Air Accident Investigation Unit Ireland

SYNOPTIC REPORT

Serious Incident
Stolp Starduster TOO SA-300, G-UINN
Ballyboy Airfield, Co. Meath

1 June 2019

An Roinn Iompair
Department of Transport

Foreword

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

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

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

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

[1] **Annex 13**: International Civil Aviation Organization (ICAO), Annex 13, Aircraft Accident and Incident Investigation.

[2] **Regulation (EU) No 996/2010** of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation.

[3] **Statutory Instrument (SI) No. 460 of 2009**: Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulations 2009.

AAIU Report No: 2022 - 001
State File No: IRL00919025
Report Format: Synoptic Report
Published: 24 January 2022

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No 996/2010 and the provisions of SI No. 460 of 2009, the Chief Inspector of Air Accidents, on 1 June 2019, appointed Kevin O'Ceallaigh as the Investigator-in-Charge to carry out an Investigation into this Serious Incident and prepare a Report.

Aircraft Type and Registration:	Stolp Starduster TOO SA-300, G-UINN	
No. and Type of Engines:	1 x Lycoming O-360-A4A piston engine	
Aircraft Serial Number:	HB1980-1	
Year of Manufacture:	1980	
Date and Time (UTC)[4]:	1 June 2019 @ 16.20 hrs	
Location:	Ballyboy Airfield, Athboy, Co. Meath (EIMH)	
Type of Operation:	General Aviation	
Persons on Board:	Crew – 1	Passengers – 1
Injuries:	Crew – Nil	Passengers – Nil
Nature of Damage:	Minor	
Commander's Licence:	Private Pilot Licence (PPL) Aeroplane (A), issued by the Irish Aviation Authority (IAA)	
Commander's Age:	59 years	
Commander's Flying Experience:	425 hours, of which 35 were on type	
Notification Source:	The Operator of the airfield on behalf of the Pilot of the aircraft	
Information Source:	AAIU Field Investigation A report submitted by the Pilot	

[4] **UTC**: Co-ordinated Universal Time. All times in this report are quoted in UTC unless otherwise stated; local time was UTC + 1 hour on the date of the occurrence.

SYNOPSIS

The Pilot had conducted a general handling and aerobatics flight in the aircraft, a Stolp Starduster TOO SA-300 biplane, followed by a return to land on the westerly grass runway at Ballyboy Airfield, Co. Meath. During the landing roll, the left main undercarriage leg gradually collapsed, causing the aircraft to veer to the left. During the subsequent runway excursion, the aircraft impacted a perimeter fence adjacent to the runway and came to rest facing in a south-easterly direction. The Pilot and Passenger were both uninjured. There was no fire.

NOTIFICATION

The AAIU was notified by the owner of the airfield immediately after the runway excursion had occurred. An Inspector of Air Accidents travelled to the airfield and commenced an Investigation.

1. FACTUAL INFORMATION

1.1 History of the Flight

The Pilot informed the Investigation that he had travelled to EIMH having decided that the weather conditions were suitable to conduct a routine flight in the aircraft. The Pilot was accompanied by one Passenger. The Pilot completed a pre-flight inspection and the aircraft departed in an easterly direction from Runway (RWY) 11 at approximately 16.00 hrs. The Pilot said that the purpose of the flight was to complete some general handling and basic aerobatic manoeuvres overhead the airfield for approximately 20 minutes. The Pilot stated that there was a gentle southerly wind, and therefore decided to land on RWY 29; the reciprocal of the runway used for take-off.

As the aircraft touched down on the grass strip, the Pilot noticed that the aircraft was leaning to the left and identified that the left undercarriage leg was probably damaged. The Pilot noted that, as the aircraft slowed, directional control on the runway became increasingly difficult to maintain, and the aircraft began to veer towards the left edge of the runway. The aircraft departed from the grass strip and continued to turn to the left. When the lower left wing made contact with the ground, the aircraft turned sharply to the left. The aircraft came to rest facing in a south-easterly direction, with the lower right wing leading edge making contact with a fencepost. The Pilot and Passenger exited the aircraft in the normal manner, unaided. There was no fire.

1.2 Injuries to Persons

No injuries were reported to the Investigation.

1.3 The Aircraft

1.3.1 General

The Stolp Starduster TOO SA-300 Biplane, the main fuselage of which is constructed from tubular steel with a Ceconite[5] fabric covering. The main wing spars are made of pre-cut and shaped Sitka Spruce with pre-cut Finnish Birch ribs. The two seats are arranged in a tandem, open-cockpit configuration, with the pilot sitting in the rear seat and the passenger seated in the front seat. The aircraft is powered by a Lycoming O-360-A4A piston engine, and is permitted to conduct basic aerobatic manoeuvres. It has a fixed main undercarriage with a steerable tailwheel.

The subject aircraft was built in 1980, and is categorised in *Regulation (EU) 2018/1139 on the common rules in the field of civil aviation* (which superseded *Regulation (EC) 216/2008*) as an Annex I aircraft. Annex I aircraft are exempt from the provisions of the Regulation. It was amateur-built in Canada and spent a number of years on the Irish civil aircraft register. The aircraft was re-registered in the United Kingdom (UK) in 1998 and was being operated under a '*Permit to Fly'* issued by the UK Light Aircraft Association[6] (LAA) in accordance with Article 40 of the UK Air Navigation Order 2016. Following an airworthiness review completed on 29 October 2018, the UK LAA issued a *Permit to Fly Certificate of Validity,* required by Article 41(4) of the UK Air Navigation Order 2016, which was valid until 6 November 2019[7]. The application for renewal of the '*Permit to Fly*' included the aircraft inspection report that was completed as part of that airworthiness review. The check of the landing gear during the inspection included *'Landing gear assemblies and attachment fittings, brake systems, hoses and pipes, wheels and tyres, skids, bungee rubbers*'. This section of the inspection report was initialled by both the aircraft owner and an LAA Inspector to indicate a satisfactory result.

The Pilot said that he purchased the aircraft from the previous owner in 2016 and based the aircraft at EIMH. The engine tachometer readings recorded in the aircraft technical log indicated a total of 5,810 hours.

The IAA informed the Investigation that when Annex I aircraft, not registered in Ireland, are intended to be operated in Irish airspace, owners are required to comply with '*Aeronautical Notice A.19: Visiting aircraft not holding ICAO compliant Certificates of Airworthiness'.* The explanatory note to A.19 states:

[5] **Ceconite:** A proprietary aircraft fabric covering based upon a specialised polyester fabric, which is approved for use by the Federal Aviation Administration (FAA).
[6] In 1998, the UK LAA was formerly called '*The Popular Flying Association'*.
[7] Article 41(4) states that '*A national permit to fly is not in force unless the permit includes a current certificate of validity issued by the CAA or by a person approved by the CAA for that purpose*.'

'Where there is a need for the aircraft to be in Ireland for a continuous period of more than 28 days, a specific permission from the IAA will be required. Aircraft which remain in Ireland beyond the 28 day limit may be excluded from availing of this exemption.

Application for exemptions for aircraft not meeting the criteria of A.19 or for extended visits must be made in the manner specified by the Irish Aviation Authority in AWSD.F.138C 'Temporary Operations in Ireland for aircraft without a Certificate of Airworthiness'.'

The IAA further informed the Investigation that there was '*no record of a permission to fly an aircraft without a valid Certificate of Airworthiness in the Republic of Ireland being applied for or being granted for an aircraft registered as G-UINN in accordance with Aeronautical Notice A.19'*.

1.3.2 Undercarriage Assembly

The aircraft was equipped with a fixed main undercarriage and with a steerable tailwheel. A construction diagram of the undercarriage is shown in **Appendix A,** and is shown in a simplified view in **Figure No. 1**. For clarity, the components called Brace (No. 10), Brace (No. 8), Strut (No. 6), and Housing (No. 14) in the original construction diagram have been renamed as horizontal brace, diagonal brace, strut and housing respectively.

