DUTCH
SAFETY BOARD

Damage to left wing spar

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The Hague, August 2018

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The Dutch Safety Board

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N.B. This report is published in the English language with a separate Dutch summary. If there is a difference in interpretation between the report and the summary, the report text wil prevail.

CONTENT

GENERAL OVERVIEW

Identification number:	2016072
Classification:	Accident
Date, time of occurrence:	15 July 2016, 14.20 hours
Location of occurrence:	Larserveld
Registration:	PH-1006
Aircraft type:	SZD-51-1 "Junior"
Aircraft category:	Glider
Type of flight:	Local
Phase of operation:	En route
Damage to aircraft:	Substantial to left wing spar
Flight crew:	One
Passengers:	None
Injuries:	None
Other damage:	None
Light conditions:	Daylight

SUMMARY

After a flight of more than one hour, the pilot decided to perform several loops. At that point, the glider was at an altitude of approximately 700 metres. The pilot stated that he increased the speed to 180 km/h and gradually initiated the loop. The first loop went without incident. The pilot then initiated a second loop in the same manner. During the final phase of this second loop, when the glider was flying horizontally again, the pilot heard a loud bang behind him. The pilot still had full control over the glider and flew an alternative circuit before landing safely.

A post flight inspection revealed cracking in the left wing, at the end of the glass-fibre reinforced plastic (GFRP) spar. Investigation revealed that the crack already existed before the occurrence took place. The aluminium insert in the wing spar had detached from the GRFP material, causing some freedom of movement, which resulted in high local stresses in the spar. It is likely that the spar eventually failed by a high load at the end of the loop. The cause of the detachment of the aluminium insert could not be established with certainty.

On the day that the occurrence took place, the gliding club, which owns the glider, notified the Dutch Safety Board. On 20 July 2016 the Dutch Safety Board notified the EU, EASA and the State Commission on Aircraft Accident Investigation (SCAAI) in Poland about the occurrence. SCAAI appointed an Accredited Representative as Poland is the State of Design and Manufacture. EASA assigned a technical adviser.

In cooperation with the Polish Civil Aviation Authorities, Allstar PZL Glider (as the Type Certificate Holder) is working on a Service Bulletin, which will define the unscheduled inspection of adhesion of the aluminium insert in the wing's spar(s). This would be applicable for all the gliders involved in hard landings and/or ground loops. Furthermore, the inspection will appear as scheduled inspection work in a supplement to the Technical Service Manual. At the time of publication of this report, the Service Bulletin and the supplement were not yet ready.

1.1 History of the flight

The single-seater SZD-51-1 "Junior" glider took off at 13.11 hours from Larserveld airfield by making use of a winch. After a thermal flight of more than an hour, the pilot decided to perform several loops to loose altitude. According to the pilot, the flight had been uneventful, so far. When the pilot started his loop manoeuvre, the glider was at an altitude of approximately 700 metres. The pilot stated that he increased the speed to 180 km/h and gradually initiated the loop. The first loop went without incident. He then initiated a second loop in the same manner. During the final phase of this loop, when the glider was flying horizontally again, the pilot heard a loud bang behind him. He described the sound to be similar to the breaking of a glass filled with water. The pilot still had full control over the glider, so he flew an alternative circuit before landing safely. A post flight inspection revealed substantial damage to the left wing spar.

1.2 Injuries to persons

The occurrence did not result in any injuries to the pilot.

1.3 Damage to the aircraft

The glider sustained substantial damage as a result of the occurrence. A crack was present at the top of the end of the spar of the left wing.

Figure 1: Failed spar of the left wing observed from the leading edge side. (Photo: NLR)

1.4 Other damage

No objects other than the glider sustained damage.

1.5 Personnel information

The pilot in command, a 54 year old man, was in the possession of a valid glider pilot licence and a valid medical certificate.

