA) issued by the UK CAA on 18 November 2014 which was valid until 2 July 2015. 'Schedule 1' of the DA is shown in **Figure No. 2** and indicates the limitations of the DA.

The DA was restricted to Category B aircraft, which was defined as “*Single-Engined Piston Aircraft between 200 and 600hp*[14]*”*, and to a minimum flypast height of 200 ft.

Categories, Types Authorised &, Minimum flypast height	Aerobatic Category & Minimum Height	Formation Member	Formation Leader	Tailchase Member	Tailchase Leader	Other (Specify)
B / 200ft		No	No			

Figure No. 2: Schedule 1 of Display Authorisation

The Investigation noted the absence of authorisation under the ‘Aerobatic Category & Minimum Height’ column, and also noted that ‘Schedule 2’ of the DA stated:

> “*Notwithstanding the validity of a Certificate of Test and Competence, display flying is not permitted unless three full display sequences have been flown or practiced, with at least one display sequence flown or practiced on the type of aircraft to be displayed, not more than 90 days prior to the flight in question*.”

The IAA informed the Investigation that the Pilot had been granted a Display Authorisation as part of a schedule of aircraft displaying at “*The Midland Flightfest*” at EIAB on 31 May-1 June 2015. The IAA or UK CAA had no records that indicated the renewal of this Authorisation after it expired on 2 July 2015.

The Investigation examined the Pilot’s Flying Logbook. It was noted that the majority of the Pilot’s total flying time was conducted in Cessna aircraft, mainly the C152, C172 and C182S variants. The Pilot’s logbook also noted that, in addition to the Slingsby that he owned, he had flown a Cessna C150, Grob 115A, Aero Moragón M1[15], Samba XXL and Bellanca Decathlon. The Decathlon, which was the only tail-wheel aircraft recorded in the Pilot’s logbook, was last flown in July 2012, consisted of five flights which were recorded as “*Aeros Training, Upset recovery + spins (erect only)*”. The Pilot acted as *‘Pilot under Tuition*’ and the Logbook was signed by a Check Pilot of the British Aerobatic Association (BAeA). There was no evidence of a course of instruction being conducted by the Pilot for the previously owned Slingsby T67 aircraft, the single-seat Laser Z200, or any other aircraft of an equivalent performance capability.

Total all types:	447 hours
Total on type:	0.75 hours
Total on type P1:	0.75 hours
Total; Last 90 days:	8.6 hours
Total; Last 28 days:	3.75 hours
Total; Last 24 hours:	1.75 hours

Table No. 3: Total flying experience of the Pilot

[14] **hp:** Horsepower.
[15] **M1:** A Spanish-built ultralight, high-wing, fixed tricycle undercarriage aircraft.

The Pilot's Flying Logbook contained an entry of a single flight in a Sbach 342[16] on 8 January 2016. The flight was recorded in the logbook as '*Pilot in Command*' for a 30 minute flight. The Investigation located a video recording of this flight on one of the *GoPro* cameras at the accident site. The owner of the Sbach 342 informed the Investigation that the purpose of the flight was to provide air experience for the Pilot and that it was not an instructional flight, hence he (the owner) was pilot in command. The Investigation reviewed the video of this flight. It was noted from the audio of the video recording that, as the aircraft taxied out to the runway prior to take-off, the owner and Pilot were engaged in general conversation. The owner asked the Pilot "*How's the Slingsby going?*" The Pilot responded that "*Yeah it's going well but, ah, I'd like to move onto something else, you know, maybe of a bit more competitive nature*". The recording showed that the flight lasted approximately 13 minutes from take-off to landing.

The Pilot took delivery of the Laser Z200 on 13 March 2016. He had conducted one flight in the aircraft at EIAB prior to the accident flight. This flight was conducted on 17 March 2016 and was his first flight in the aircraft. A number of witnesses to that flight confirmed that the Pilot conducted a number of touch and go circuits at EIAB.

1.5.2 Personnel Licensing Regulations

1.5.2.1 General

Regulation (EC) 216/2008, which details common rules in the field of civil aviation within the European Union, also established The European Aviation Safety Agency (EASA). The mission of EASA[17], *inter alia*, is;

> "*…to promote the highest common standards of safety and environmental protection in civil aviation…The main tasks of the Agency currently includes:*
>
> *Rulemaking: drafting aviation safety legislation and providing technical advice to the European Commission and to the Member States*"

Aircraft which are categorised under *Annex II of Regulation (EC) 216/2008* are exempt from basic EASA Regulations and are the responsibility of the National Authority of the State of Registration for regulatory oversight.

The Investigation noted that Regulation (EU) 1178/2011 (The *EASA Aircrew Regulation*) as amended by Regulation (EU) 290/2012, was first published in November 2011. This document initially set April 2012 as the latest date for adoption of the Regulation by Member States[18]. The Regulation introduced an aerobatic rating requirement (the *FCL.800 Aerobatic Rating)*, which stated;

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[16] **Sbach 342:** A low-wing, high performance aerobatic aircraft of similar design to the Laser Z200, but with a 315 hp piston engine and equipped with two seats in a tandem configuration and dual controls.
[17] https://www.easa.europa.eu/the-agency/faqs/agency#category-about-easa
[18] CAA NL will apply Regulation (EU) 1178/2011 with effect from 8 April 2018, but not to Annex II aircraft.

(a) Holders of a pilot licence for aeroplanes, TMG[19] *or sailplanes shall only undertake aerobatic flights when they hold the appropriate rating.*

(b) Applicants for an aerobatic rating shall have completed:

(1) at least 40 hours of flight time or, in the case of sailplanes, 120 launches as PIC in the appropriate aircraft category, completed after the issue of the licence;
(2) a training course at an ATO[20]*, including:*

(i) theoretical knowledge instruction appropriate for the rating;
(ii) at least 5 hours or 20 flights of aerobatic instruction in the appropriate aircraft category.

(c) The privileges of the aerobatic rating shall be limited to the aircraft category in which the flight instruction was completed. The privileges will be extended to another category of aircraft if the pilot holds a licence for that aircraft category and has successfully completed at least 3 dual training flights covering the full aerobatic training syllabus in that category of aircraft."

1.5.2.2 Netherlands – State of Registration

On 25 September 2014, the CAA NL issued the document "*Conversion aerobatic rating"* which prescribed 8 April 2017 as the revised implementation date for *Regulation (EU) 1178/2011* in the Netherlands, and described National interim arrangements for the intervening period. The CAA NL informed the Investigation that the implementation date had been subsequently amended to 8 April 2018. This document did not refer to *Annex II* aircraft. However, the CAA NL informed the Investigation that it is their policy that any EU person that possesses an EU PPL (A) with a SEP (Land) rating is allowed to fly an EU registered SEP aircraft. This includes *Annex II* aircraft (excluding microlights) registered in the Netherlands.

1.5.2.3 United Kingdom – State of Licensing

The UK CAA issued publication *CAP 804*[21] dated 8 April 2015, to provide guidance on flight crew licencing in the UK during the implementation period for Regulation (EU) 1178/2011, including the requirements for an aerobatic rating. It stated that*:*

"The CAA has amended the Air Navigation Order [ANO] *so that EASA aeroplane licences with the appropriate class ratings are valid for non-EASA aeroplanes within those classes; thereby avoiding the need for the holder of an EASA PPL (A) with SEP rating to also hold a national licence in order to fly an amateur-built aeroplane"*

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[19] **TMG:** Touring Motor Glider
[20] **ATO:** Approved Training Organisation
[21] **CAP 804:** *Civil Aviation Publication 804: Flight Crew Licensing: Mandatory Requirements, Policy and Guidance.*

The CAP 804 stated that an applicant for a non-EASA Aeroplane Class or Type rating to be added to a UK Licence was required to comply with the Part-FCL requirements as listed in *CAP 804, Section 4, Part H, Subpart 1: EASA – Class and Type Ratings for Aeroplanes.* This subpart stated that:

> "*In the case of a Class rating, Article 62(5) of the ANO renders the EASA licence and Class ratings valid with the same privileges for non-EASA Aeroplanes."*

While *CAP 804* was cancelled on 24 August 2016, the *UK Air Navigation Order 2016* was amended to state:

> ***"Requirement for appropriate licence to act as member of flight crew of non-EASA aircraft registered in the United Kingdom.***
>
> ***137****.—(1) Subject to articles 139 to 147, a person must not act as a member of the flight crew of an aircraft to which this paragraph applies without holding an appropriate licence granted or rendered valid under this Order.*
> *(2) Paragraph (1) applies to any non-EASA aircraft registered in the United Kingdom other than such an aircraft that is referred to in paragraphs (a)(ii), (d) or (h) of Annex II of the Basic EASA Regulation and that is flying for the purpose of commercial air transport (an "excepted aircraft").*
> *(3) A person must not act as a member of the flight crew of an excepted aircraft unless…*
>
> > *(b) the person holds an appropriate licence granted, converted or rendered valid under the EASA Aircrew Regulation.*
>
> ***Appropriate licence***
>
> ***138****. An appropriate licence for the purposes of this Part and Schedule 8 means a licence which entitles the holder to perform the functions being undertaken in relation to the aircraft concerned on the particular flight."*

The effect of the UK ANO is to establish Regulation (EU) 1178/2011 as a basis to issue UK national flight crew licenses to persons wishing to fly *Annex II* aircraft. The UK ANO did not refer to additional requirements for an aerobatic rating.

1.5.2.4 Ireland – State of Occurrence

On 21 April 2015 the IAA issued *Aeronautical Notice P24: EXEMPTION FROM NATIONAL REQUIREMENTS FOR PART-FCL LICENSED PILOTS OPERATING AIRCRAFT REFERRED TO IN ANNEX II OF REGULATION (EC) No. 216/2008*. The Notice explained that "*This Direction exempts the holder of a Part-FCL pilot licence from the requirement to hold an Irish-issued national licence or an Irish-issued validation of a foreign licence when acting as a pilot of an aircraft which is listed in or subject to Annex II of Regulation (EC) No 216/2008."* The Notice further stated that:

"This exemption is necessary because Regulation (EC) No 216/2008 which, inter alia, provides for the implementing rules governing the conditions applicable to a Part-FCL pilot licence, also acts so as to make such licences invalid for the operation of 'Annex II aircraft'. Pilots of Annex II aircraft are thereby left subject to national or JAR-FCL pilot licensing requirements. This exemption eliminates the requirement to hold both a national and a Part-FCL pilot licence for the same category, class or type of aircraft."

On 30 November 2015, the IAA issued *"PERSONNEL LICENSING ADVISORY MEMORANDUM 02/11: Introduction of European Legislation in the area of Pilot Licensing"*, which stated;

"The scope is determined by the Basic EASA Regulation. … Aircraft (and pilots thereof) not covered by the Basic EASA Regulation are typically known as Annex II aircraft… Aircraft (and pilots thereof) not within the scope of the Basic EASA Regulation remain under National regulation."

These exemptions mean that the IAA accepts the possession of an EASA Part-FCL licence in lieu of a national licence for persons wishing to act as flight crew in an *Annex II* aircraft. There are no national requirements to complete a course of instruction for aerobatic flying or obtain an aerobatic rating for an "*Annex II*" aircraft.

1.5.2.5 Europe

The Investigation requested EASA to comment on the scope of Regulation (EU) 1178/2011 in regard to the aerobatic rating requirements. EASA stated that "*Annex II aircrafts do not fall under EASA Basic Regulation (Reg 216/2008)*" and that as such "*cannot be addressed by the Part-FCL Implementing Rule*[22]*. Therefore an extension of the EASA remit is needed. Such action is out of the mandate of EASA*". EASA informed the Investigation that enacting such an extension would be the responsibility of *The European Commission.*

Within the European Commission, the *Director General of Mobility and Transport* retains responsibility for civil aviation. The *2016 Mission Statement* of the *Directorate of Mobility and Transport of the European Union* stated, *inter alia*, that;

"The mission of Unit E.4[23] *is to help ensure that Europe remains [among] the world's safest aviation region[s] and to contribute to the maximum level of aviation safety worldwide. To achieve these objectives, the Unit has the following activities:…*

- *Further developing the legal framework where necessary, including by seeking the adoption of the new basic aviation safety Regulation, and by developing and adopting implementing rules in new areas (e.g. on drones).*
- *Overseeing the work and governance of EASA, including monitoring the EASA rule-making, certification and standardisation programmes,…*

Unit in charge of: *European Aviation Safety Agency (EASA), European Network of Civil Aviation Safety Investigation Agencies (ENCASIA)."*

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[22] **Part-FCL Implementing Rule***:* *Regulation (EU) 1178/2011 FCL.800 Aerobatic rating*.
[23] **Unit E.4:** A sub-division of "*Directorate E: Aviation"* which is responsible for Aviation Safety.

1.5.2.6 Summary

The scope of Regulation (EU) 1178/2011 (*The Aircrew Regulation*) is determined by Regulation (EC) 216/2008 (*The Basic EASA Regulation)*. The *Basic EASA Regulation* excludes *Annex II* aircraft from EASA's remit and national regulations apply to these aircraft. The National Authorities of Ireland, Netherlands and the UK have each issued national regulations which accept a licence issued in accordance with Regulation (EU) 1178/2011 in lieu of a national licence for *Annex II* aircraft. However, EASA have stated that "*Annex II aircrafts do not fall under EASA Basic Regulation (Reg 216/2008)*" and that as such "*cannot be addressed by the Part-FCL Implementing Rule".*

1.5.3 Rules of the Air

Regulation (EU) 923/2012 sets out the standardised Rules of the Air (SERA). Under *Section 3 General Rules and Collision Avoidance, Chapter 1 Protection of Persons and Property*, it states;

"SERA.3101 Negligent or reckless operation of aircraft

An aircraft shall not be operated in a negligent or reckless manner so as to endanger life or property of others.