5

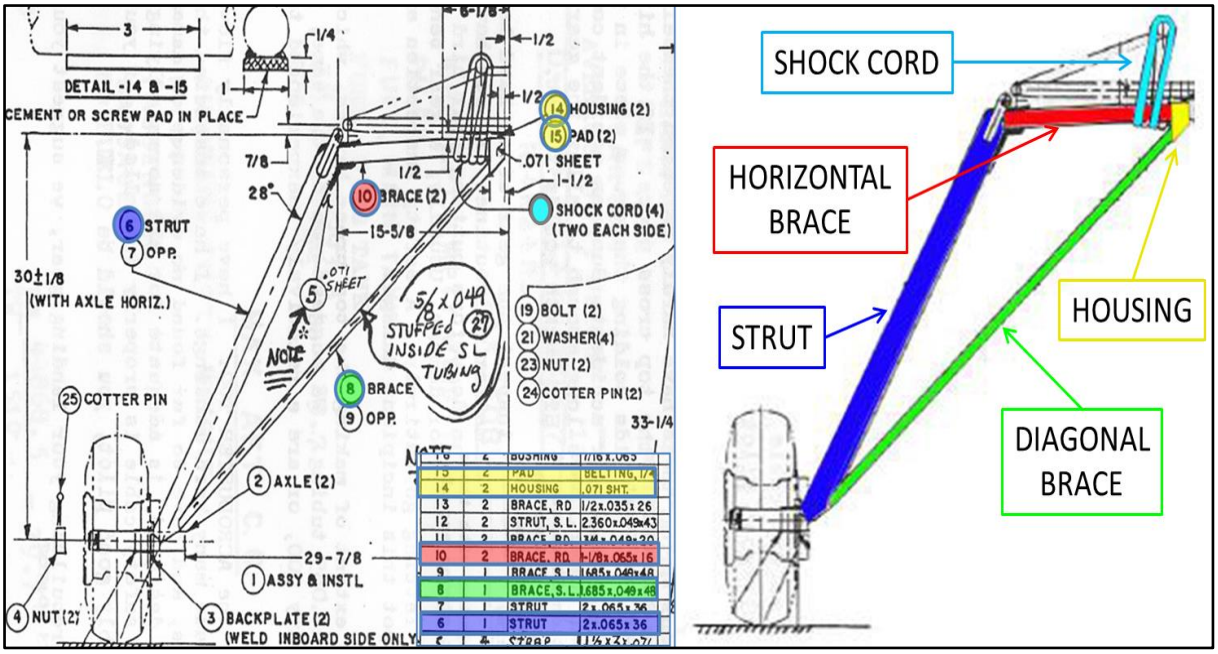


Figure No. 1: Left Main Undercarriage (looking forward), with simplifed view (right).

Each main undercarriage leg consists of a strut attached to a horizontal brace. A diagonal brace, which provides rigidity, is fitted between the bottom of the strut and the housing. A rubber mounting pad (No.15 in **Figure No. 1**) is attached to the housing for damping. The shock cords (two on each side) are fitted between the horizontal brace and the aircraft structure, and function as both vibration dampers and shock absorbers for the undercarriage leg during taxi, take-off and landing. A close-up of the undamaged right main undercarriage assembly is shown in **Photo No. 1**.

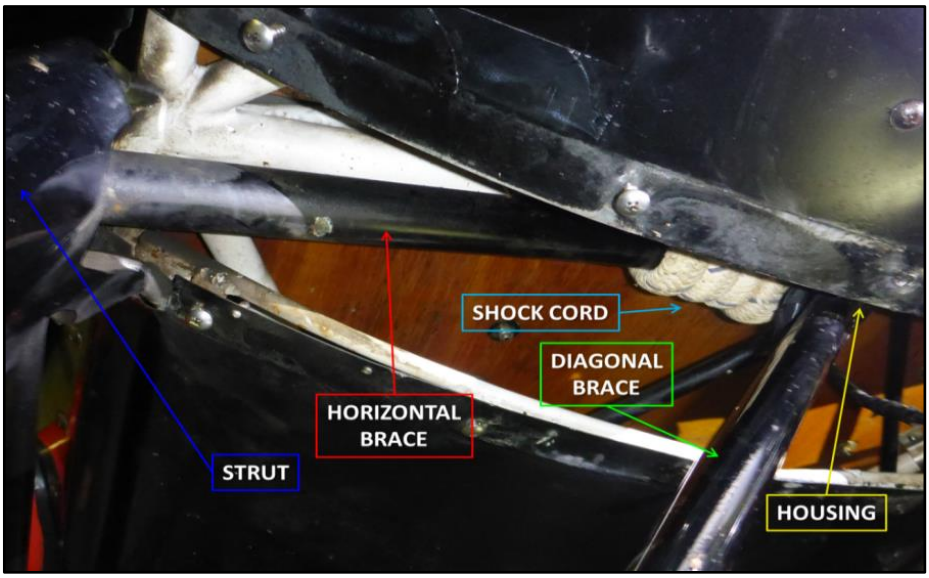


Photo No.1: Right main undercarriage assembly of G-UINN looking rearwards.

The horizontal brace is made from tubular steel and is specified in the original drawing as having a diameter of 1.125 in (inches) and a wall thickness of 0.065 in. Although this aircraft type is purchased in kit form for later assembly, the landing gear leaves the factory as a complete assembly.

In an April 1996 edition of the Aircraft Manufacturer's publication '*The Starduster Magazine*' (See **Appendix B**), it was noted that *'The Starduster TOO landing gear was designed to collapse or fail, before damage was done to the fuselage. The gear was easier, and cheaper, to repair than is the fuselage.'* Subscribers to the Manufacturer's magazine were also informed by the author that;

> *'We are modifying our gears to the extent of making the top cross* [horizontal] *braces, which the shocks wrap around, out of 1¼ x .065 tubing. We suggest you do the same, particularly if you have an extra heavy TOO, or are a relatively inexperienced tail dragger pilot'*

The Investigation noted that any proposed modifications by the Manufacturer were suggestions, and not mandatory. The author of the article further stated that '*Therefore, I believe the gear, as designed, is adequate for all normal flying and quite hard landings.'* The article concluded by suggesting that anybody who is '*just now building, or rebuilding, your landing gear, we suggest you increase the size of the top cross piece'.*

The article also noted that

> *'…many owners have the safety cable which wraps around the gear, on much too tight. This safety cable is on for one purpose only; and that is to keep the gear from collapsing if the shock cords break. It is NOT on there to keep the shocks from breaking; but only to save the situation in case they DO break. If the safety cable is too tight, the gear will hit the cable, hard, before the shocks have hardly extended themselves. This means that the cable will probably bend the top cross piece* [horizontal brace]. *If the hit is hard enough, and the bend great enough, the welds holding the cross piece in place will fracture, and we will have another landing gear accident.'*

1.4 The Airfield

Ballyboy Airfield (also known as Athboy Airfield) is a privately owned airfield that is located 47 kilometres (km) north-west of Dublin Airport (EIDW). The Aeronautical Information Publication (AIP) that was valid at the time of the occurrence stated that the grass runway[8] was 600 metres (m) in length and 18 m wide, which was contained inside an overall grass strip area of 675 x 60 m. The prepared grass runway was designated as RWY 11/29 (**Figure No. 2**). The aircraft documentation did not quote specific take-off or landing distances, but the Pilot informed the Investigation that the normal landing roll for the aircraft was in the order of 300 m.