He had a total flying experience on gliders of 266 hours of which 34:30 hours were on type. He had made a total of 1026 flights of which 106 flights were on type. In the last three months the pilot had made 99 flights, totalling 45:48 hours. The pilot stated that he had made a total of about 100 loops.

1.6 Aircraft information

The SZD-51-1 "Junior" is a single-seater glider with a wing span of 15 meters, specifically designed for early solo and recreational flying. It has a fixed undercarriage. The glider is made up of a glass-fibre/epoxy and glass-fibre reinforced plastic (GFRP) structure.

The glider is certified in the "U" (utility) category. According to the Flight Manual a positive loop is an aerobatic manoeuvre that is permitted. Section 4, normal procedures, of the manual mentions that before starting an aerobatic manoeuvre the glider should be trimmed at 120 to 140 km/hour airspeed, and locking of the trimming device and air brakes should be checked. The flight manual also states that the glider performs a loop correctly and smoothly with an entry airspeed of 165 to 175 km/hour. The limits for the load factor are +5,3g and -2,65g. The ultimate load factor limits are +7,95g and -3,97g.

According to the manufacturer, Allstar PZL Glider, a total of 251 SZD-51-1 "Junior" gliders had been produced which have a combined average total flying time of 3000 hours. The manufacturer stated that no occurrences similar to the event with PH-1006 have been reported.

PH-1006 was manufactured by PZL Bielsko[1] in Poland in 1993 and has serial number B-2129. The glider had made a total of 16.009 flights and had flown 4124 hours up to and including the date of the occurrence. The last 50 hours inspection was performed on 24 June 2016.

PH-1006 had undergone scheduled maintenance checks, during which no failures in the area of the main fittings of the wing spar were revealed.

The glider was not equipped with a G-force indicator.

1 Allstar PZL Glider is a successor of the former SZD, also called "PZL Bielsko" for a couple of years.

Wing spar

The wing spar consists of two unidirectional glass-fibre reinforced plastic (GFRP) spar cups that extend from the wing; see Figure 2. Between the spar cups two C-frames, that consist of ten layers of GFRP, are put together to make a tubular shape. An aluminium insert is enclosed at the end of the tubular shape consisting of the two C-frames. This structure is wrapped in three layers of GFRP. The aluminium insert is pickled and coated with a primer prior to assembly. The aluminium insert is then glued to the C-frames using an epoxy resin with a filler. A steel pin is inserted into the aluminium insert. During assembly of the wings to the glider the steel pins slide into the opposite wing and the positions of the two spars are secured with another pin that goes through the middle of both spars; see Figure 3.