SERA.3105 Minimum heights

Except when necessary for take-off or landing, or except by permission from the competent authority, aircraft shall not be flown over the congested areas of cities, towns or settlements or over an open-air assembly of persons, unless at such a height as will permit, in the event of an emergency arising, a landing to be made without undue hazard to persons or property on the surface. The minimum heights for VFR flights shall be those specified in SERA.5005 (f)…

SERA.5005 Visual Flight Rules

(f) Except when necessary for take-off or landing, or except by permission from the competent authority, a VFR flight shall not be flown:

(1) over the congested areas of cities, towns or settlements or over an open-air assembly of persons at a height less than 300 m (1,000 ft) above the highest obstacle within a radius of 600 m from the aircraft;

(2) elsewhere than as specified in (1), at a height less than 150 m (500 ft) above the ground or water, or 150 m (500 ft) above the highest obstacle within a radius of 150 m (500 ft) from the aircraft."

1.6 The Aircraft

1.6.1 Airframe Information

The aircraft, a Laser Z200 (**Photo No. 1**), was a single seat, competition aerobatic, mid-wing monoplane, with an enclosed cockpit situated between the front (main) and rear wing spar positions. The aircraft fuselage and tail section was of a welded steel tube construction with cantilever plywood-covered wooden wings. The wing was a one-piece unit bolted directly to the fuselage frame truss. The aircraft was fitted with a cantilever sprung, aluminium alloy, fixed main undercarriage and a sprung and steerable tail wheel fitted to a cantilever steel spring. The aircraft can be built from plans purchased from the owners of the design, either by manufacturing the parts or by purchasing prefabricated individual components.

Photo No. 1: The Laser Z200, PH-LSR, 13 March 2016 (Source: K. Donohoe)

The aircraft was first registered in the UK on 15 June 1995. It was originally amateur-built in the UK and issued with an Airworthiness Approval by the *Popular Flying Association* (PFA), on behalf of the UK CAA, on 29 June 1996. The aircraft was transferred to the *Netherlands Civil Aircraft Register* on 21 June 2011. As part of the transfer, the CAA of the Netherlands issued an amendment to the Flight Manual for PH-LSR which stated, inter alia; "*Flights must be restricted to the airspace of the Netherlands. For flights over foreign territory a written permission of the national aviation authority must be obtained*." Documentation associated with the delivery of the aircraft on 13 March 2016 included a leaflet which was issued by the *UK Light Aircraft Association* (LAA, formerly the PFA) titled "*Operational Leaflet – Travelling Abroad in a Permit Aircraft*", which listed the requirements for overflight of various European countries.

When referring to *Ireland*, the document stated that;

> *"The Irish Authority confirm that in accordance with the 1980 ECAC agreement UK home built Permit aircraft may visit Ireland without needing special permission, (they quote Irish Aeronautical Notice A.19 to be the relevant publication)."*

The referenced *Irish Aeronautical Notice A.19* is titled "*Visiting aircraft not holding ICAO compliant Certificates of Airworthiness*" and was dated 3 July 2014. The LAA *"Operational Leaflet – Travelling Abroad in a Permit Aircraft"* stated that this exemption applied to:

> *"…any amateur-built/home-built aircraft registered in a Member State of the European Civil Aviation Conference (ECAC), and certain other UK and French registered aircraft not holding an ICAO Certificate of Airworthiness, from the provisions of Article 7 of the said Order to the extent necessary to enable them to fly in accordance with the flight permit, or equivalent document, issued by the State of Registry of the aircraft.*
>
> ***This exemption applies to all amateur-built/home-built aircraft registered in ECAC member states."*** (Emphasis in original LAA document)

The Appendix to the Notice stated that "*The intent of this exemption is to allow amateur-built/home-built aircraft, which are registered in an ECAC Member State, to enter or overfly Irish airspace without the need to apply for an individual exemption*".

The Appendix clarified that the purpose of the exemption was to facilitate short-term visits and not to accommodate aircraft that were to be based in Ireland. The exemption allowed aircraft to operate in Irish Airspace for a period of up to 28 days unless otherwise agreed with the IAA. At the time of the accident, the aircraft had been in Ireland for seven days. The IAA informed the Investigation that "*as the aircraft was an amateur-built/home-built aircraft registered in a Member State of the European Civil Aviation Conference (ECAC), specific permission would not be required. The exemption published in Aeronautical Notice A.19 would apply. The Conditions of Exemption, as detailed in A.19, would also apply."*

A Special Certificate of Airworthiness for the aircraft was issued by the *CAA of the Netherlands* on 22 June 2011. The Special Certificate of Airworthiness was re-issued annually thereafter and was valid until 22 June 2016. The Pilot purchased the aircraft on 1 February 2016 and the aircraft was delivered to EIAB on 13 March 2016.

The Investigation was provided with comprehensive maintenance and flying records that had been delivered with the aircraft. The aircraft logbook indicated that the aircraft had been flown for a total of 564.47 hours and completed 761 landings. It recorded that the previous 100 hour inspection had been completed at 547.25 hours and 726 landings on 8 May 2015. A '*Maintenance History*' folder included an itemised list of the work completed during the inspection, including the relevant Airworthiness Directives and Service Bulletins that had been complied with.

The aircraft had also completed a recertification of Weight and Balance during the inspection. The weight of the aircraft (including 62 kg of fuel and a pilot of 80 kg) was certified as 635 kg. The maximum permitted mass listed in the *Flight Manual* for PH-LSR (dated 1 Feb 2011) was 660 kg on condition that the maximum 'g'[24] loading was limited to +6g/-3g, which increased to +7.5g/-6g once the aircraft weight was below 600 kg. A previous version of the Flight Manual (dated 29 Aug 2001) stated that the maximum loading was ±9g if the aircraft weighed less than 590 kg.

The next scheduled inspection of the aircraft was a 25 hour inspection that was noted in the logbook as due at 572.25 hours. The records indicated that the design-life time limit for this aircraft was 3,000 hours flying time or 9 June 2026 (whichever occurred first), unless the condition of the aircraft warranted it. There was no evidence or record of aircraft defects noted in the maintenance or flying records.

1.6.2 Engine Information

The aircraft was fitted with a Lycoming AEIO-360-A1E piston engine, which was a fuel injected, horizontally opposed, four-cylinder, four-stroke, air-cooled unit. The engine delivered a power output of 149 kW[25] (200 hp) at 2,700 RPM[26].

Maintenance records showed that the engine had accumulated a total of 697 hours. The Investigation noted that the engine had previously been installed on a UK registered Pitts Special S1-T aircraft. The maintenance records showed that following removal from this airframe, the engine was tested on 22 March 1993 for shock loading and rebuilt in accordance with the manufacturer's overhaul manual at a CAA-approved repair facility in the UK. There was no record of any defect with the engine.

An *EMS-D10 Engine Monitoring System Unit* was installed in the cockpit. This unit was designed to monitor engine and other aircraft systems and the information was displayed to the pilot in an easy to read format. The unit incorporated internal data logging, which functioned continuously once manually activated by the user from the unit's main menu. The previous owner informed the Investigation that he did not have internal logging active on the unit. The Investigation was unable to determine if this capability had been activated by the Pilot in the seven days following delivery to Ireland. For completeness, the unit was shipped to the manufacturer's facility near Seattle, Washington, USA. The unit was analysed under the supervision of a representative of the NTSB[27] to determine if there was useful data retained internally. The manufacturer's report stated that the unit had received significant damage and that the "*enclosure, bezel, and other structure components were bent and crushed"*. The unit was stripped down to examine the individual components. The report noted that "*The display control printed circuit board assembly (PCBA) was extracted from the crashed unit and thoroughly inspected.*

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[24]**'g':** Acceleration due to gravity.
[25]**kW:** Kilowatt
[26]**RPM:** Revolutions Per Minute
[27]**NTSB:** The National Transportation Safety Board

Some components had been sheared off the board and had taken surface mount pads with them. The printed circuit board (PCB) was damaged to the point where it was unfeasible to repair the board to enable extracting data from the non-volatile memory (NVM) integrated circuit (IC).” The manufacturer installed the NVM IC onto a functional PCBA. However, the manufacturer informed the Investigation that the “*NVM IC from the incident was damaged or corrupted in such a way that the processor which facilitates the datalog download from the component could not run and therefore communicate with the […] Support Program utility.”* Consequently, the Investigation was unable to obtain any valid flight or engine data from this unit.

1.6.3 Propeller Information

The aircraft was fitted with a MTV-9-B-C three-bladed, constant speed, variable pitch propeller system manufactured in March 2011 by MT-Propeller GmbH of Atting, Germany. The Maintenance Records included an *EASA Form 1: Authorised Release Certificate* which was signed by an inspector authorised by the Luftfahrt-Bundesamt (LBA), the competent authority of Germany. The propeller assembly and three model C193-52 propeller blades[28] were fitted to the engine on 21 June 2011 and the aircraft had flown for 101.15 hours since installation. There was no record of any defect with the propeller system.

1.6.4 Fuel Information

The aircraft fuel tank (**Photo No. 2**) was mounted in front of the cockpit instrument panel. The Flight Manual stated that the permissible fuel types were 100/130 or 100LL aviation grade fuel. The Textron Lycoming Operator’s Manual similarly stated that minimum aviation grade fuel for the AEIO-360-A1E engine was 100/130 or 100LL, commonly referred to as AVGAS.

Photo No. 2: The fuel tank (painted yellow) as seen during aircraft construction.

[28] **Propeller Blades:** Serial numbers ACA-41647, ACA-41648, and ACA-41649.

The Flight Manual stated that the maximum fuel capacity was 72 litres (L), with a maximum usable fuel of 68 L. There was no fuel quantity gauge in the cockpit. Fuel quantity was measured through an externally accessible sighting gauge. A placard mounted on the inside of the cockpit instrument panel (**Photo No. 3**) listed the total fuel quantity as 78 L.

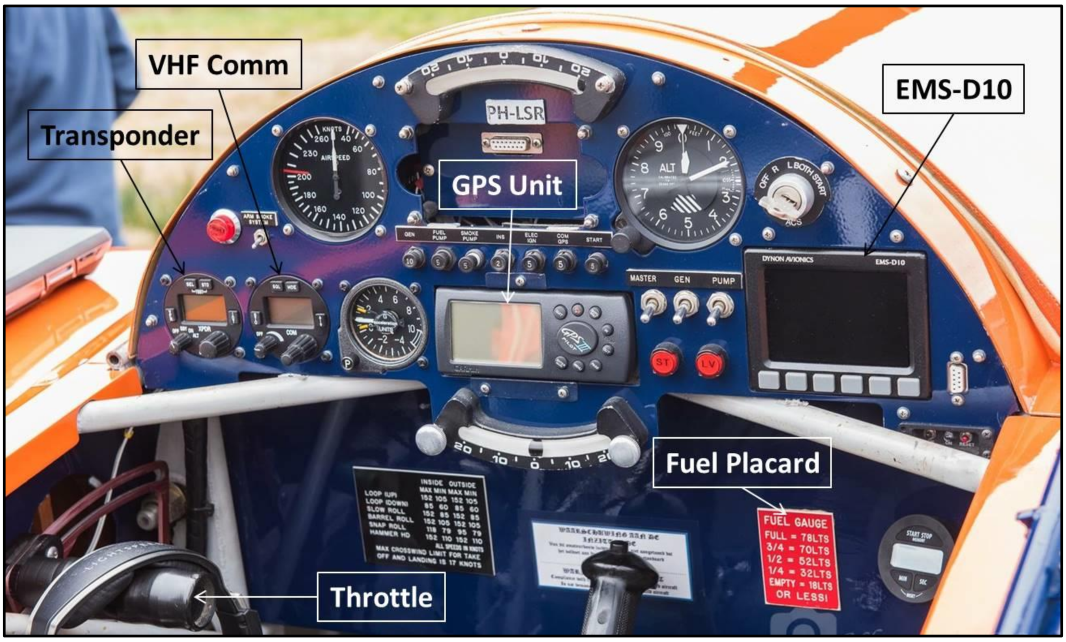

Photo No. 3: Laser Z200 cockpit instrument panel including Fuel Placard (K. Donoghoe)

The fuel tank ruptured as a result of the impact forces experienced during the accident sequence. Consequently the Investigation was unable to measure the fuel remaining in the tank or test a sample of the fuel. However, the Investigation was obliged to establish whether insufficient fuel quantity, or contaminated fuel, was a factor in the accident.

The three AAIU Inspectors, who attended the site of the accident, each noted a strong smell of fuel upon arrival at the site. Furthermore, the pathologist noted during the post-mortem that "*there was a strong smell of petroleum…*". This indicated that fuel had been present at the accident site. Witnesses interviewed by the Investigation did not consider that the engine noise during the flight indicated any form of fuel starvation or mechanical problem. Audio recorded by the *GoPro* cameras mounted on the aircraft was consistent with the sound of an engine operating normally.

The aircraft was refuelled at Haverfordwest Airfield (EGFE) in the UK during the delivery flight. The Investigation found no evidence that the aircraft had been refuelled at EIAB following its arrival on 13 March 2016. The operator of the refuelling service at EGFE informed the Investigation that there had been no reports of fuel problems from other aircraft that had received fuel from the same refuelling truck as PH-LSR. The Investigation reviewed the activity of the aircraft prior to arriving at EIAB on 13 March 2016 and identified the following flights, listed in **Table No. 4**.

Date (2016)	Depart	Arrive	Flt Time	Fuel Uplift	Est. Fuel Flow	Notes
12/3	EHLE (Lelystad)	LFAC (Calais)	1.25	38.2 L	27 L/hr	
12/3	LFAC	EGGD (Bristol)	1.35	43.0 L	27 L/hr	
12/3	EGGD	EGFE	1.40	46.5 L	28 L/hr	Due Weather
13/3	EGFE	EIAB	1.15	NIL		

Table No. 4: Flights by PH-LSR prior to arrival at EIAB

For the third flight on 12 March 2016, the aircraft departed EGGD for EIAB. While en-route the pilot received weather updates indicating low cloud cover at EIAB. The Laser Z200 does not have an artificial horizon for flight under Instrument Flight Rules (IFR) that would have allowed the pilot to descend through cloud to the airfield. Furthermore, the Limitations Section of the Flight Manual approved by the CAA of the Netherlands stated that "*Operation under Instrument Flight Rules is……PROHIBITED".* The pilot who delivered the aircraft to EIAB told the Investigation that in order to be assured of continued visual references, he decided to divert to EGFE on the Welsh coast.