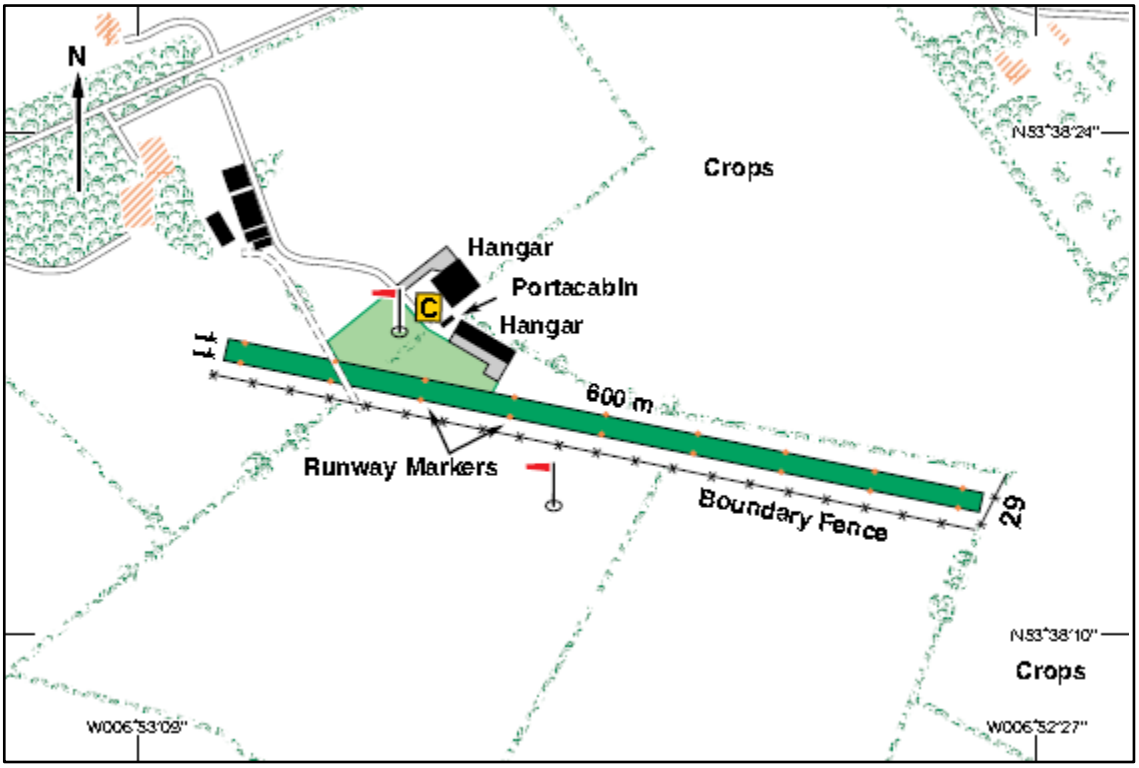


Figure No. 2: Ballyboy Airfield (EIMH), Co. Meath (Pooleys)

[8] Since the date of the occurrence, a tarmac runway of 600 m in length has been constructed parallel to, and to the south of, the grass runway at EIMH.

1.5 Weather

The Irish Meteorological Service (*Met Éireann*) provided the Investigation with an aftercast of the prevailing weather conditions at the time of the occurrence.

The general meteorological situation showed that a warm front was moving northwards across the country giving a light south to south-east airflow. Between the surface and 3,000 feet (ft), there were stable warm sector conditions with light winds, which would have resulted in a relatively uniform flow.

The surface wind was from a southerly direction at 5 knots (kts), the estimated visibility was 35 kilometres, and the outside air temperature was 17 degrees Celsius. There was a layer of broken[9] stratocumulus clouds at 2,000 ft and the aftercast indicated that there were outbreaks of drizzle in the vicinity. Photographic and video data taken soon after the time of the excursion showed that the runway was dry. An Inspector of Air Accidents examined the runway two hours after the occurrence and noted that the surface of the grass strip was dry.

1.6 Wreckage Information

The aircraft was examined by an Inspector of Air Accidents shortly after the occurrence[10]. It was located approximately 390 metres (m) from the threshold of RWY 29 (**Photo No. 2**). It had come to rest against a wooden fencepost which was supporting the perimeter fence on the south side of the airfield. The fence ran parallel to the runway, approximately 12 m from the runway edge. The propeller blade was loosely entangled in the strands of the fence-wire, but the strands were not wrapped around the propeller hub.

Photo No. 2: The position of G-UINN following the runway excursion.

[9] **Broken:** A measure of cloud cover defined as between 5/8th and 7/8th of full cover.

[10] A subsequent inspection was conducted by two Inspectors of Air Accidents in a hangar at the airfield a number of days later.

The leading edge of the lower right wing had contacted a fence post causing some scuffing and deformation of the leading edge (**Photo No. 3A**), and there was a hole in the underside of the lower left wing where it had contacted the grass during the excursion **(Photo No. 3B**).

Photo No. 3A: Lower right wing Leading Edge. **Photo No. 3B:** Underside of lower left wing.

The housing from the left undercarriage assembly was visible below the aircraft fuselage, having detached from the horizontal brace. The housing had also fractured where it joined the diagonal brace, but was still partially attached. (**Photo No. 4**).

Photo No. 4: Housing partially attached to the diagonal brace

There were ground scars on the runway (**Photo No. 5A and 5B**) that extended from the point where the Pilot said that the aircraft touched down, to the aircraft's final position. These scars were made by the aircraft's right undercarriage leg. The scars originated near the centre of the runway and curved gradually to the left prior to exiting the runway. The final scars also showed where the left wingtip contacted the ground as the aircraft pivoted to its final position against the fence.

Photo No. 5A: Initial ground scar **Photo No. 5B:** Final ground scars

An examination of the left undercarriage assembly showed that the safety cable was present, and was not tightened to the point that would prevent the horizontal brace from moving freely as described in the *Starduster Magazine*. The rubber mounting pad (No.15 in **Figure No. 1**) was missing from the housing (**Photo No. 6**). The Pilot subsequently informed the Investigation that the respective rubber mounting pad from the right undercarriage housing was also missing, and may have been missing for a considerable period of time. The Investigation noted that the cockpit 'g' meter indicated that a maximum of +3.4 g, and a minimum of +0.6 g had been recorded[11].