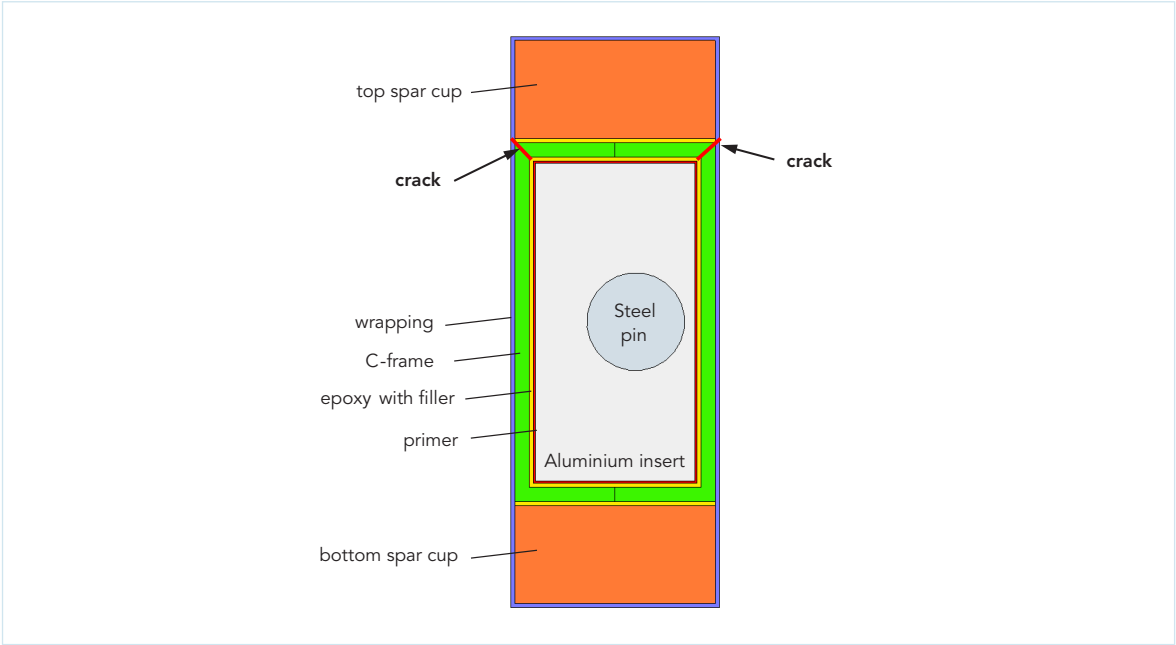

Figure 2: Schematic of the cross-section of the spar. (Photo: NLR)

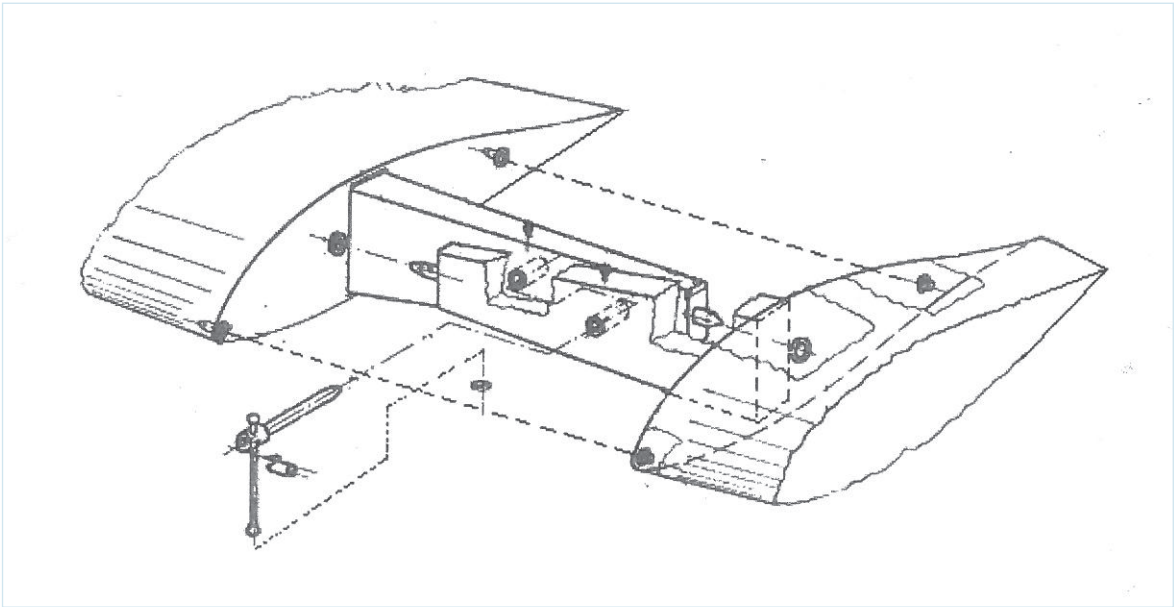

Figure 3: Representation of how both wings are mounted to each other via the spars. (Photo: Allstar PZL Glider)

Mass and centre of gravity
Based on the weight of the pilot it was determined that the mass and centre of gravity of the glider were within the prescribed limits.