The pilot also informed the Investigation that during the delivery of the aircraft from EHLE to EIAB, he filled the aircraft fuel tank to full after each flight leg. He stated that although the placard said 78 L and the Flight Manual said 72 L, the actual fuel capacity of the tank was 76 L. The Investigation obtained the fuel receipts from the refuelling companies to crosscheck the fuel figures and the receipts confirmed the delivery pilot's recollection of events. The Investigation found no evidence documenting the fuel quantity on board the aircraft after it was filled at EGFE prior to departure on 13 March 2016.

1.7 Meteorological Information

The Investigation was provided with an aftercast (**Table No. 5**) by the *Aviation Services Division* of *Met Éireann*[29]. The report stated that the weather at the time of the accident was dominated by a high pressure system that was centred just to the South West of Ireland. After a cloudy start to the day, the general meteorological situation had become bright with long sunny periods, light winds and no precipitation.

Wind:	Surface:	Variable or northerly 3 to 5 KT
	2000 feet:	Northerly 6 to 8 KT
Visibility:	25-30 km	
Weather:	No significant weather	
Cloud:	Satellite imagery from the date/time of incident shows skies to be generally cloud free apart from possibly some isolated patches of Stratocumulus/Stratus	
Surface Temp/Dew Pt:	11/3 degrees Celsius	
MSL[30] Pressure:	1027 hectopascals (hPa)	
Freezing Level:	7500 ft	
Other Comments:	Inversion height is estimated to be at 3000 ft	

Table No. 5: Aftercast provided by Met Éireann

[29] **Met Éireann:** The Irish Meteorological Service
[30] **MSL:** Mean Sea Level

Photographs and video taken at the time by the *GoPro* cameras mounted on the aircraft indicated benign meteorological conditions. The Investigation is satisfied that meteorological conditions did not play a part in the accident.

1.8 Aids to Navigation

Artificial Horizon (AH): Most aircraft cockpits are fitted with either an AH or attitude indicator that can provide the pilot with a representation of aircraft attitude relative to the horizon. This assists in identifying aircraft pitch and roll angle if meteorological visibility is limited or if the ergonomic design of the aircraft restricts the view of the horizon from the cockpit. Such an instrument contains a gyroscope, which is powered electrically or by a pneumatic air system to enable the aircraft attitude to be graphically displayed to the pilot.

Examination of the Pilot's logbook showed that all of the previous aircraft flown by the Pilot were fitted with some form of AH as standard equipment. The Laser Z200, in common with other competition aerobatic aircraft, was not fitted with an AH. This was because high 'g' aerobatic manoeuvres can cause a gyroscope to topple and therefore may provide misleading information for the pilot. With no AH to indicate aircraft attitude, the Pilot had to rely on his limited previous experience on type to visually select the required aircraft attitude and then use the remaining cockpit instruments, such as a the altimeter or compass, to confirm the accuracy of the selected pitch or roll attitude. This process becomes even more challenging when conducting aerobatic manoeuvres.

Altimeter: Atmospheric pressure reduces with altitude. An altimeter is an aneroid barometer that measures the local static atmospheric pressure and displays the resultant measurement on a graduated scale to provide the pilot with altitude information. The Laser Z200 was fitted with a *United Instruments 5934PM-1* altimeter, which was certified for use between -1,000 ft and 20,000 ft. The altimeter had a barometric subscale setting knob which was used to adjust the instrument to changes to local barometric pressure. It did not have the capability to provide altitude information to the transponder system.

The altimeter had been checked and calibrated on 8 May 2015 as part of a 100 hour maintenance inspection. The instrument was substantially damaged during the impact sequence. The rear of the altimeter had been torn open and the components inside had broken away from their internal mounting points. The setting knob had sheared off and the glass covering the front of the instrument had shattered. The pointer needles that were used to indicate current altitude had separated from the internal mechanism and were free to turn. Photographs taken at the accident site of the altimeter subscale indicated a pressure setting of 1021 hpas. The aftercast by *Met Éireann* provided a sea-level barometric pressure of 1027 hPa. The difference of 6 hPa[31] equates to 180 ft. Consequently, the altimeter would read -180 ft at MSL, and 0 ft at a height of 180 ft above MSL. **Photo No. 3** showed an altimeter subscale setting of 1035 hPa, which was the required subscale setting on the day that the aircraft was delivered. The change in subscale between the two photographs indicated that the subscale had been changed since the delivery flight. EIAB is 195 ft above MSL[32].

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[31] The conversion calculation used was 1 hPa = 1 millibar = 30 ft.

[32] Airfield height data obtained from *VFR Flight Guide Ireland* by Kevin Glynn.

Terrain Warning System: The aircraft was not fitted with any form of Terrain Awareness Warning System (TAWS) or Ground Proximity Warning System (GPWS), nor was such equipment required to be fitted.

GPS[33] Unit: A *Garmin GPS III Pilot* GPS Unit was recovered from the aircraft. However, it was determined that the device contained no useful information, as data logging was not enabled.

Transponder: The aircraft was equipped with a BXP6401 Altitude Encoding Transponder Unit manufactured by Becker Avionic Systems of Germany. An *ACK A-30 Altitude Encoder* unit provided altitude data to the transponder. The Investigation contacted the transponder manufacturer through the BFU[34] in order to establish whether the unit contained any non-volatile memory (NVM) that would record data from the flight. The manufacturer informed the Investigation that the unit "*only stores a fault history. Therefore, it would be possible for example to check whether the failure of the attached altimeter was recorded or whether the altitude was flagged as invalid. Altitude data are not recorded within the device*". The Investigation noted that on first examination, the power selector switch on the front panel of the unit was selected to 'ALT' which indicated that the unit may have been transmitting altitude data during the flight.

1.9 Communications

The aircraft was equipped with an AR4201 VHF[35] transceiver manufactured by Becker Avionic Systems of Germany. The unit received impact damage to the tuning knob, the main body of the unit, the rear antenna and connecting pins. The unit could not be powered. On first examination, the power switch on the front panel of the unit was found in the 'ON' position with maximum volume selected. The Watch Manager of the *IAA Air Navigation Services Division* '*Shannon Centre'* informed the Investigation that there had been no radio communications between ATC and PH-LSR prior to the accident. This would not be unusual for an aircraft conducting a local circuit detail at EIAB.

1.10 Aerodrome Information

Abbeyshrule Aerodrome (EIAB) is a private licenced aerodrome located 11 nautical miles south east of Longford Town. The *Aeronautical Information Publication (AIP) Section AD 1.5* noted that EIAB was certified by the IAA on 15 July 2009. The main asphalt runway (RWY) is 790 m long and 18 m wide. It is designated as RWY 28/10[36] and is 195 ft above MSL. The EIAB website stated that there is a displaced threshold for landing at both ends of RWY 28/10. When taking off from either RWY at EIAB, a pilot will normally conduct a left-hand circuit. The airfield information stated that *"Inbound aircraft join overhead at 1500 ft agl. All circuits LH* [Left Hand] *at 800 ft agl, avoid low flying on western approach",* and included a warning which stated "*Warning: beware of high trees on approach to r/w 10."*

[33] **GPS:** Global Positioning System
[34] **BFU:** *Bundesstelle für Flugunfalluntersuchung;* (German Federal Bureau of Aircraft Accident Investigation)
[35] **VHF:** Very High Frequency
[36] **28/10:** Runways are designated according to compass alignment rounded to the nearest ten degrees. Runway 28 is aligned on a magnetic heading of approximately 280 degrees. Conversely, runway 10 is aligned with an approximate magnetic heading of 100 degrees.

An aerial photograph of the aerodrome (**Photo No. 4**) shows the layout of the airfield. There is no lighting or radio navigation aid at the airfield and all flights are conducted under daytime Visual Flight Rules (VFR).

The Pilot stored his aircraft in a hangar at the north parking area adjacent to the reception area. This is the point from where the flight in the Laser Z200 commenced.

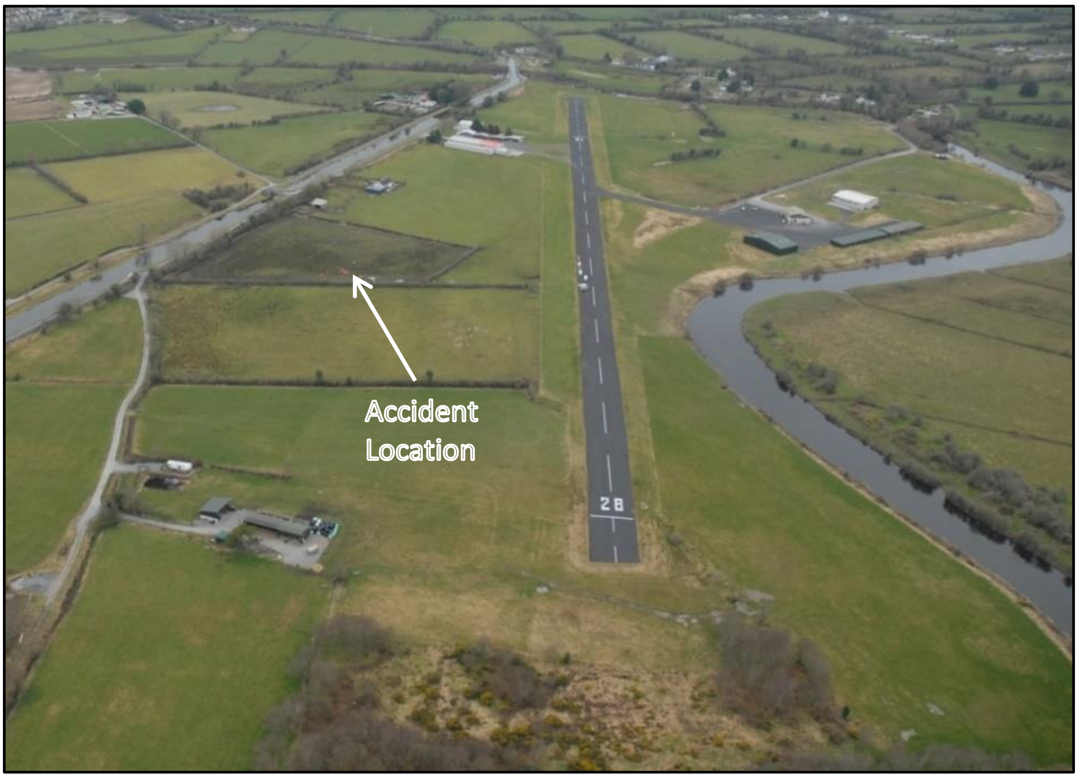

Photo No. 4: EIAB as viewed from East of the airfield. (An Garda Síochána)

1.11 Recording Devices

1.11.1 Flight Data Recorder / Cockpit Voice Recorder

The aircraft was not equipped with a Flight Data Recorder or a Cockpit Voice Recorder, nor was either recorder required for this class or category of aircraft.

1.11.2 ATC Radar Data

The Investigation reviewed the Air Traffic Control (ATC) radar data which was retained on behalf of the Investigation by the Watch Manager of the *IAA Air Navigation Services Division* '*Shannon Centre'* at the time of the accident. Subsequent review of the radar data for transponder signals did not indicate the receipt of primary or secondary surveillance radar (SSR) signals in the vicinity of EIAB during the time of the accident. This would not be considered unusual given the location of the airfield and the circuit altitude used by aircraft operating there.

1.11.3 *GoPro* Cameras

1.11.3.1 General

The aircraft was fitted with mounting plates in two positions for *GoPro* video cameras. Photographs taken one week prior to the accident (**Photo No. 1**) did not show any evidence of cameras mounted on the aircraft. However, components from two *GoPro* cameras were located within the wreckage field. A photograph (**Photo No. 5**) taken just prior to take-off by an eyewitness recorded the location of the cameras during the flight.

Photo No. 5: Location of *GoPro* Cameras during accident flight (Cockpit obscured)

The Investigation recovered both cameras at the accident site. The first camera recovered (*Camera 1*) was substantially damaged (**Photo No. 6**). The rear cover assembly consisted of two main parts; a grey plastic inner cover to protect the components and an outer clear plastic cover to provide a waterproof casing for the camera. Both parts had separated from the camera, along with the retaining clip for the rear cover. The outer clear plastic casing had sheared from the camera at the point where it was attached to the mounting on the aircraft cowling. The internal battery pack and connecting wires had been torn from the unit.

The camera was fitted with a 32 GB[37] *micro-SDHC*[38] memory card that was located in the appropriate slot in the camera. There was general contamination from the site, both inside and outside the camera housing. The camera lens was shattered.

A second camera (*Camera 2*) was also recovered at the accident site (**Photo No. 7**). It was damaged but was still powered upon recovery. The retaining clip for the rear cover assembly was missing. The rear cover assembly, the grey plastic inner cover and the outer clear plastic cover were attached to the camera, but were open, leaving the camera's internal components exposed to the elements.

[37] **GB**: Gigabyte. One gigabyte is equivalent to 1,000,000,000 bytes.
[38] **SDHC:** Secure Digital High Capacity

Camera 2 was fitted with a 32 GB *micro-SDHC* memory card that was located in the appropriate slot in the camera. However, the front display of the camera was powered and showed the message 'NO SD'. The camera battery was almost fully exhausted and the charging port was contaminated with dirt, so the device was powered down to prevent any loss of data resulting from power failure. Both cameras were transported to the AAIU in Dublin in order to recover any data that had been retained on the cameras or on the SDHC memory cards.