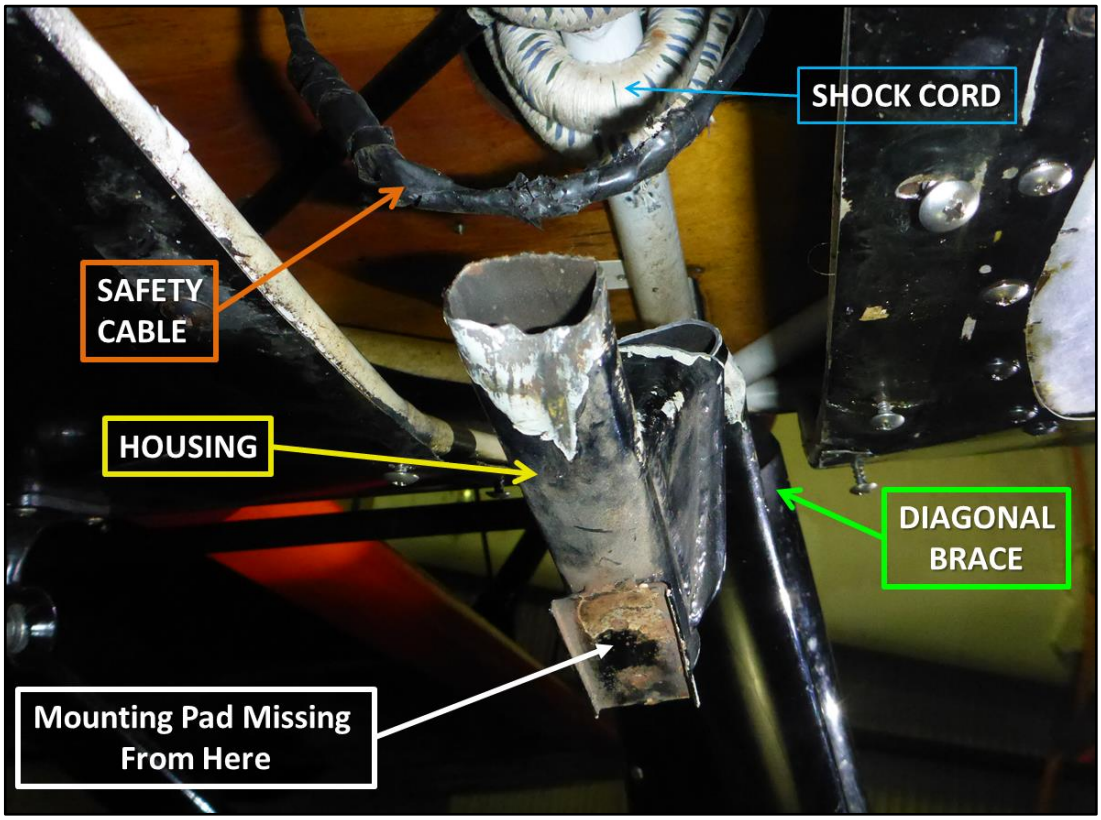


Photo No. 6: View of the damaged left undercarriage assembly

[11] The Aircraft Manufacturer's Pilot's Operating Handbook states that the aircraft is limited to ±6g in both normal and inverted flight.

1.7 Personnel

The Pilot held a Private Pilot Licence (Aeroplane), issued on 11 February 2011 by the IAA. The Pilot held a Single Engine Piston rating for Landplanes (SEP (Land)), which had been revalidated on 20 April 2019. The rating was valid until 30 June 2021. The Pilot held a Class Two Medical Certificate issued by the IAA, which was valid until 3 July 2019. The Pilot had a total of approximately 35 flight hours on type, six of which were in the previous 90 days.

Total all types:	425 hours
Total on type:	35 hours
Total on type P1:	35 hours
Last 90 days:	6 hours
Last 28 days:	3 hours
Last 24 hours:	30 minutes

Table No. 1: Pilot's Flying Experience

1.8 Interviews

1.8.1 Pilot in Command

The Pilot said that the taxi and take-off was normal. He said that he departed at 17.00 hrs local time and practiced some loops and rolls. He said that although the aircraft is limited to 6 g, the aerobatic manoeuvres during the flight did not exceed 2-3 g approximately. After 30 minutes, he returned to the field to land on RWY 29. The approach and initial landing was normal. He said that soon after touchdown he felt what he described as a '*mushy, sinking feeling*'. As the aircraft decelerated on the runway, he found it increasingly difficult to maintain directional control, and it required '*huge control inputs*' to keep the aircraft straight. He said that he noticed that the left wing was dropping and so he shut down the engine to minimise any damage to it or the propeller. As the speed further reduced, the left wing touched the ground and the aircraft turned sharply to the left. The aircraft came to rest against the perimeter fence, facing in a south-easterly direction. The Pilot said that he and the Passenger exited the aircraft unaided, and that they were both uninjured. He said that the entire event from touchdown until the aircraft came to a stop was a gradual event, and he did not recall any specific moment where the failure of a component could be identified.

The Pilot stated that he bought the aircraft in late 2016, and it was stored at Ballyboy, prior to which the aircraft was based in the UK. He was aware that the aircraft had been involved in an accident in 1998 (See **Section 1.10**) and had been rebuilt at that time. He also said that, around the same time, the roof of the hangar that the aircraft was being stored in collapsed due to snow. This had caused the aircraft undercarriage legs to splay due to excessive weight. He understood that the '*bungee*' cords had been replaced after this event.

1.8.2 Passenger

The Passenger was interviewed by the Investigation. He said that he had flown in the aircraft a number of times previously, and that this flight was no different to the other flights. He said that following some aerobatics, the aircraft returned to the airfield and conducted a normal approach. After the touchdown, which was normal and without any bounce, he felt the aircraft sinking on the left side. He looked down at the left wheel and saw it canting out to where it should not be. He knew that it was not possible to see the undercarriage wheels from the rear seat, so he called to the Pilot to '*cut mags*' to shut down the engine.

He said that the turn rate and bank angle increased as the speed reduced until the left wing touched the ground. He said that it was like '*being in slow motion'*. He said that they confirmed that the fuel and magnetos were off and they both exited the aircraft. The Passenger also confirmed that the aircraft did not experience any type of sudden failure event, and that the entire landing and excursion was a gradual process.

1.9 Recording Devices

The Pilot provided the Investigation with a video which was recorded by an acquaintance. The video consisted of five seconds of recorded data consisting of a portion of the aircraft's take-off roll on RWY 11. The video was taken from in front of a hangar located to the north of the runway. The Investigation extracted seven still images from the video, and created a composite image of the take-off roll (**Photo No. 7**). As the aircraft comes into view on the right of the image, it is travelling at sufficient speed for the Pilot's control inputs to lift the tail-wheel off the ground. As the aircraft continues its initial take-off roll, it encounters a dip in the grass runway. As the aircraft exits the dip, the wheel struts can be seen to compress initially and then expand causing the aircraft to become airborne momentarily. The aircraft does not appear to have sufficient airspeed to remain airborne and it touches down again. There appears to be a small incline on the runway at this point, and the wheel struts can be seen to compress when the aircraft touches down. For the remainder of the take-off roll following this touchdown (the three aircraft images on the left side of **Photo No. 7**), the aircraft appears to be travelling consistently in a left wing low attitude. The aircraft disappeared from view behind another aircraft, and the video ended before the aircraft was seen again.

Photo No. 7: Composite image of the take-off roll extracted from recorded video

1.10 Previous Event

On 19 July 1998, the aircraft (while under previous ownership) was involved in an off-field landing in the UK. An Investigation Report[12] published by the UK Air Accidents Investigation Branch (AAIB) stated that the aircraft experienced an engine failure, most likely due to carburettor icing. The aircraft landed in a barley field and pitched forward onto its nose. The Report indicated that the aircraft would be rebuilt the following winter. The UK AAIB informed the Investigation that it did not have any additional information relating to the occurrence or subsequent maintenance or repair other than what was published in the original Report.

1.11 Maintenance History

In light of the previous accident, combined with the Pilot's statement about a hangar roof collapsing on the aircraft, the Investigation requested the assistance of the UK AAIB to locate previous records of maintenance carried out on the aircraft. The UK LAA provided the Investigation with comprehensive documentation relating to the maintenance and annual permit renewal inspections conducted on the aircraft from when it was placed on the UK register in early 1998.

The records indicate that between late 1998 and mid-2001, the aircraft underwent a substantial schedule of work which included a complete disassembly and rebuild of the aircraft. The schedule of work noted that tasks to dismantle the aircraft commenced in February 1999, and an entry in the records for March 1999 noted that the aircraft fuselage was beyond repair and would need replacement. This process continued through March and April 1999. The records noted that, in late April 1999, two full days were dedicated to repairing the undercarriage, and it was noted as being fitted to the fuselage in May 2000.

Contemporaneous photographs of the work in progress were submitted to the UK LAA with the schedule of work. The photographs provided additional evidence to support the schedule of work entries which indicated that, although the aircraft fuselage was replaced, the original undercarriage was retained and repaired. The work was completed in July 2001, and the final summary of the work done by the repair facility stated:

> *'**WORK DONE:** Receive aircraft dismantled, check damage and found requires new airframe, port upper and starboard lower wings. Repairs to vertical fin and one undercarriage leg. Remove engine and sent to* [Named Engine Maintenance Facility]*. Carry out all work to return aircraft to airworthy condition, as per drawings supplied by Stolp Starduster Corporation. Details of work retained on worksheets held on record at* [Named Repair Facility]*.'*

The worksheets did not identify which undercarriage leg had been repaired, or what specific repair had been completed. The undercarriage bungee shock cords were not mentioned in the worksheets.

[12] UK AAIB Report Number EW/G98/07/26 published in AAIB Bulletin No. 10/98.