Photo No. 6: *GoPro Camera 1*

Photo No. 7: *GoPro Camera 2*

1.11.3.2 Data Recovery Process

The SDHC memory cards were numbered in accordance with the respective camera; *SDHC Card 1* came from *Camera 1* and *SDHC Card 2* came from *Camera 2*. The SDHC memory cards were examined under a microscope for physical damage (**Photo No. 8** and **Photo No. 9**). The metallic strips on both memory cards appeared to be physically undamaged and showed signs of routine wear and tear associated with insertion and removal of each memory card from the memory card slot in the respective camera. Once it was established that the memory cards appeared to be physically intact, a working copy was made of both SDHC cards for diagnostic purposes.

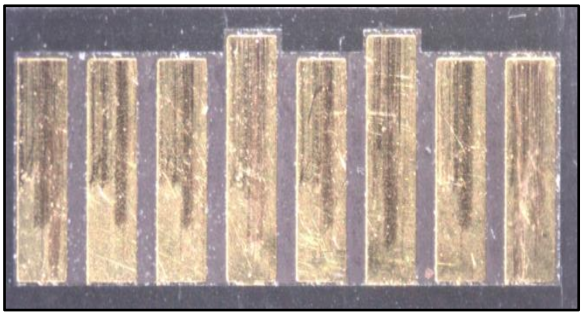

Photo No. 8: Image of *SDHC Card 1*

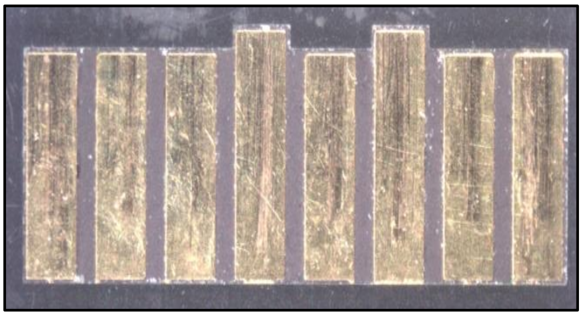

Photo No. 9: Image of *SDHC Card 2*

SDHC Card 1 contained a total of 27 items which occupied 9.33 GB of memory space on the card. This included seven video files in *.MP4*[39] format, which were 9.30 GB in size. Two of the video files were recorded on the day of the accident. The first file (*'GOPR0348'*), which was 1.94 GB in size and recorded 17 min 33 sec of video, included footage of the accident flight.

The second file (*'GOPR10348'*) appeared to be a video file of 207 MB[40] in size, but was corrupted and could not be played in standard video playback software. The file numbering conventions utilised by *GoPro* indicated that this file was recorded immediately after the file '*GOPR0348'*.

SDHC Card 2 contained 11 items which occupied 9.17 GB of memory space on the card. This included six video files in *.MP4* format, which were 9.07 GB in size. Two of the video files were recorded on the day of the accident. The first file ('*GOPR0349*'), which was 1.94 GB in size and recorded video for 17 min 33 sec, included footage of the accident flight. The second file (*'GOPR10349'*) appeared to be a video file of 433 MB in size, but was corrupted and could not be played in standard video playback software. File numbering conventions indicated that this file was recorded immediately after the file '*GOPR0349'*.

The Investigation noted a number of sequential files on the SDHC memory cards; each of approximately 1.94 GB in size. This process is called *'File Chaptering'* by the Camera Manufacturer. *'File Chaptering'* on the model of camera used by the Pilot was approximately 1.94 GB per file. According to the *GoPro* Camera website:

> *"When taking a video recording, the camera will automatically segment into a new file chapter once it has reached a certain size. These files when put together with editing software will play seamlessly as if they were never chaptered, and when played back from the camera directly will also play through as one continuation.*
>
> *This chaptering is intentional and there is no way to keep the camera from doing so. Chapters are divided like this so that in the event of a jolt or crash that causes a file to become corrupted, only a portion of your video will have become corrupted and you won't lose the whole thing in case our file recovery feature is unable to fix the file."*

The manufacturer's file recovery feature was unable to repair the corrupted file from either SDHC card. The original SDHC cards and both cameras were transported by an Inspector of Air Accidents to the UK Air Accidents Investigation Branch (AAIB) at Farnborough, for additional analysis. The AAIB recovered an additional 1 min 51 sec of video and audio from *SDHC Card 1 / Camera 1*, and 3 min 54 sec of audio and video from *SDHC Card 2 / Camera 2*.

SDHC Card 1 recorded a total time of 13 mins 46.5 secs from take-off until the end of the recording. *SDHC Card 2* recorded a total time of 13 mins 47 secs from take-off until end of recording. Neither of the recovered video files recorded the moment of impact.

[39] **.MP4:** A digital video file extension format. MP4 is a contraction of MPEG4 which is *Moving Picture Expert Group – Layer 4.* On both recovered cameras the video recording quality was '1080p' (1920 x 1080 pixels).
[40] **MB:** Megabyte

In order to calculate the exact time that the recovered recordings ended, the Investigation combined the *GoPro* data with the video recording provided by *Eyewitness 6.* This indicated a total flight time of 13 mins 48 secs, and indicated that the recording on each *GoPro* camera ended at approximately one second prior to impact with the ground.

Camera 1 was mounted on the engine cowling facing rearwards and *Camera 2* on the left wingtip of the aircraft facing the cockpit. The respective view from each camera can be seen in **Photo No. 10** and **Photo No. 11**.

Photo No. 10: *Camera 1* view

Photo No. 11: *Camera 2* view

1.11.3.3 Detailed Flight Description

The following detailed description of the flight is based on the *GoPro* camera footage contained on the SDHC memory cards that were found at the accident site. It describes the events from the point at which the aircraft was first boarded with the intention of flight.

Once the Pilot boarded the aircraft and closed the canopy, he started the engine and taxied the aircraft to the threshold of RWY 10. As he taxied in a westerly direction past a hangar that was located on the south side of the runway, he gave a 'thumbs-up' signal to some observers[41] adjacent to the runway. He turned the aircraft around at the westerly end of the paved surface and aligned it with the runway in an easterly direction. The aircraft engine noise increased for a period of approximately 30 seconds in what appeared to be pre-take off power checks. During these power checks, the sound of the engine reduced slightly on successive occasions in a manner characteristic of a functional check of the engine magnetos. On each occasion the sound returned to the previous level. When the engine power reduced to an audio pitch commensurate with idle power, it remained at that setting for approximately 18 seconds, during which time the flight control surfaces were moved to the full extent of travel a number of times in what appeared to be a flight control check by the Pilot[42]. The aircraft then began to roll forward, the engine noise increased consistent with a high power setting and the aircraft began the take-off.

[41] The observers are referred to in this Report as 'E*yewitnesses 3, 4 and 7*'.
[42] The control surface deflections observed during this procedure were used as benchmarks to analyse the control surface deflections during the flight.

First circuit: The aircraft departed in an easterly direction. The take-off roll was 150 m (metres) approximately. The aircraft pitched up into a constant climb attitude for a short period of time (16 seconds approximately) before the pitch attitude of the nose was reduced towards level flight at what was considered by eyewitnesses to be the standard circuit height for EIAB. It turned onto a westerly track using a bank angle of 60 degrees (°) and flew westwards towards the threshold of RWY 28. On crossing the Inny River, 350 m east of the RWY 28 threshold, the aircraft entered a 57° bank angle descending turn to the right to align with RWY 28 as it flew towards EIAB. Upon reaching overhead the airfield the aircraft conducted six rapid banking manoeuvres of up to 50° bank angle to the left and right, which is commonly referred to as a '*wing-waggle*' and is often used as a method of acknowledging people watching from the ground.

Second circuit: The aircraft then turned approximately 30° to the right before reversing the turn to the left onto an easterly direction parallel to, and south of, the airfield on the downwind leg for RWY 28. During this phase of the flight the aircraft conducted three aileron rolls to the left with an approximate one second interval between each roll. During the rolls, the pitch attitude of the aircraft was not significantly raised prior to beginning each manoeuvre and it was noted that the pitch attitude on completion of each roll was nose-low compared to the pitch attitude prior to the manoeuvre.

The Pilot appeared to correct the pitch attitude prior to commencing the next manoeuvre. The aircraft continued east on the downwind leg and then completed a left turn with a bank angle of up to 85° to align with RWY 28 again. The aircraft appeared to maintain altitude during the circuit, but as it passed overhead the threshold of RWY 28 in a westerly direction it rolled quickly to the left, initially through 215° of roll, before returning to a wings-level, inverted attitude. It then climbed whilst inverted at an angle of approximately 45° above the horizon. This manoeuvre lasted in the region of seven seconds. The aircraft was then rolled into an upright orientation.

Third circuit: The aircraft commenced a left turn onto an easterly downwind leg. The bank angle used during this turn was 25-30° which resulted in a downwind leg that was further south than previously flown. During the downwind leg the engine and propeller noise was noted to change in both pitch and volume, while the aircraft appeared to maintain a constant altitude. This reduced the speed of the aircraft prior to turning onto a westerly heading to align with RWY 28. It completed a touch and go landing on the runway. The aircraft was seen to bounce on the undercarriage a number of times during the landing before the engine noise increased again, indicating the application of engine power.

Fourth circuit: The aircraft departed from RWY 28. After take-off, the aircraft was maintained in a shallow climb until it passed the location of the people observing from the hangar south of the airfield. At this point, approximately 600 m from the threshold of RWY 28, the aircraft pitched into a steep nose-up attitude for around six seconds before reducing the pitch attitude. It then turned left onto a downwind leg. The aircraft completed another standard left-hand circuit and a touch and go landing. The aircraft touched down on the runway approximately 140 m past the threshold of RWY 28 and between the centreline and right edge of the runway.

Fifth circuit: The aircraft became airborne again at around 350 m from the threshold of RWY 28. The aircraft was then maintained in level flight just above the tarmac for a further 250 m, at which point the Pilot was seen to give a ‘thumbs up’ signal to observers standing on the south side of the runway. The aircraft then pitched into a steep nose-up attitude for approximately six seconds and then returned to a level flight attitude. It completed a left turn onto the downwind leg using 25-30° of bank angle, which resulted in a wider downwind leg than the previous circuit. The Pilot extended the downwind leg further east and when it turned westwards again to align parallel with the runway, it was further north than it had been during previous circuits. Upon reaching abeam the threshold of RWY 28, the aircraft completed two sequential aileron rolls. The pitch attitude of the aircraft was raised slightly prior to commencing the manoeuvre. As the aircraft completed the first roll, the pitch attitude could be seen to be significantly lower than it had been at the start of the manoeuvre. On this occasion the aircraft continued through a wings level attitude, into a second roll to the left without a pause, so a correction in pitch was not applied after the first aileron roll. As a result, when the second roll was completed the aircraft had a pitch down attitude of approximately 30° to the horizon when compared to the pitch attitude on entering the roll sequence of approximately 1° nose-down below the horizon. The Pilot adjusted the aircraft pitch attitude and height loss with subsequent upward elevator input.

Sixth circuit: The aircraft then turned left onto a downwind leg using a bank angle of 25-30°. This downwind leg was closer to the runway than the previous circuit because the aircraft had commenced the crosswind turn from a point north of the runway. It flew a routine downwind leg and positioned onto final approach to RWY 28 and completed a touch and go. The aircraft landed at a similar point on the runway centreline to the previous touch and go landing (140 m past the RWY 28 threshold). It bounced a number of times before power was applied and it became airborne again.

Seventh circuit: Once airborne, the aircraft maintained a shallow rate of climb and the Pilot was seen to wave to the observers to the south of the runway. The aircraft then entered a steep climb attitude (25-32° pitch-up) for approximately seven seconds and then returned to a level flight attitude. It completed a left turn onto a downwind leg and continued in the circuit. The aircraft turned westwards again to align with RWY 28 but maintained a similar altitude to that which was flown on the downwind leg. As the aircraft passed overhead the threshold of RWY 28 (33 seconds prior to end of flight) it pitched nose up by approximately 3°. The aircraft then completed an aileron roll to the left. As the aircraft reached a wings level attitude the nose had dropped approximately 1° relative to the initial start point. The aircraft maintained a wings level attitude for approximately two seconds and then pitched up in the region of 15° before completing a second aileron roll to the left. At the end of the second roll the pitch attitude had reduced from 15° pitch-up to 2° pitch-up. Following a wings level flight of a further one second the aircraft pitched nose-up again by a further 5° approximately and completed a third aileron roll to the left. The aircraft continued the left roll past the wings level attitude into a steep turn to the left onto downwind for an eighth circuit. As the aircraft passed through the wings level attitude into the turn onto downwind, the nose was 10° lower than the attitude prior to the start of the third aileron roll.

Eighth circuit: The left turn onto the downwind leg used a bank angle of approximately 60-68°. The aircraft rolled wings level momentarily on downwind and appeared to be in level flight. However, the aircraft's pitch attitude at this point was approximately 7-8° more nose-up than when the aircraft was previously in straight and level flight, suggesting that the aircraft was travelling at a slower speed than on previous downwind legs. The aircraft then commenced an aileron roll to the left. As the aircraft reached a wings level attitude, the pitch attitude was 22-23° lower than at the start of the manoeuvre. Without increasing the pitch attitude, the aircraft continued into a second aileron roll. As the aircraft passed 50° bank angle to the left, the deflection of the left aileron was gradually reduced until at 160° angle of bank to the left, the aileron reached the neutral position. This caused the roll to stop while the aircraft was almost inverted. At the same time, the elevator was seen to move to the full '*nose-up*' position, which caused the nose to drop towards the ground (due to the inverted attitude of the aircraft). The aircraft orientation at this moment was pointing in a northerly direction, inverted with approximately a 50° nose-down (towards the ground) pitch attitude. Full *'nose-up'* elevator and a neutral aileron position were maintained as the aircraft pulled through a vertically nose-down pitch attitude. As the pitch attitude of the aircraft began to increase towards the horizon in a southerly direction and in an upright orientation, left aileron was gradually introduced and the aircraft began a left turn back towards an easterly downwind leg.

As the aircraft pitch attitude passed 65° nose-down with full rearward elevator applied, the aircraft pitch attitude momentarily oscillated in a manner that was consistent with the onset of aerodynamic buffeting associated with a stalled wing and the aircraft commenced a rapid roll to the left. Within a quarter of a second after the left roll, the left aileron input was reduced and full right aileron was applied. Full rearward elevator was maintained and the aircraft nose continued to rise. The aircraft pitch attitude moved to 50° nose-down as the right aileron input slowed the rate of roll, and reduced the bank angle to 35° to the left. The sun's position as seen in the video footage indicated that the aircraft was pointing in a south easterly direction. Just prior to the end of the recording, while full right aileron was still applied, the aircraft suddenly rolled to the left and pitched nose-down rapidly. The final frame of video showed the aircraft rolling to the left with a bank angle of 65°, a pitch attitude of 83° nose-down, and with full right aileron and full rearward elevator applied. The aircraft was turning through a magnetic heading of 030° approximately. The elapsed time from take-off until the end of the flight was estimated to be 13 min 48 sec flying time.

1.11.4 Other Recorded Data

The Investigation reviewed a total of nine other video files that were present on the *GoPro* cameras, and also footage that had been uploaded to the internet. The Pilot made use of a number of internet video sharing sites to upload many of the flights that he had conducted or participated in. These videos included footage from an external, wing mounted camera of the Pilot conducting aerobatic manoeuvres in his Slingsby T67 Firefly. In particular the Investigation studied the technique that the Pilot used to complete aileron rolls.

There was also footage taken from within the cockpit, of the Pilot conducting aileron rolls. It was noted that at the beginning of the roll manoeuvre, the Pilot would initially pitch the aircraft slightly nose-up. Thereafter, the Pilot would commence a roll, usually to the left, and as the aircraft completed the manoeuvre and returned to a wings-level position, the nose of the aircraft could be seen to be significantly lower against the horizon than prior to commencement of the aileron roll. The aircraft altimeter was visible in these videos and it was noted that the aircraft initially climbed by 50-100 ft and maintained altitude until almost halfway through the roll in an inverted attitude. Thereafter, the altimeter showed a descent which resulted in an overall altitude loss of approximately 500 ft during the roll.

On one occasion the Pilot completed two sequential rolls similar to those conducted in PH-LSR on 20 March 2016, and the altimeter on the Slingsby showed that the aircraft had descended by 1,200 ft during the manoeuvres. The additional loss of altitude was due to the aircraft not pitching nose-up again prior to the second roll.

When viewed from a wing-mounted camera, it could be seen that there was little use of elevator to prevent the nose of the aircraft dropping below the horizon during inverted flight, and minimal use of rudder to maintain the nose on the horizon during the roll manoeuvre when the wings were near vertical to the horizon.

1.12 Wreckage and Impact information

The accident site was located in an agricultural field adjacent to the southern perimeter fence of the aerodrome (**Photo No. 12**). It was 130 m south of the runway centreline and 280 m west of the displaced threshold of RWY 28 at EIAB. The soil in the field was soft and felt '*spongy*' when walked on.

The forward section of the aircraft including the engine, propeller hub and blades, cowling, main undercarriage, main wing spar and instrument panel were located at the main site. The initial impact caused a crater that was approximately 180 cm long, 60 cm wide and 40 cm deep. There was a witness mark through the centre of the crater. The mark was 5-10 cm in depth, lay directly underneath and was of approximately the same lateral dimensions as the leading edge of the wing. The centreline of the engine block and propeller hub assembly was oriented on a magnetic heading of 295°.

The remaining parts of the aircraft consisting of the fuselage aft of the cockpit, the tail assembly, and wing components, were located in an area 7-17 m north east and south east of the main site. Initial examination of the engine and propeller components at the site indicated that the engine was providing power at the time of impact.

The Investigation examined the rods and cables associated with the aircraft's flight controls. The aileron control rods were sheared at the wing root on each side, at the point where the wing had separated from the fuselage and main spar. The elevator and rudder control cables had failed in tension overload, at the point where the rear fuselage had separated from the cockpit and forward fuselage consistent with a ground impact. Subsequent inspection confirmed the continuity of the aileron, elevator and rudder controls prior to impact. Examination of the cables and rods showed that there was no evidence of corrosion or fatigue.

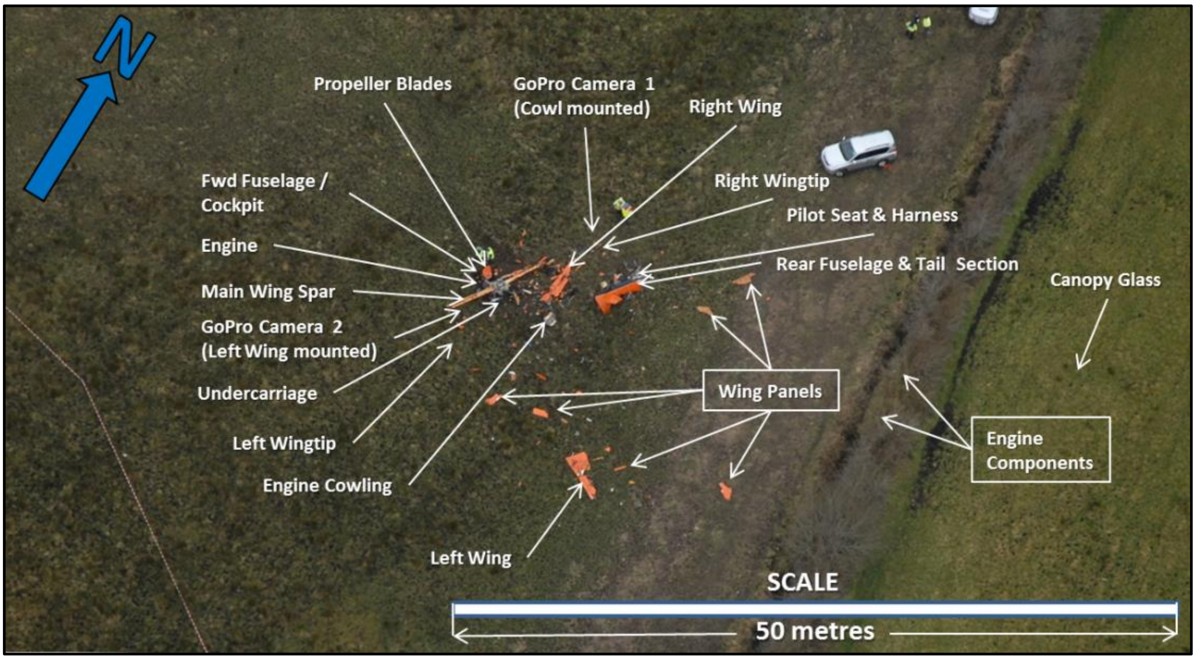

Photo No. 12: Wreckage Distribution (Overlaid on photo courtesy of Irish Air Corps / GASU)

The front main wing spar was still attached to the engine and forward cockpit area, and had rotated rearward laterally on the right side of the aircraft by approximately 20° from its original alignment. Most of the remaining wooden components of the wing structure had shattered and were scattered around the main wreckage site. The engine was substantially damaged. The throttle, propeller and fuel mixture levers were found to be in the full forward, high power position. It was noted that there was significantly less impact damage and soil contamination to the left side of the engine (**Photo No. 13**) when compared to the right (**Photo No. 14**).

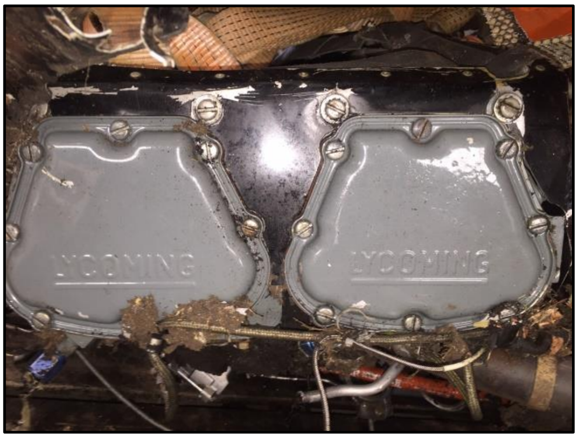

Photo No. 13: Left cylinder rocker covers

Photo No. 14: Right cylinder rocker covers

The propeller hub was attached to the engine and the three propeller blades were present from the root of the blade for approximately 10-20 cm. The remaining wooden propeller blades had been shattered into small pieces from this point outward and a significant number of these pieces were located within the immediate area of the propeller hub.

The pitot tube, located on the right wing leading edge (**Photo No. 15**), which senses dynamic air pressure in order to provide airspeed indications to the Pilot, was found under the right main wing spar. It had been torn from the main spar mounting point (**Photo No. 16**). The bending of the tube indicated that it had suffered a lateral impact from the right.

Photo 15: Right wing and pitot tube

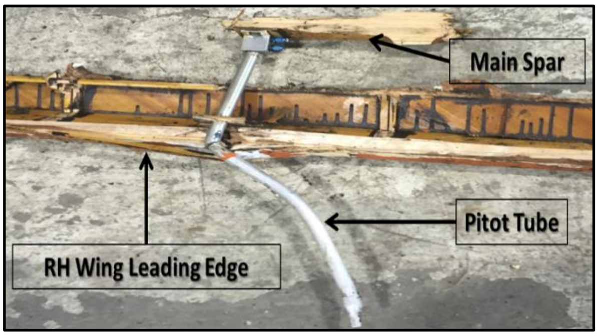

Photo No. 16: Impact damage to pitot tube

The rear cockpit and tail section was located eight metres north east of the engine and forward cockpit. It had completely separated from the forward section and was pointing in a north easterly direction. There was evidence of compression damage on the left side of the fuselage behind the cockpit area. The left elevator (**Photo No. 17**) was intact while the right elevator showed damage consistent with a ground impact (**Photo No. 18**). The damage pattern indicated that the tail section struck the ground in a right elevator down orientation and was travelling tail first in a north easterly direction.

Photo No. 17: Left elevator (facing rearward)

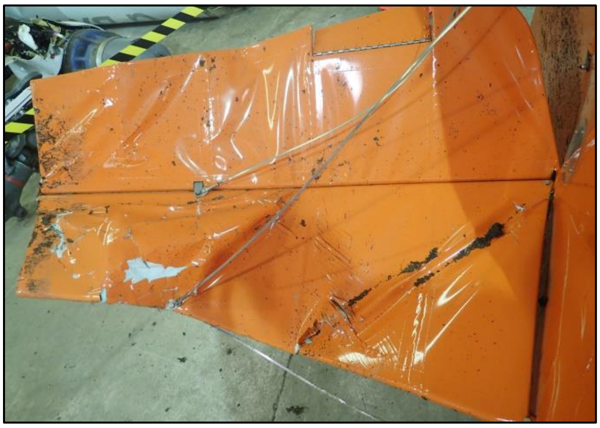

Photo No. 18: Right elevator (facing rearward)

1.13 Medical and Pathological Information

The Pilot, who was fatally injured, was found at the site of the rear fuselage and tail section of the aircraft, which included the pilot seat and restraining harness. The Pilot was removed from the aircraft by the emergency services and taken to hospital. The Investigation was provided with a copy of the post mortem examination report which was conducted on 21 March 2016. The external examination of the Pilot noted evidence of severe trauma with multiple fractures, lacerations and contusions to the head, upper body and limbs. It noted the presence of *"a strong smell of petroleum…"*. The external examination also noted that there was "*a 6 cm laceration on the palm of the left hand*".

The internal examination noted that the cardiovascular, respiratory, gastrointestinal and endocrine systems showed no evidence of any pre-existing medical condition that would have affected the ability of the Pilot to undertake the flight.

A toxicological analysis of a blood sample noted that carbon monoxide was at a saturation level of less than 10%[43] which would be considered normal. It also noted that the sample did not contain the optimal preservative for the analysis[44]. The analysis did not detect the presence of ethanol in the blood. A sample of the Pilot's urine was tested and the toxicology report stated that "*drugs*" were "*not detected*".

1.14 Fire

There was no fire.

1.15 Survival Aspects

1.15.1 Immediate Response

The emergency services were notified by a '999' telephone call from one of the eyewitnesses at EIAB. The Irish Air Corps Emergency Aeromedical Helicopter from Athlone was tasked by the National Aeromedical Coordination Centre (NACC) at 17.46 hrs to attend the scene. The helicopter landed at EIAB at 18.00 hrs to provide medical assistance.

1.15.2 Restraint Systems

The video footage from the *GoPro* cameras showed that the Pilot put on the shoulder straps and appeared to attach them to the lap-strap harness restraint on the aircraft. He was seen to tighten and secure the shoulder straps prior to starting the engine for the flight. The harness restraint was intact when examined after the impact and appeared to be functional. The aircraft structure had separated at the cockpit area and the Pilot was located with the rear fuselage. The accident was not survivable.

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[43] The post mortem stated that saturation levels in blood range from 1-5% for a non-smoker and 8-10% for a smoker. Carbon monoxide may be toxic from 25-35% and lethal at 50-60% saturation.

[44] The Journal of Analytical Toxicology (October 2000) reported on the results of a study that suggested that "*carboxyhemoglobin is stable in blood specimens collected in vacutainer tubes, with or without preservative, and stored refrigerated for up to two years*".

1.16 Tests and Research - Aerodynamics

1.16.1 Stalling

As an aerofoil travels through the air, it is subjected to aerodynamic forces. A pictorial representation of an aerofoil in an airstream is shown in **Figure No. 3** which indicates the distribution of pressure above and below the aerofoil. The lower pressure above the aerofoil combined with the higher pressure below causes the aerofoil to experience a lifting force. The angle between the aerofoil (chordline) and the airstream is known as the angle of attack (AoA). Changing the AoA will change the amount of lift generated.