1.12 Metallurgical Examination

1.12.1 General

The Investigation sent the horizontal brace and the housing to a metallurgical expert to conduct an examination and failure analysis of the components. The horizontal brace had fractured at both ends, and the diagonal brace had fractured where it joined the housing.

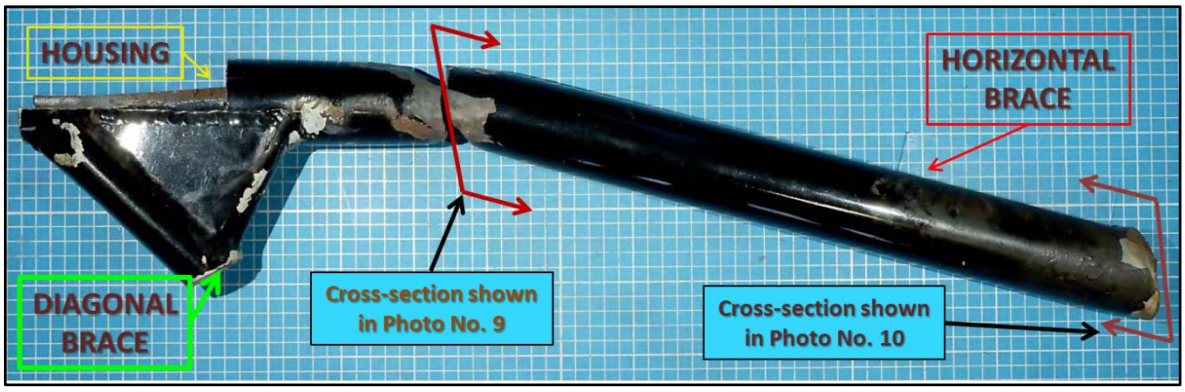


Photo No. 8: Horizontal brace and housing

1.12.2 Horizontal Brace

The outer diameter of the brace was measured to be 1.125 in. The metallurgical expert informed the Investigation that the horizontal brace had not been modified per the suggestion in '*The Starduster Magazine'*, which proposed increasing the diameter to 1.25 in. The wall thickness of the tube was measured to be 0.055 in., which was less than the 0.065 in specified in the original drawings. However, it was difficult to gain an accurate measurement of the wall thickness, due to the curvature of the tube and the presence of paint coatings. Furthermore, tube specifications typically allow a tolerance of around ±12%[13], for the wall thickness of tubes of comparable diameters to the horizontal brace. Therefore, the metallurgist did not consider the difference between the measured and specified wall thickness to be significant.

The metallurgical expert determined that the modification proposed in '*The Starduster Magazine'* represented a 28% increase in the resistance to buckling failure, compared to the original specification that was fitted to G-UINN. However, since the applied loading which caused the buckling of the brace was not known, it was impossible to determine whether or not the modification, or the difference in the wall thickness of the tube, would have prevented the occurrence. Furthermore, it was not possible to differentiate between any distortion, which may have been caused during fabrication, or from the buckling caused by overloading during operation.

[13] The UK LAA informed the Investigation that the exact tolerance for aircraft tubing of this type quoted in AMS6360 and AMS-T-6736 is ±10%.

1.12.2.1 Inboard Fracture

The inboard fracture surface of the horizontal brace is shown in **Figure No. 3**. Images labelled **B**, **C**, and **D,** are microscopic images of the respective areas highlighted in image **A**. Near its inboard end, the brace had fractured 50 millimetres (mm) from its joint with the housing.

There was significant buckling of both the topside and the underside of the tube, adjacent to the fracture plane. Bending of the tube in the downward direction had caused its underside to become buckled and flattened. Within this region, crack progression markings were evident on the fracture surface. They indicated that multiple, incipient fatigue cracks had initiated on the outer diameter of the tube and propagated through its wall thickness **(Image B)**. As they did so, they coalesced to form a single fatigue crack front, which had reached approximately 25 mm in length. The remainder of the fracture surface was inclined on 45 degree shear planes. This was consistent with instantaneous overloading of the remaining cross-section, due to the advancing fatigue crack. Much of this region of final separation showed a shiny, burnished appearance, caused by rubbing against the mating fracture surface (**Image C**). Rusting was present on those regions of final separation (**Image D**), which had not been burnished by rubbing. The metallurgist stated that these characteristics indicated that, prior to the accident, there had been a period of operation of the aircraft after the tube had separated.

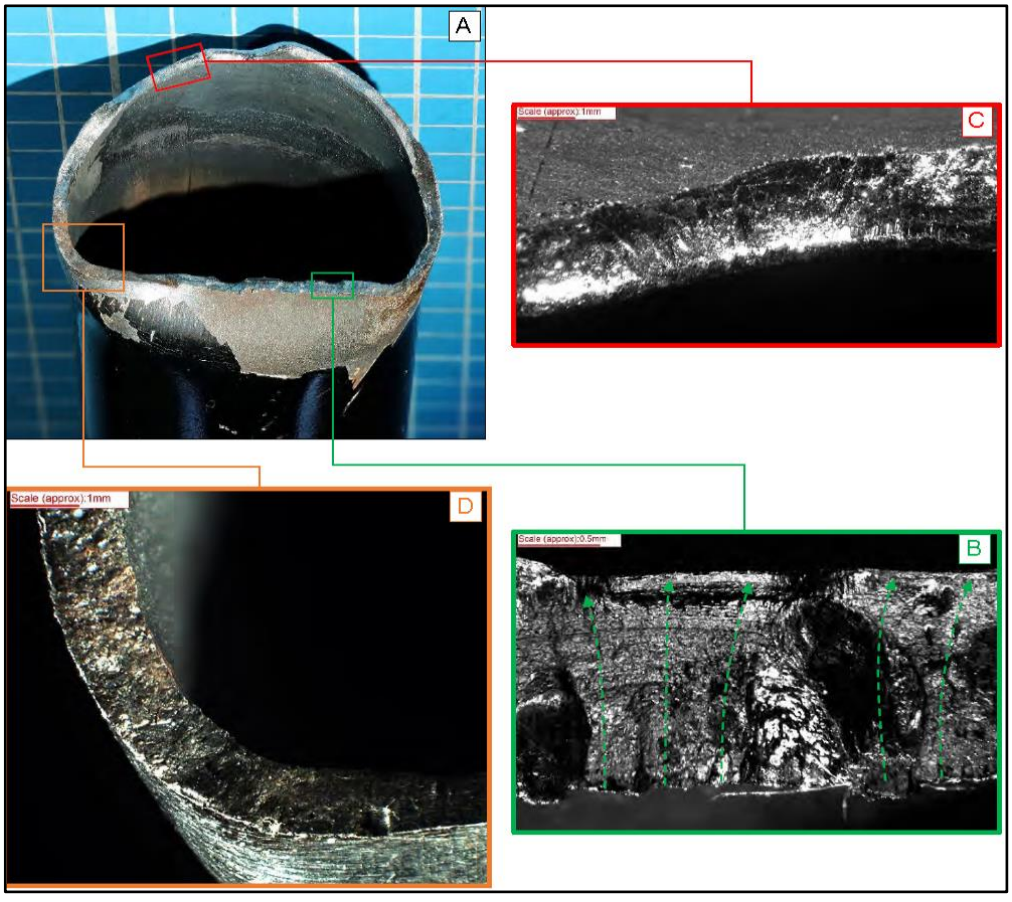


Figure No 3: Microscopic images of the inboard failure of the horizontal tube

The metallurgical expert noted that the buckling on the underside of the tube was consistent with bending of the brace in the downward direction. The magnitude of this downward bending load had exceeded the yield stress of the tube and, according to the metallurgical expert, had occurred at some time prior to the occurrence landing. The consequent buckling had provided a site of concentration for cyclic stresses arising from take-off, landing and taxiing loads, which acted in an upward direction. Over multiple flight cycles, this had caused the initiation and growth of fatigue cracks within the buckled region, until the remaining un-cracked cross-section became overloaded. At this point, the horizontal brace separated at its inboard end. The metallurgical analysis could not specifically determine when this yield stress was exceeded.

The buckling on the topside of the tube was most evident on the section which had remained attached to the housing. It was considered by the metallurgical expert that this buckling most likely had occurred either during the act of final separation or by contact between the opposing fracture surfaces, after separation.

The metallurgical expert considered it possible that the buckling described above could have been caused during an emergency landing which had taken place on 19th July 1998. However, this could not be proven. It was considered equally possible that it may have occurred at some time afterwards but before the date of the subject occurrence, including during the roof collapse described by the Pilot.

The aircraft owner reported that the rubber mounting pads may have been missing from the landing gear housings for some time prior to the accident. Their purpose was to ameliorate impacts between the housing and the underside of the airframe, as the landing gear moved up and down against the force provided by the shock cords. Their absence would have allowed metal to metal contact between the housing and the airframe. The metallurgical expert stated that this would have caused abnormal dynamic loading on the landing gear and may have contributed to the failure.

1.12.2.2 Outboard Fracture

At its outboard end, the brace had fractured at its joint with the strut (**Figure No. 4**). Buckling was evident on the topside of the tube, adjacent to the fracture plane. It was consistent with a bending load, which had exceeded the yield stress of the tube. The entire fracture surface area was clean and free from rusting. This indicated that there had been no significant period of aircraft operation, post-fracture. The characteristics of the fracture surfaces indicated that an instantaneous overload failure had initiated at the bottom of the tube and spread around its circumference, with final separation occurring at the top.

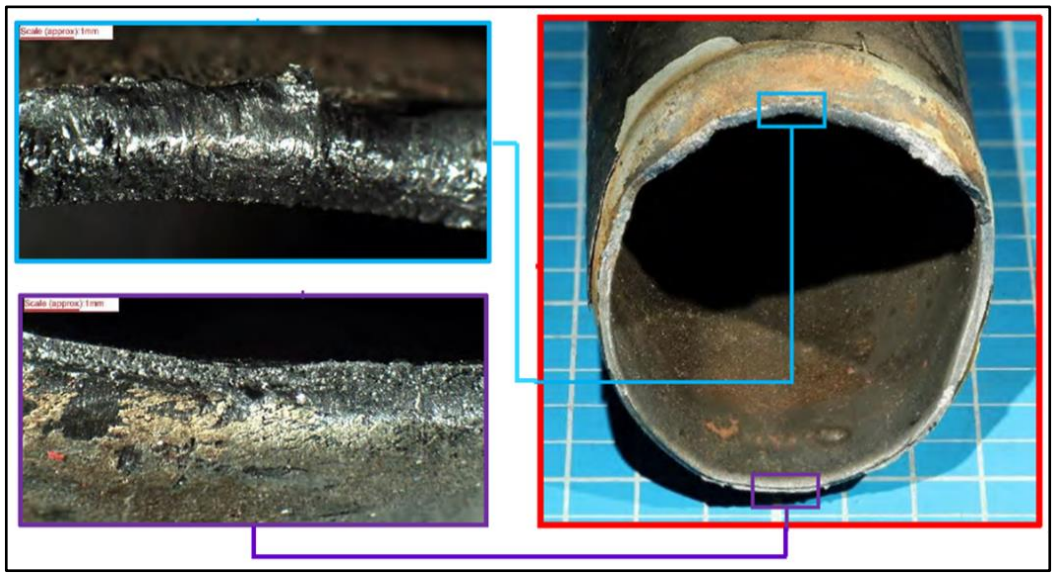


Figure No. 4: Microscopic images of the outboard failure of the horizontal tube

1.12.3 Diagonal Brace

The diagonal brace had fractured at its junction with the housing (**Photo No. 9**). The fracture plane was predominantly aligned on 45 degree shear planes, consistent with an instantaneous overload failure. The entire fracture surface area was clean and free from rusting. This indicated that there had been no significant period of aircraft operation post-fracture. The lighter coloured fracture surface on the diagonal brace, shown in the lower portion of **Photo No. 9**, occurred when the diagonal brace was manually separated from the housing by an Inspector of Air Accidents for the metallurgical analysis to be conducted.

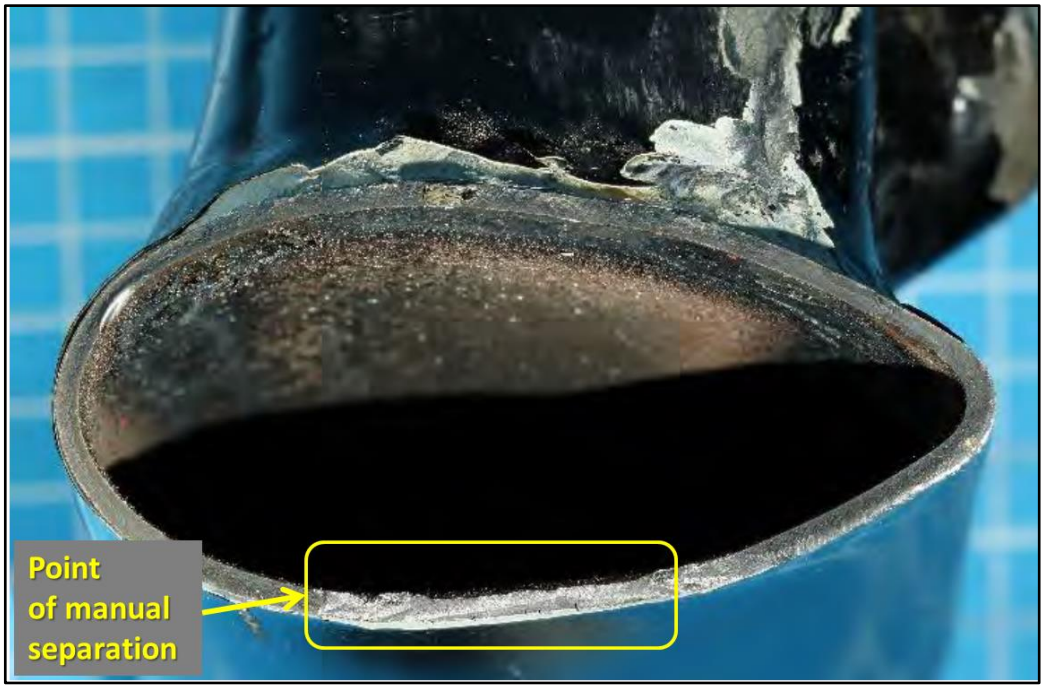


Photo No. 9: Fracture point of the diagonal brace with the housing

2. ANALYSIS

2.1 General

Following a general handling flight that included aerobatics, the aircraft returned to the airfield to land on RWY 29. Both the Pilot and Passenger stated that the landing was normal, without any bounces or hard impact. The aircraft's left wing began to gradually drop until the left wingtip touched the ground, causing the aircraft to turn rapidly to the left. The aircraft came to rest against the perimeter fence to the south of the runway, facing in a south-easterly direction.

An inspection of the wreckage by two Inspectors of Air Accidents indicated a failure of the left undercarriage leg. The horizontal brace and housing were sent to a metallurgical expert for examination. The Investigation was also provided with a video recording of a portion of the aircraft's take-off roll. The UK LAA provided the Investigation with historic records of the aircraft's '*Permit to Fly*' certifications, and previous maintenance records dating back to 1998 when the aircraft was first placed on the UK civil aircraft register.

The IAA informed the Investigation that that there was no record of a permission to fly an aircraft without a valid Certificate of Airworthiness in the Republic of Ireland being applied for or granted for an aircraft registered G-UINN in accordance with Aeronautical Notice A.19.