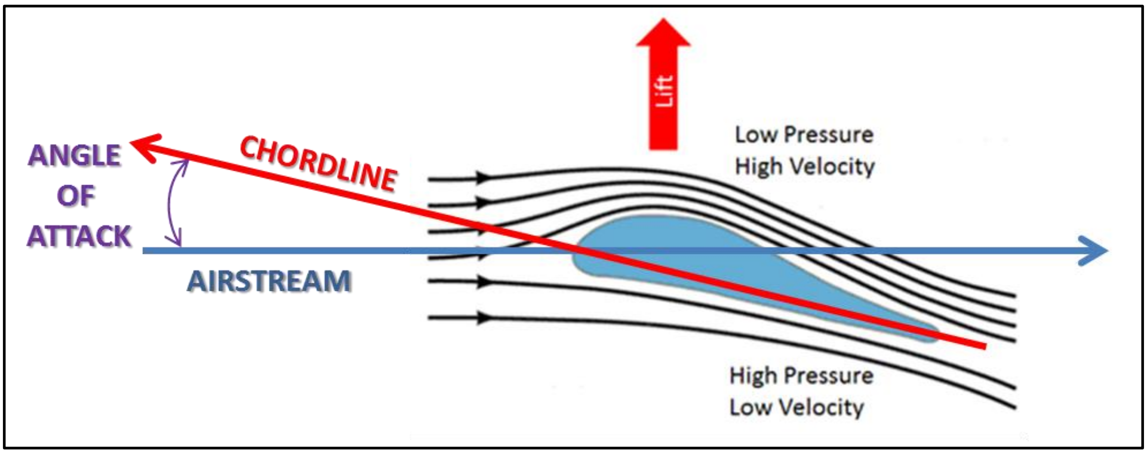

Figure No. 3: An aerofoil in an airstream (Adapted from Woodbank)

As the AoA increases, the relative pressure differential becomes greater and lift increases. However, at a certain *critical AoA*, the airstream boundary layer cannot remain attached along the upper surface of the aerofoil and the airflow separates from the surface (**Figure No. 4**). The aerofoil is at this point considered to be in a stalled condition. A stall causes a sudden loss of lift.

The turbulent, separated airflow over the upper surface of the wing will cause aerodynamic buffeting which can feel similar to atmospheric turbulence to the pilot. The severity and duration of stall-related buffeting varies across different aircraft and wing shapes.

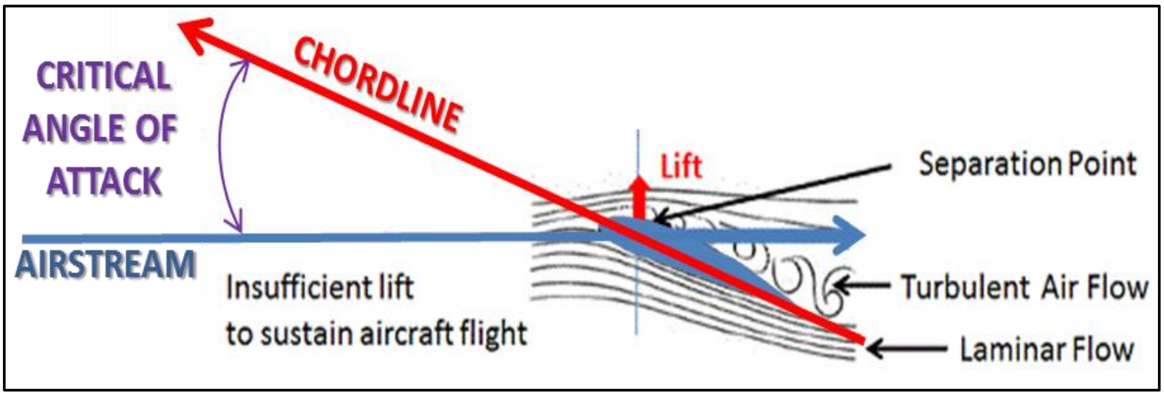

Figure No. 4: An aerofoil at critical AoA in an airstream (Adapted from Woodbank)

It is important to recognise that the critical AoA is that which the chordline of the aerofoil makes with the airstream and not with the ground. An aircraft can stall at any angle relative to the ground once the critical AoA between the airstream and aerofoil is exceeded. Recovery from the stall can only be achieved by reducing the AoA below the critical angle. Furthermore, if the aerofoil is subjected to an increased 'g' loading, the stall speed of the aircraft will increase due to the rapid increase in aircraft apparent weight when conducting high 'g' manoeuvres. The amount of 'g' that is required to cause an aircraft to stall at any given speed and weight can be calculated by use of the following formula;

$$G = \left(\frac{W1}{W2}\right)\left(\frac{V}{Vs}\right)^2$$

Where: '*W1*' is the quoted aircraft gross weight[45] for the stall speed at 1 g.
'*Vs*' is the quoted aircraft stall speed at 1 g for the gross weight *'W1'*.
'*W2*' is the gross weight of the aircraft for which *'G'* is to be calculated.
'*V*' is the speed of the aircraft for which *'G'* is to be calculated.
'*G*' is the force of gravity required to cause the aircraft to stall.

1.16.2 Wing drop

For the majority of general aviation aircraft, when both wings reach the critical AoA simultaneously during straight and level flight, the AoA will tend to reduce symmetrically relative to the airstream. However, there are a number of factors that individually or collectively can influence the symmetrical motion of an aircraft in such a scenario:

a. **Unbalanced Flight / Use of Rudder:** The presence of a yaw input can cause a slip or skid which can result in an asymmetric stall. If the slip causes sufficient discrepancy in AoA between the wings, then one wing will reach the critical AoA before the other wing, and will stall first with a resultant wing drop. This effect can also occur in an unbalanced turn, as the secondary effect of roll is yaw.

b. **Wing Surface Condition:** Contamination or damage to a wing surface can result in minor differences in the laminar airstream over each wing. Minor surface irregularities that can develop over time can negatively affect stall behaviour. Additional items mounted on the wing, such as cameras, could have a detrimental effect on the airstream near the wingtip and could contribute to disruption of the laminar flow over the wing near the aileron.

c. **Lift Augmentation Devices:** Devices designed to increase lift performance can also influence the stall characteristics of the aerofoil. The Laser Z200 did not employ lift augmentation devices such as flaps or slats.

[45] The result of the formula is a ratio; hence the terms '*mass*' or '*weight*' may be used interchangeably once applied consistently during the calculations.

d. Effect of Power: Single engine, propeller driven aircraft will experience a faster airstream near the wing root when power is applied due to the slipstream from the propeller backwash. This will move the position where the airstream first separates from the aerofoil outboard towards the ailerons and wingtip. This makes recovery from the stall more challenging. Furthermore, due to the rotational nature of the airflow coming from the propeller slipstream, the increase in airstream speed over the wing root may be asymmetrical, which can increase the possibility of a wing drop during a stall with power applied. Power application during stall recovery can generate pro-spin yaw due to the gyroscopic effects associated with the increasing rotational speed of the propeller.

e. Wing Sweep: A wing that is angled (or swept) rearwards is preferable in high performance aircraft as it improves manoeuvrability and agility at higher airspeeds. However, this wing sweep can increase the possibility of a wing drop at the critical angle of attack (**Figure No. 5**) as the stall tends to originate at a point on the wing that is closer to the wingtip. This characteristic can also result in a reduction in aileron effectiveness during stall recovery. The Laser Z200 had a sweep angle of five degrees approximately, which was a marginally greater sweep than the Slingsby T67.

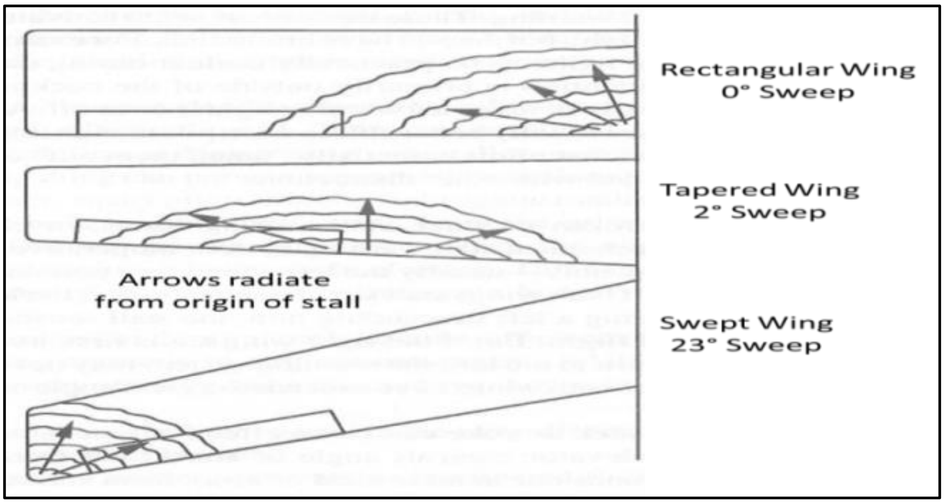

Figure No. 5: Effect of Wing Sweep on the Location of Origin of a Stall (Rich Stowell)

f. Aileron Use: The downward deflection of an aileron will effectively increase the local AoA of the wing. This will cause the wing to reach the critical AoA sooner than the opposing wing with the upward deflected aileron. For example, if a left wing drop occurs during a stall, application of opposite aileron in an attempt to return to a wings level condition will introduce a downward deflected aileron on the left wing thereby causing an increased AoA. This will result in a more pronounced stall on that side and a more rapid wing drop. Furthermore, the upward aileron on the right wing will reduce the AoA on that side thereby contributing to the increased roll rate to the left during the stall.

A wing drop can often be the prelude to the aircraft entering a spin. From the moment that the aircraft first stalls until the time that it has entered a fully developed spin, the aircraft will normally go through a series of transient pitch, roll and yaw movements. These unsteady motions can last for a number of rolling and yawing cycles before motion settles into the relatively constant rates of roll and yaw which characterise the fully developed spin. This intermediate period of motion is referred to as the incipient phase of the spin.

1.16.3 Aerobatic Manoeuvres – The Aileron Roll

An aileron roll is an aerobatic manoeuvre where the aircraft completes a roll through 360° along the longitudinal axis of the aircraft. Although simple in concept, the aileron roll is a complex coordination exercise involving continuously varying, coordinated aileron, elevator and rudder inputs to compensate for the constantly changing lift vector acting on the aircraft.

In order to understand the aileron roll, it is also necessary to understand how the forces of lift, roll and yaw act on an aircraft. The aircraft wings generate lift which acts perpendicularly to the wing (**Figure No. 6**). As the aircraft begins to roll, the resultant force provides a reduced vertical component of lift and an increased horizontal component of lift which causes the aircraft to turn. To compensate for the reduced lift, upward elevator is applied to increase the angle of attack and therefore increase the lift produced by the wing.

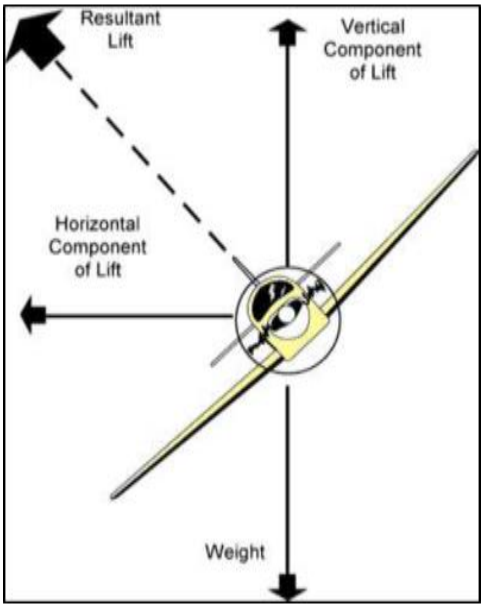

Figure No. 6: Lift Vector during a roll (ATP Inc., 2003)

As the aircraft rolls through 90° (also known as the *'knife-edge'*), the wings do not produce a vertical component of lift, and upward elevator increases the horizontal component of lift only. Hence rudder input opposite to the direction of roll is required to prevent the nose of the aircraft and thrust line from dropping below the horizon due to the absence of the vertical component of lift. As the aircraft rolls towards an inverted attitude, the rudder is reduced, and the elevator is moved forward to keep the nose at an attitude that prevents a descent.

As the aircraft rolls through inverted and into the second half of the manoeuvre, the forward elevator is reduced and left rudder is gradually added to compensate for the absence of a vertical lift component at the 270° point in the roll. From this second '*knife-edge'* onwards, some rearward elevator will increase lift until the wings begin to provide a sufficient vertical component of lift once again. As the aircraft returns towards level flight, the rudder is reduced to neutral again, the elevators are moved to the neutral position and the ailerons return the aircraft to wings level flight.

In the book "*Better Aerobatics*", the author (Alan Cassidy) identifies the most common errors seen in order of occurrence during a roll manoeuvre as;

- *"Insufficient up elevator (back stick) during the first 20° to 30° roll*
- *Insufficient down elevator (forward stick) at the inverted point*
- *Failure to maintain enough forward stick from inverted to the second knife-edge* [270°] *position.*

The first two errors will result in a roll on a descending flight path…The third error results in "dishing out" which is a combination of height loss and heading change to the right"

The author further noted common rudder errors, which included:

- *"Not increasing right rudder from the first knife-edge position to inverted as the adverse yaw changes direction*
- *Excessive use of left rudder from the second knife-edge position onwards."*

In the book "*Emergency Maneuver Training*", the author (Rich Stowell) makes the following observations on recovery from an over-bank or inverted flight scenario;

"*A roll input offers the shortest route back to wings level. Rolling doesn't increase the g-load either. On the other hand, pulling forces the airplane into a half-loop earthward – called a split-S. Pulling traps us in a Catch-22: the diving loop rapidly consumes altitude, resulting in a dramatic increase in airspeed, causing the loop's radius to grow exponentially, necessitating higher g's to bend the airplane around in an arc, demanding a progressively harder pull to minimise altitude loss and airspeed build-up."* (**Figure No. 7**)

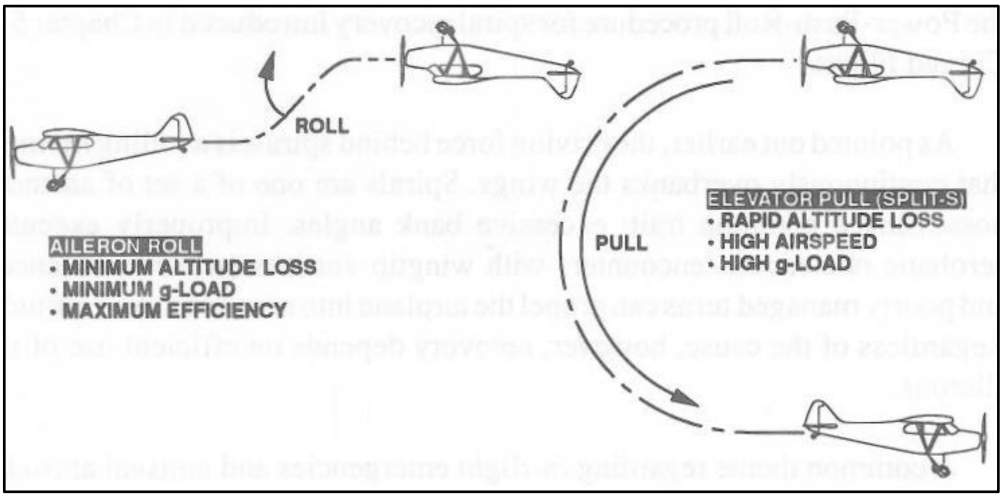

Figure No. 7: Comparing a Roll versus a Pull recovery from inverted (Rich Stowell)

1.17 Organisational and Management Information

Not applicable.