2.2 Metallurgical Analysis

The metallurgical examination found that the outer diameter of the brace was 1.125 in. indicating that the landing gear on G-UINN had not been modified per the proposal in '*The Starduster Magazine*', which suggested increasing the diameter to 1.25 in. The metallurgical expert found that bending of the tube in the downward direction had caused its underside to become buckled and flattened. The analysis indicated that at its inboard end, the horizontal brace had failed by fatigue. Buckling on the underside of the tube had acted as a point of concentration for cyclic stresses, arising from take-offs, landings and taxiing. Over multiple flight cycles, the fatigue cracks grew (**Photo No. 10**) until the remaining cross-section became overloaded, resulting in separation of the tube. This indicated that the buckling had occurred at some time prior to the date of the occurrence.

The metallurgical expert stated that the mating fracture surfaces at the inboard end of the horizontal brace had rubbed against each other after the tube had separated, as indicated by the burnished appearance of the surfaces. This indicated that there had been a period of aircraft operation, after the brace had separated at its inboard end. The Pilot provided the Investigation with a video which showed the aircraft settling abnormally low on the left landing gear leg during the take-off roll that had immediately preceded the accident landing. The Investigation considered the possibility that this may have coincided with the separation of the horizontal brace at its inboard end. However, rusting was present on those regions of final separation which had not been burnished by rubbing. This would indicate that the inboard final separation probably occurred at an earlier time.

Photo No. 10: Failure sequence of the inboard horizontal tube

19

Metallurgical examination indicated that the fractures at the outboard end of the horizontal brace and on the diagonal brace had both been caused by instantaneous overloading. There was no significant evidence of rubbing or rusting on their fracture surfaces. This indicated that these failures were recent, with no significant period of aircraft operation afterwards. It was considered most likely that they had occurred during the occurrence flight.

2.3 Video Recording

The video recording showed part of the aircraft's take-off at the start of the occurrence flight. During the take-off roll, the aircraft can be seen to become airborne momentarily as it exited a dip in the grass runway. However, the aircraft had not attained sufficient flying speed and landed back onto the grass runway. There was a small incline on the runway at this touchdown point and the touchdown appeared to be firm. From this point onwards in the video, the aircraft can be seen to be in a consistent left wing low attitude.

The metallurgical examination revealed that there had been a period of aircraft operation after separation of the inner end of the brace. This was evidenced by burnishing of the fracture surfaces. However, the rusting of the inner end of the brace identified during the examination indicated that this failure had occurred at some time prior to the occurrence flight. The video recording indicated that a partial failure of the undercarriage leg may have occurred during the take-off roll, causing the aircraft to maintain a left wing low attitude thereafter. The Pilot and Passenger said that they did not experience a sudden failure of the undercarriage leg during the landing. This would suggest that the aircraft's left wing low attitude during the take-off was probably as a result of the failure of the outer end of the horizontal brace at the moment of the firm touchdown on the runway during the take-off roll. The diagonal brace would then have been subjected to atypical loading, and may have failed during either the take-off or landing.

2.4 Previous Events

The Investigation was informed of two previous events involving G-UINN. The first was subject to an Investigation by the UK AAIB, and involved a forced landing in a barley field in July 1998. This was four months after the aircraft was placed on the UK civil aircraft register. The AAIB Report indicated at the time that the aircraft would be subject to a rebuild in the winter of 1998/99. The other previous event involved a report by the Pilot that the roof of a hangar collapsed on the aircraft around the same time, resulting in the replacement of the shock cords on the undercarriage.

20

The maintenance history provided by the UK LAA showed that a rebuild of the aircraft was carried out between February 1999 and July 2001, including removal of the undercarriage to allow replacement of the fuselage structure. Given that this was due to a heavy vertical loading on the aircraft, and that the Manufacturer's April 1996 publication stated that "*The Starduster TOO landing gear was designed to collapse or fail, before damage was done to the fuselage",* it is reasonable to assume that the undercarriage would have experienced significant vertical loads during this event. The worksheets recorded a repair of one of the undercarriage legs. The removal and refitting of the undercarriage would likely have also required the fitting of rubber mounting pads which were noted to be missing during the Investigation's examination of the aircraft. The Pilot said that he thought they may have been missing for some period of time. The metallurgical examination noted that this would have caused abnormal dynamic loading on the landing gear and may have contributed to the failure.

2.5 Failure Sequence

The metallurgical examination determined that the inner end of the horizontal brace failed at some point prior to the occurrence landing, as indicated by the rusting on the inner end of the horizontal brace. The metallurgical examination of the outer end of the brace, combined with the video recording, would indicate that the final failure in overload of the outer end of the horizontal brace probably occurred during the take-off roll on the occurrence flight. The assembly, which was not under load once airborne, was probably held in place by the shock cords until the landing. The landing loads caused the left undercarriage leg to splay out, as witnessed by the Passenger. This would have adversely affected directional control, resulting in the runway excursion. Following the failure of the horizontal brace, the diagonal brace was likely subjected to atypical loading and may have failed either during the take-off or landing. The absence of damage to the propeller, and the fact that the wire from the perimeter fence was not wrapped around the propeller hub, indicated that the propeller was not rotating at the moment of impact with the fence.

3. CONCLUSIONS

3.1 Findings

1. The aircraft was originally home-built in Canada in 1980. The aircraft was registered in the United Kingdom (UK) in 1998 and operated under a *'Permit to Fly'* issued by the UK LAA.

2. The UK LAA Certificate of Validity was valid at the time of the occurrence.

3. The IAA informed the Investigation that that there was no record of a permission to fly an aircraft without a valid Certificate of Airworthiness in the Republic of Ireland being applied for or being granted for an aircraft registered G-UINN in accordance with Aeronautical Notice A.19.

4. The Pilot's licence, rating and medical certificate were valid for the flight being undertaken.

5. The aircraft's horizontal brace for the undercarriage was made from tubular steel, which was specified in the original drawing as having a diameter of 1.125 in and a wall thickness of 0.065 in.

6. In the April 1996 edition of an Aircraft Manufacturer's publication, it was suggested to modify the landing gear to make the horizontal brace from 1¼ x 0.065 in tubing, while also noting that '*the gear, as designed, is adequate for all normal flying and quite hard landings.'*

7. The UK LAA informed the Investigation that the dimensional checks of the horizontal brace determined that the diameter was outside the 10% tolerance specified in AMS6360 and AMS-T-6736. The metallurgical expert did not consider the observed difference between the measured and specified wall thicknesses to be significant.

8. The rubber mounting pads were missing from both undercarriage housings.

9. There was significant buckling of both the topside and the underside of the left horizontal brace, adjacent to the fracture plane. Bending of the tube in the downward direction had caused its underside to become buckled and flattened. Within this region, crack progression markings were evident on the fracture surface.

10. The presence of both rusting and burnishing on the inner face of the left horizontal brace indicated that it had failed at some time prior to the occurrence flight.

11. The characteristics of the fracture surfaces at the outer end of the horizontal brace indicated that an instantaneous overload failure had initiated at the bottom of the tube and spread around its circumference, with final separation occurring at the top.

12. The left diagonal brace had fractured at its junction with the housing. The fracture plane was consistent with an instantaneous overload failure.

13. The video recording provided to the Investigation indicated that the outer end of the left horizontal brace probably failed during the take-off roll on the occurrence flight.

14. The aircraft had been involved in a previous event in the UK, and the Pilot informed the Investigation of a second event at the time involving the collapse of a hangar roof onto the aircraft.

15. The UK LAA records indicated that the aircraft underwent a substantial rebuild between 1998 and 2001, including the replacement of the aircraft fuselage.

16. During this maintenance, one of the undercarriage legs was noted in the work sheet to have been repaired.

17. The Pilot and Passenger noted that they did not experience any sudden failure of the undercarriage during the landing sequence. Both noted that the landing gear leg gradually splayed to the left as the aircraft decelerated.

3.2 Probable Cause

The aircraft experienced a runway excursion on landing, following the collapse of the left undercarriage leg, due to fatigue cracking at the inner end of the landing gear horizontal brace.