1.18 Additional Information

1.18.1 Documentation

The Investigation was provided with a substantial volume of documents associated with the manufacture, certification, airworthiness, operation and purchase of the aircraft. Many of these documents, including the 58 page '*Flughandbuch*'[46], were the German and/or Dutch language versions only. There was also a shortened, English language version of the *Flughandbuch* which was six pages long, and included basic specifications, operating limitations, aircraft performance data, and weight and balance information.

The documentation included details of maintenance conducted on the airframe, engine and propeller from the date that the aircraft was built in 1995. The Investigation also recovered a single A5 size laminated pilot's checklist, which was the only piece of documentation found at the accident site. The video recordings appear to show the Pilot consulting a document in the cockpit as he completed checklist items prior to departure.

1.19 Useful or Effective Investigation Techniques

1.19.1 Photogrammetry

Photogrammetry is the measurement and interpretation of photographic and video imagery in order to calculate additional parameters from the flight, such as speed and height. The Investigation conducted photogrammetry on the *GoPro* Camera footage and on a number of still photographs taken by eyewitnesses during the flight.

[46] **Flughandbuch:** Flight Manual

The alignment of the *GoPro* camera mountings on the aircraft, combined with the optical field of view for video recordings of 127° resulted in a camera view that did not provide sufficient undistorted ground references to calculate the height of the aircraft during the flight. However, the video did provide sufficient information to estimate an average groundspeed during the manoeuvres listed in **Table No. 6**.

Flight Phase	Description	Average Groundspeed (KTS)	Notes
Circuit No. 1	Wing Waggle	141	(heading west)
Circuit No. 2 downwind	1st-2nd Aileron roll	163	(heading east)
Circuit No. 2 downwind	2nd -3rd Aileron roll	129	(heading east)
Circuit No. 2 final approach	Inverted flight	174	(heading west)
Circuit No. 5	1st-2nd Aileron Roll	147	(heading west)
Circuit No. 7	1st-2nd Aileron Roll	131	(heading west)
Circuit No. 7	2nd-3rd Aileron roll	96	(heading west)
NOTE: The estimated margin of error for groundspeed calculations is ± 6 kts approx.			

Table No. 6: Aircraft average groundspeed based on photogrammetric calculations

The Investigation noted that the aftercast indicated that the wind speed at the time of the flight was 3-6 kts at the surface and 6-8 kts at 2,000 ft. Additionally, the northerly wind direction meant that there was unlikely to be a significant discrepancy between groundspeed and airspeed when on easterly or westerly headings. There appeared to be no consistency in the speed of the aircraft at the same point in the roll manoeuvres, with a variance between the average entry speeds for aileron rolls of 67 kts (96 - 163 kts).

During the aileron rolls conducted as part of the second, fifth and seventh circuits, the aircraft was seen to be '*dishing out'* as described in section **1.16.3** of this Report. The entry speed into the turn onto the downwind leg prior to the final aileron roll manoeuvres during the eighth circuit was calculated to have commenced at 96 kts, which is significantly slower than during previous circuits.

A photograph taken from the ground by an eyewitness provided sufficient EXIF[47] data and picture quality to calculate that the height of the aircraft during level flight over the aerodrome was approximately 824 ft. This calculation was supported by the information provided to the Investigation by eyewitnesses, many of whom flew regularly at EIAB.

1.19.2 Test Flight

The Investigation was provided with the assistance of a qualified test pilot who made available the use of a Laser Z200 in order to test the aerodynamic performance of this aircraft type during the manoeuvres that were seen on the video recordings. The Investigation requested the test pilot to complete a number of manoeuvres and record the results for comparative purposes.

[47] **EXIF:** Exchangeable Image File - Data saved with a digital photograph which is comprised of, but not limited to, a range of settings such as shutter speed, aperture, white balance, camera model and make, date and time, lens type, focal length etc.

1.19.2.1 First Manoeuvre - Steep Turns

A steep turn of 180° was conducted in order to assess the aerodynamic effect on aircraft performance as the Laser Z200 turned onto the downwind leg of each circuit. The turns onto downwind conducted by PH-LSR were recorded as being between 65°-75° angle of bank, with the turn being commenced from level flight overhead the airfield or after a touch and go landing.

To simulate a turn onto downwind following a touch and go and subsequent climb to circuit altitude, the first turn was conducted with an entry speed of 100 kts using a 65° bank angle approximately. This manoeuvre resulted in 3.5 g during the turn and an exit speed from the 180° turn of 85 kts, indicating a speed loss in the turn of 15 kts.

To simulate a turn onto downwind following level flight at a normal cruising speed at circuit altitude, a second steep turn was conducted with a faster entry speed of 140 kts, using 75° bank angle approx. This manoeuvre resulted in 7 g during the turn and an exit speed from the 180° turn of 115 kts indicating a speed loss in the turn of 25 kts.

1.19.2.2 Second Manoeuvre - Accident Sequence

The Investigation requested the test pilot to fly a sequence of manoeuvres similar to those seen on the *GoPro* camera footage, but at an altitude selected by the test pilot. This sequence consisted of three aileron rolls to the left, taking approximately 2.5 seconds to complete each roll, with a one second phase of level flight between each roll. At the end of the third aileron roll the aircraft continued the roll into a left turn of 180° onto a downwind followed immediately by two aileron rolls to the left. The selected entry speed was 140 kts and the flight sequence was completed twice; with and without elevator deflection during the rolling manoeuvres:

With elevator deflection: During the three initial aileron rolls, the aircraft maintained altitude throughout the manoeuvres and only minimal airspeed was lost. In order to complete the 180° steep turn, the pilot required to pull 7 g. This resulted in a speed loss of approximately 25 kts. As the aircraft completed the steep turn it immediately commenced another two rolls; this time using elevators. On completion of these manoeuvres the exit speed was 115 kts and no altitude had been lost.

Without elevator deflection: During the three initial aileron rolls, the aircraft entered a shallow dive during which the speed increased to 145 kts. In order to complete the 180° steep turn, the pilot required to pull 7 g. This resulted in a speed loss of approximately 25 kts. As the aircraft completed the steep turn it immediately commenced another two rolls without elevator. The aircraft entered a dive and the pilot recovered the aircraft to level flight. The aircraft exit speed from the manoeuvre was 135 kts. The altitude loss for the complete sequence was 500 ft.

2. ANALYSIS

2.1 The Flight

The Pilot was seen to take the Laser Z200 aircraft out of the hangar upon his return from EIIM. No flight plan was filed, nor was one required for a local flight of circuits at EIAB. While the exact time when the Pilot decided to conduct a flight in the Laser Z200 is unknown, based on the statements of those who travelled to EIIM with the Pilot, it appeared to have been a decision that was made at short notice, around the time that the Pilot returned to EIAB.

There were a number of occasions during the flight when the Pilot acknowledged spectators adjacent to the runway during the touch and go take-offs, and during the first circuit of the airfield when he conducted a 'wing waggle' manoeuvre. The Investigation considered that this was indicative of the Pilot's awareness that spectators were viewing the flight in the newly-acquired aircraft, and that this may have influenced the Pilot's decision to conduct aerobatics during the flight.

The video evidence recovered at the accident site allowed the Investigation to analyse the sequence of events leading up to the accident. The video and photogrammetry showed that the Pilot was conducting aerobatics at a circuit height of approximately 800 ft AAL. This was an insufficient height to permit a safe recovery to stable flight during the final aileron rolls. The technique used by the Pilot when conducting aileron rolls earlier in the flight, and as seen in previous flights uploaded to the internet, showed that appropriate elevator and rudder inputs were not used during the roll manoeuvre, resulting in a substantial nose-down attitude with, on one occasion, a loss of altitude during the manoeuvre of approximately 500 ft for a single roll and 1,200 ft for a double roll.

The altimeter was noted to have a subscale setting of 1021 hPa, which provided a reading of 0 ft on the altimeter at an altitude of 180 ft above MSL. EIAB is 195 ft above MSL. The altimeter subscale setting indicated that the Pilot may have adjusted the altimeter to zero feet prior to take off. The Investigation concluded that the altimeter subscale was set to provide the Pilot with an indication of height above the ground during the flight.

The Pilot attempted a '*Split-S*' manoeuvre as a recovery technique, by pulling through a vertical nose-down attitude until facing southwards. This was an unsuitable manoeuvre given the height of the aircraft at that time. In light of the technique used by the Pilot, the Investigation considered whether the Pilot lost consciousness as a result of high 'g' during the final recovery attempt. The *Flughandbuch* provided a maximum take-off weight (*W1*) of 635 kg and a stall speed (*Vs*) of 55 kts. Photogrammetry conducted by the Investigation calculated a groundspeed of 96 kts prior to the aircraft's turn onto downwind. The test flight that was undertaken showed that at 100 kts, and using 65° bank angle, a 180° turn onto downwind would lose approximately 15 kts, resulting in a speed on entry into the aileron roll manoeuvres of 81 kts (*V*) The fuel calculations indicated that the aircraft weighed approximately 591 Kg (*W2*) at the end of the flight.

Hence, during the recovery attempt, the maximum 'g' that the aircraft could achieve before reaching the critical AoA under these conditions was;

$$G = \left(\frac{W1}{W2}\right)\left(\frac{V}{Vs}\right)^2 \quad \rightarrow \quad G = \left(\frac{635}{591}\right)\left(\frac{81}{55}\right)^2 \quad = \quad 2.33\text{ g}$$

During the test flight, when the aircraft conducted aileron rolls without using elevators, it exited the manoeuvre having increased speed by 15 kts (135 kts – (145-25) = 15 kts). Hence, during the recovery attempt, the maximum 'g' that the aircraft could achieve before reaching the critical AoA was;

$$G = \left(\frac{W1}{W2}\right)\left(\frac{V}{Vs}\right)^2 \quad \rightarrow \quad G = \left(\frac{635}{591}\right)\left(\frac{96}{55}\right)^2 \quad = \quad 3.27\text{ g}$$

For completeness, the Investigation repeated the calculations factoring the margin of error of 6 kts quoted in **Table No. 6**, which resulted in a total of approximately 3.7 g. Therefore during the final sequence of aileron rolls, the 'g' force required for an aircraft to enter an accelerated stall under these conditions was between 2.33 and 3.7 g. The Investigation concluded that the accident aircraft probably did not exceed any Flight Manual limitations of 'g' during the final manoeuvres that could have resulted in structural failure, and that the wing would have reached the critical AoA and stalled at a level of 'g' that was unlikely to cause the Pilot to experience a significant loss of consciousness. The calculated range of 'g' during the final manoeuvre was less than that experienced during the steep turns conducted by the Pilot without loss of consciousness earlier in the flight.

The video showed that the control surfaces were functioning until the end of the recording. The Investigation noted during the initial wreckage examination that the throttle, propeller and mixture levers were in the full power position, indicating an attempt at recovery had been initiated by the Pilot. The laceration identified on the Pilot's left hand during the post-mortem was consistent with it resting on the throttle lever at the moment of impact, which would only have been possible if the Pilot was conscious and keeping his hand up on the throttle itself.

During the attempted recovery from the second aileron roll, the Pilot used what appeared to be full rearward elevator. This caused an accelerated stall and a wing drop to the left. At this point the Pilot applied full right aileron to counter the roll to the left and maintained the rearward elevator. The right aileron input would have increased the AoA on the left wing. Evidence indicated that in the final moments of the flight, the aircraft entered the incipient phase of a spin to the left from the accelerated stall and impacted the ground at a speed significantly higher than the 1 g stall speed of 55 kts.

2.2 Fuel Calculations

The Investigation analysed the available fuel consumption data for the aircraft during the flights conducted on 12 March 2016. The aircraft had not received fuel since arrival at EIAB. Using an estimated average fuel flow for the previous flights of 28 L/hr, the Investigation calculated that the fuel used for the final leg of the delivery flight to EIAB on 13 March 2016 was 35 L, resulting in 41 L remaining in PH-LSR. The flight conducted by the Pilot at EIAB on 17 March 2016 was recorded as completing six circuits in 30 minutes duration. At an increased average fuel flow in the circuit[48], the flight used an estimated 17 L of fuel.

Therefore, there was an estimated 24 L of fuel remaining, or approximately 42 minutes of endurance at the start of the flight[49] on 20 March 2016. Based on the fuel calculations above and the weight of the Pilot of 87 kg[50], the aircraft weight at the commencement of the flight was calculated to be approximately 596 kg and would have decreased to approximately 591 kg by the end of the flight. The remaining fuel and endurance at the end of the flight was estimated to be 16.5 L and 28 minutes of flying time respectively. Consequently, the Investigation considers that fuel starvation was not a factor in the accident.