3.3 Contributory Causes

1. Instantaneous overload failure of the outer horizontal and diagonal braces, following the fatigue cracking of the inner horizontal brace.

2. A previous event had caused buckling of the inner horizontal brace, which acted as a point of concentration for the cyclic stress.

3. The fact that the mounting pads were missing from both undercarriage legs likely resulted in abnormal dynamic loading on the landing gear over time.

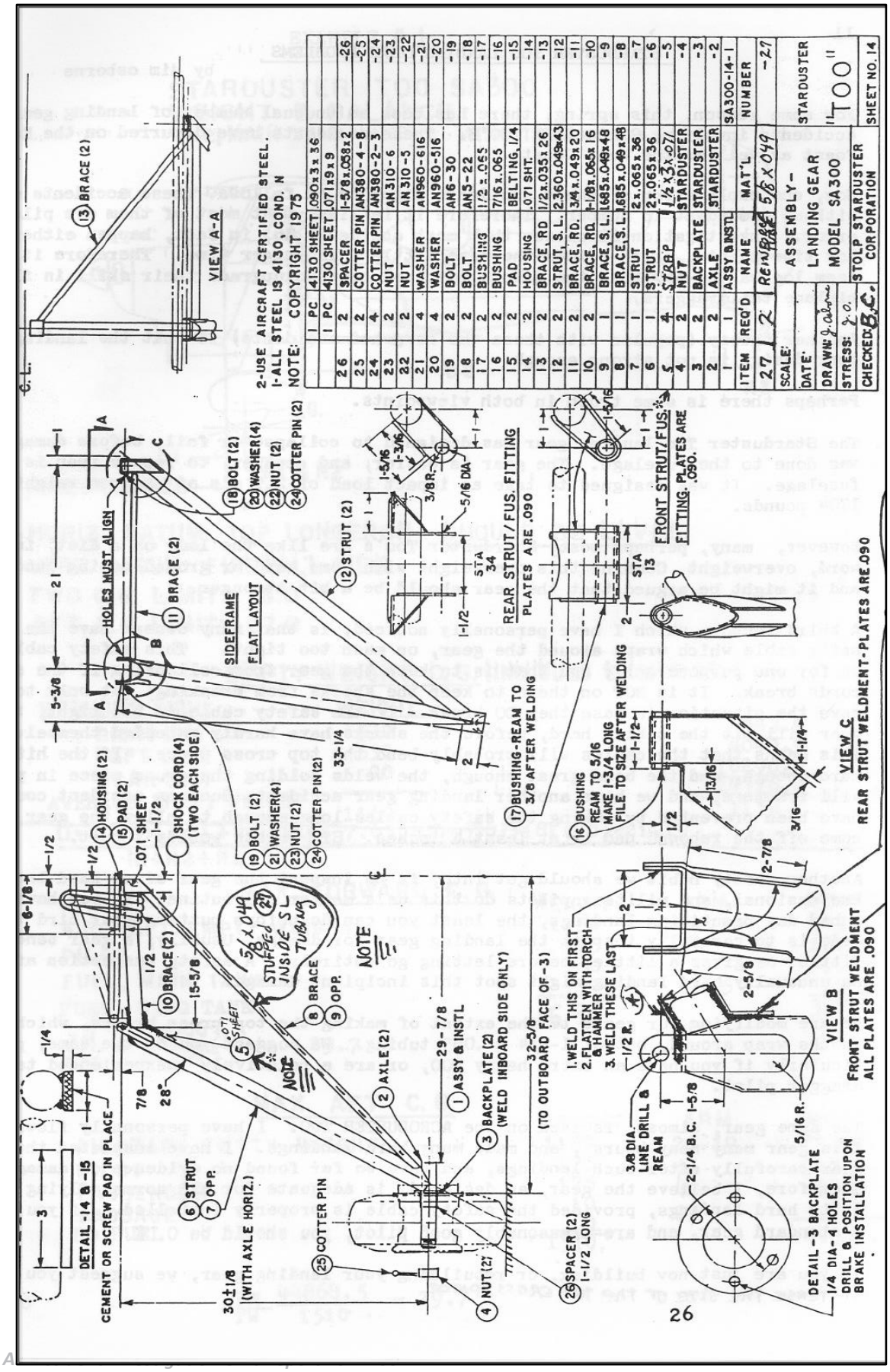
4. SAFETY RECOMMENDATIONS

This Investigation does not sustain any Safety Recommendations.

- END -

Appendix A:

Undercarriage Construction – Stolp Starduster TOO



Appendix B:
Extract from *'The Starduster Magazine'* – April 1996 Edition

STARDUSTER TOO LANDING GEAR PROBLEMS

by Jim osborne

FOR some reason, this spring, there has been an unusual number of landing gear accidents involving STARDUSTER TOO'S. These accidents have occurred on the East Coast as well as the West Coast.

Now, one explanation of these accidents might be as follows. These accidents are without precedent in number. Therefore it is likelythat most of them are pilot error. Investigation discloses that most accidents do, in fact, happen either to low time pilots, or to pilots who have little taildragger time. Therefore it would seem logical to say that the pilots involved need to upgrade their skill in flying biplane taildraggers.

Another theory (popular with those who have had accidents) is that the landing gear design is not strong enough.

Perhaps there is some truth in both viewpoints.

The Starduster Too landing gear was designed to collapse or fail, before damage was done to the fuselage. The gear is easier, and cheaper, to repair than is the fuselage. It was designed to take an impact load of 2.5 g's at a gross weight of 1704 pounds.

However, many, perhaps most, Starduster Too's are like the lady on a diet, in a word, overweight. Combine this overweight with some hard or groundlooping landings and it might be argued that the gear should be a bit stronger.

A third factor, which I have personally noticed, is that many owners have the safty cable which wraps around the gear, on much too tight. This safety cable is on for one purpose only; and that is to keep the gear from collapsing if the shock cords break. It is NOT on there to keep the shocks from breaking; but only to save the situation in case they DO break. If the safety cable is too tight, the gear will hit the cable, hard, before the shocks have hardly extended themselves. This means that the cables will probably bend the top cross piece. If the hit is hard enough, and the bend great enough, the welds holding the cross piece in place will fracture, and we have another landing gear accident. Such an accident could have been prevented by making the safety cables long enough to allow the gear to come off the rebound pad by at least 4 inches. Six inches wouldn't hurt.

Another safety habit we should get into, is to inspect the gear after hard landings. Professional, and military pilots do this as a matter of routine. If you have had a bad day practicing landings, the least you can do before putting your bird to bed, is to carefully inspect the landing gear for damage. Usually, a gear bends a little. or gives a little, before letting go entirely. A safety inspection after an unusually hard landing might spot this incipient damage.

We are modifying our gears to the extent of making the top cross braces, which the shocks wrap around, out of 1-1/4 x .065 tubing. We suggest you do the same, particularly if you have an extra heavy TOO, or are a relatively inexperienced tail dragger pilot.

The same gear, almost, is used on the ACRODUSTER TOO. I have personally flown this gear many many hours , and made many hard landings. I have inspected the gear carefully after such landings, and have so far found no evidence of damage. Therefore, I believe the gear, as designed, is adequate for all normal flying and quite hard landings, provided the safety cable is properly installed. If you have a standard gear, and are areasonably good pilot, you should be O. K.

If you are just now building, or rebuilding your landing gear, we suggest you increase the size of the top cross piece

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

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

Produced by the Air Accident Investigation Unit

AAIU Reports are available on the Unit website at www.aaiu.ie

An Roinn Iompair
Department of Transport

Air Accident Investigation Unit,
Department of Transport,
2nd Floor, Leeson Lane,
Dublin 2, D02TR60, Ireland.

Telephone: +353 1 604 1293 (24x7)
Email: info@aaiu.ie
Web: www.aaiu.ie
Twitter: @AAIU_Ireland