2.3 Wreckage Analysis

The forward fuselage, including the engine, propeller hub and blades, cowling, main undercarriage, main wing spar and instrument panel were located at the main site. The initial impact had caused a crater that was approximately 180 cm long, 60 cm wide and 40 cm deep. There was a witness mark through the centre of the crater. The mark was directly underneath, and approximately the same dimensions as the leading edge of the wing, and was 5-10 cm deep. The Investigation concluded from the location of the wreckage and the observed ground scarring, that the aircraft impacted in a steep nose down attitude. This conclusion was supported by the recovered video footage from the *GoPro* Cameras, and interviews with eyewitnesses to the accident. The extent of the ground scarring and damage to the aircraft indicated that it was travelling at a relatively high speed at the moment of impact. This suggested that the aircraft had experienced an accelerated stall during the attempted recovery by the Pilot.

The aircraft centreline was oriented on a magnetic heading of 295°. However, the remaining wreckage was located to the east of the main site. The main spar had rotated rearward laterally on the right side of the aircraft by approximately 20° from its original alignment. There was lateral damage to the pitot tube, compression damage on the left side of the fuselage behind the cockpit area, and additional damage to the right side of the main engine block.

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[48] A figure of 34 L/hr taken from the Flight Manual was used to calculate fuel used in the circuit.

[49] It was noted that the recorded block times for the flight of 8 January 2016 (13 min recorded as 30 min), and that on 20 March 2016 the aircraft completed seven full circuits in 13 min 38 sec. The Investigation considers that fuel usage of 35 L for the flight of 17 March 2016 is a conservative estimate.

[50] **87 kg:** The weight of the Pilot as recorded by the pathologist during the post-mortem.

This wreckage orientation combined with the footage from the *GoPro* cameras indicated that the aircraft, in addition to being in a steep nose down attitude, was inverted while still travelling in a general easterly direction (**Figure No. 8**).

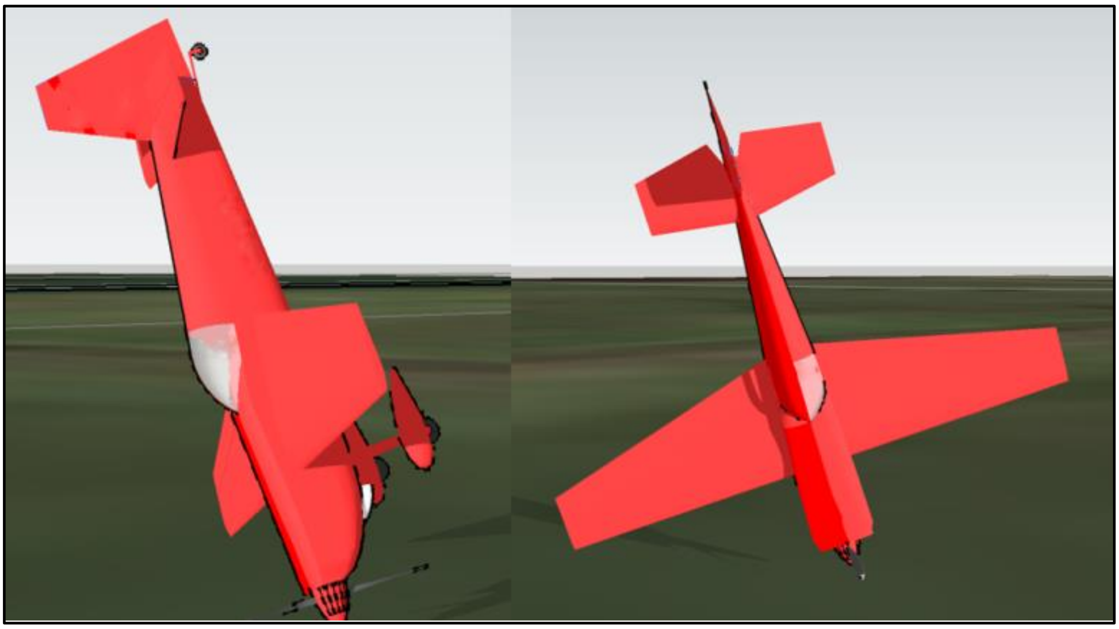

Figure No. 8: Graphic of aircraft's probable final orientation viewed from different angles

Evidence indicated that the combination of pitch attitude, speed and orientation caused the aircraft to pitch over into a westward facing, upright orientation, upon impact with the ground. The force of the impact caused the rear fuselage and tail section to separate and continue travelling eastwards for an additional 10 m approximately, resulting in damage to the elevator consistent with this section travelling tail first at the moment that the elevator impacted the ground. The Investigation concluded from the analysis of the wreckage that it was probable that the aircraft entered the incipient phase of a spin.

2.4 Personnel Licensing

The Investigation examined the Pilot's documentation and concluded that he was appropriately licensed to fly PH-LSR. The aircraft was categorised under *Annex II of Regulation (EC) 216/2008* as an "*aircraft of which at least 51 % is built by an amateur…"* The scope of *Regulation (EU) 1178/2011* is determined by the *Regulation (EC) 216/2008* (the *Basic EASA Regulation*), *Annex II* of which provided specific exemptions from EASA's remit. The specific exemptions, which remain under national regulations, mean that pilots of '*Annex II'* aircraft such as PH-LSR are not required to obtain an aerobatic rating.

The Investigation examined the interpretation of licensing and regulation associated with '*Annex II*' aircraft in general, and noted the potential for inconsistent implementation across the national regulatory authorities concerned. This had resulted in a lacuna in the regulatory framework, whereby the national authorities of Ireland, the Netherlands and the UK had issued guidance accepting an EASA licence issued under Regulation (EU) 1178/2011 for *Annex II* aircraft, while EASA have stated that the licensing of flight crew of *Annex II* aircraft cannot be addressed by the Part-FCL implementing rule relied upon by the various national authorities.

While it was noted that national licensing regulations were in place for those wishing to conduct routine flying in *Annex II* aircraft, the Investigation is of the opinion that amateur-built aircraft such as the Laser Z200 have been designed and built with the specific performance capabilities necessary for the conduct of advanced aerobatic flying. However, the lacuna in the European regulatory framework means that those who conduct aerobatics in such aircraft do not require any specific aerobatic training or qualification by virtue of being exempt from *Regulation (EC) 216/2008* and consequently *Regulation (EU) 1178/2011*.

The Investigation was cognisant that Article 2 of the *Basic EASA Regulation (Regulation (EC) 216/2008)* which stated that "*The principle objective of this Regulation is to establish and maintain a high uniform level of civil aviation safety in Europe*." The Investigation considers that *Regulation (EU) 1178/2011 FCL.800 Aerobatic Ratings* has the potential to provide an additional level of uniform safety for such a relatively high risk aviation activity. However, EASA informed the Investigation that this Part-FCL implementing rule cannot be applied to *Annex II* aircraft under the current EASA mandate. EASA informed the Investigation that enacting such an extension would be the responsibility of *The European Commission*. Although Part-FCL requirements for *Annex II* aircraft are currently the responsibility of National Authorities, the *Director General of Mobility and Transport of the European Commission* engaged proactively with the Investigation to consider how best to develop an effective methodology to address this lacuna in the regulatory framework. The Investigation accordingly issues a Safety Recommendation to the *Director General of Mobility and Transport of the European Commission* in this regard.

Safety Recommendation No. 1

The *Director General of Mobility and Transport* should consult with EASA in order to define common minimum aerobatic training requirements for pilots wishing to operate, for the purposes of aerobatic flight, aircraft categorised under Annex II of Regulation (EU) 216/2008. (**IRLD2017012**)

2.5 Summary

The flight was recorded by two *GoPro* cameras mounted on the engine cowling and left wingtip respectively. These cameras, and eyewitness statements, established that the aircraft conducted inverted flying and low-level aerobatics at circuit height during the flight. The footage indicated that inappropriate rudder and elevator inputs were used during the aerobatic manoeuvres. The final moments of the footage showed that the aircraft suffered a wing drop and rapid roll to the left, consistent with the incipient phase of a spin, while attempting to recover from a nose-down, inverted pitch attitude during the conduct of an aileron roll. The engine and airframe damage, and wreckage distribution, indicated that the aircraft impacted terrain in a steep nose-down, inverted attitude, while rolling rapidly to the left. This is also consistent with the conclusion that the aircraft entered the incipient phase of a spin. The Investigation concluded that the attempted '*Split S*' manoeuvre was an unsuitable recovery technique given the height of the aircraft at that time. It was noted that there was no evidence of a failure of the engine, airframe or flight controls during the flight. The Investigation determined from the available evidence that there was no fuel starvation or excessive 'g' loading involved in the accident.

It was identified that aircraft categorised under *Annex II* of *Regulation (EC) 216/2008*, are exempt from the requirements of *Regulation (EU) 1178/2011* and are subject to national licensing requirements. National licensing authorities have issued exemptions in order to accept an EASA Part-FCL licence as valid for pilots wishing to fly *Annex II* aircraft. The Investigation concluded that in order to provide a high uniform level of safety in Europe for aerobatic flying, which is a high risk activity, pilots wishing to conduct aerobatics should be subject to a minimum standard, even if the aircraft has been categorised as *Annex II* under Regulation (EC) 216/2008. Following discussions with *Director General of Mobility and Transport,* the Investigation has issued a Safety Recommendation in this regard.

3. CONCLUSIONS

3.1 Findings

1. The Pilot had taken delivery of the aircraft on 13 March 2016, which was seven days prior to the accident.

2. A *'Special Certificate of Airworthiness'* had been issued by the CAA of the Netherlands and was valid at the time of the accident.

3. The Pilot was appropriately licensed to conduct the flight in accordance with the requirements of the CAA of the Netherlands.

4. The Pilot had previously held a Display Authorisation issued by the UK CAA which expired on 2 July 2015.

5. The Pilot had previously been granted a Display Authorisation by the IAA for the *Midland Flightfest* at EIAB for 31 May-1 June 2015, on the basis of the UK CAA Display Authorisation.

6. The aircraft was authorised by the IAA to operate in Ireland under the terms of Aeronautical Notice *AN19: Visiting aircraft not holding ICAO compliant Certificates of Airworthiness.*

7. The aircraft was exempt from the Basic EASA Regulation (Regulation (EC) 216/2008) by virtue of being categorised under 'Annex II' of the Regulation as an "aircraft of which at least 51 % is built by an amateur".

8. *Regulation (EU) 1178/2011* (The EASA Aircrew Regulation) introduced additional ratings for a number of air activities, including *FCL.800 Aerobatic Ratings.*

9. The aircraft "(*and pilots thereof*)" were exempt from *Regulation (EU) 1178/2011 FCL.800 Aerobatic Ratings* by virtue of being an '*Annex II*' aircraft under the *Basic EASA Regulation.*

10. There was no record of the Pilot undergoing a course of instruction for the Laser Z200 or any other aircraft of an equivalent performance capability.

11. The Pilot had previously conducted one flight in the Laser Z200 since taking delivery of the aircraft.

12. The Pilot was aware that people were watching the flight from the ground, and that this may have influenced the Pilot's decision to attempt aerobatics at circuit height.

13. Meteorological conditions were not a factor in the accident.

14. The Investigation concluded that the altimeter subscale was set to provide the Pilot with a display of his height above the ground during the flight.

15. Fuel contamination or starvation was not a factor in the accident.

16. The aircraft completed three touch and go landings.

17. Eyewitnesses were of the opinion that each sequence of manoeuvres was initiated from the published circuit height of approximately 800 ft. Photogrammetric calculations supported this opinion.

18. The aircraft conducted a number of aerobatic manoeuvres including inverted flight and aileron rolls at a height lower than that prescribed in *SERA.5005 Visual Flight Rules*.

19. The total flight time was approximately 13 minutes and 48 seconds.

20. Comprehensive maintenance and flying records that had been delivered with the aircraft were available to the Investigation. The records indicated that there were no pre-existing mechanical issues and that the aircraft was airworthy prior to the accident flight.

21. There was no indication of an in-flight mechanical failure of the engine or propeller system.

22. Examination of the wreckage and video footage confirmed the continuity of the controls prior to impact.

23. A loss of consciousness by the Pilot due to 'g' force was considered to be unlikely to have occurred.

24. The Watch Manager of the IAA Air Navigation Services Division 'Shannon Centre' informed the Investigation that there had been no radio communications between ATC and the Pilot of PH-LSR prior to the accident.

25. During the final circuit, the Pilot attempted two sequential aileron rolls on the downwind leg.

26. The attempted second aileron roll resulted in the aircraft exiting the manoeuvre in a nose-down, inverted attitude.

27. During the recovery from the nose-down, inverted attitude, the aircraft was seen to descend and roll rapidly to the left, consistent with the incipient phase of a spin.

28. The aircraft impacted in a steep nose-down, inverted attitude.

3.2 Probable Cause

Impact with terrain following entry into the incipient phase of a spin while attempting to recover from a low-level aerobatic manoeuvre.

3.3 Contributory Cause(s)

1. Aerobatic manoeuvres conducted at an altitude that provided an insufficient safety margin.

2. Inexperience on the Laser Z200 aircraft type.

3. Inexperience conducting aerobatic manoeuvres in a competition aerobatic aircraft with the performance capabilities of the Laser Z200.

4. Inappropriate control inputs when conducting aileron rolls resulting in a significant loss of altitude.

5. An absence of uniform regulatory requirements to complete formal training in the conduct of aerobatic flying in *Annex II* aircraft such as the Laser Z200.

4. SAFETY RECOMMENDATIONS

No.	It is Recommended that:	Recommendation Ref.
1.	The Director General of Mobility and Transport should consult with EASA in order to define common minimum aerobatic training requirements for pilots wishing to operate, for the purposes of aerobatic flight, aircraft categorised under Annex II of Regulation (EU) 216/2008.	IRLD2017012

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- END -

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