Aircraft History
During its lifespan, PH-1006 was involved in one earlier (known) occurrence. It made an off-field landing in 1994 in high vegetation where both wings were damaged. On 8 August 1994 both wing spars were repaired. In the corresponding work order it is stated that the laminate and sandwich fractures at the bottom and top of the left wing in the spar area had to be repaired.

On 12 March 2015 Allstar PZL Glider issued a certificate of release to service[2] for PH-1006 after a 1000 hours inspection had been performed. The glider had made a total of 3797:40 flying hours. No remarks regarding damage to the spar of the left wing were made on the certificate. The glider was recognized as airworthy.

1.7 Meteorological information

At the time of the occurrence visual meteorological conditions prevailed. The wind came from the west with a speed of 5 meters per second (m/s). The visibility was more than 10 kilometres. Scattered cumulus clouds were present at 1.000 meters.

1.8 Aerodrome information

Larserveld airfield is located close to the village of Biddinghuizen and has a grass strip with a length of 1200 meter. The runway direction is 05/23.

1.9 Data recorders

The glider was not equipped with data recorders.

1.10 Tests and research

On behalf of the Dutch Safety Board the Netherlands Aerospace Centre (NLR) carried out a failure analysis of the left wing spar of PH-1006. The results of this analysis were recorded in a report and handed over to the Dutch Safety Board.[3] The Dutch Safety Board received a report of Allstar PZL Glider regarding their assessment of the occurrence with PH-1006.[4]

2 No 46/2015.
3 Failure analysis of a glider left wing spar, Junior SZD-41, tail number PH-1006; report number NLR-CR-2016-412; November 2016.
4 Assessment of the incident of SZD-51-1 Junior sailplane, reg. PH-1006, S/N B-2129; 7 February 2017.

1.11 Additional information

Allstar PZL Glider informed the Dutch Safety Board that a hard landing had taken place with another SZD-51-1 "Junior", which had caused some white discoloration in the corner, along the glue layer of the upper part of the spar towards the inner wall. After removing three layers of fabric, which form the outer wall, it turned out that the discoloration was a crack of the inner wall, which had penetrated in the glue.

This glider was manufactured in 1987 and has serial number B-1789. It had flown 2.027 hours.

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The Dutch Safety Board (DSB) informed the parties involved, among which the State Commission on Aircraft Accident Investigation in Poland, by a notification about the occurrence. The DSB then requested the Netherlands Aerospace Centre (NLR) to investigate the cause of the cracking in the glass-fibre reinforced plastic (GRRP) spar of the left hand side wing. The glider was transported to the NLR location Marknesse for investigation. Designers from Allstar PZL glider visited this location for one day and carried out the inspection of the affected glider. They initially concluded that a fault in the manufacturer process might have been the cause of the detachment of the aluminium inset from the GRPF material. The following days the NLR inspected parts of the spar by the scanning electron microscope (SEM). After the DSB had released the glider, the owner transported it to Allstar PZL glider in Poland for repairs. Allstar PZL glider also performed further inspections on the glider.

Description of work by NLR
The spars of the left and right hand wings were inspected and photographed. The lower fracture surface at the trailing edge (TE) and the aluminium insert were removed from the spar of the left hand wing. A cross-section of the lower TE fracture surface was made to observe the lay-out of the TE C-frame and the wrapping. The lower TE fracture surface near the end of the spar was coated with platinum to avoid electric charging. This was inspected by the SEM. A cross-section of the leading edge C-frame was made to inspect the lay-out.

Results and conclusions of NLR
The number of layers in the TE C-frame and the wrapping were according to specification. During removal of the aluminium insert it was noticed that the aluminium insert had some freedom of movement and was not fixed to the C-frames anymore. With loss of adhesion between the GFRP spar and the aluminium insert the load is transferred to a small line of contact at the end of the spar and the top of the aluminium insert and a small line of contact at the bottom of the aluminium insert towards the middle of the spar. This would result in high local stresses in the C-frames and in the wrapping at the end of the spar. At the end of the loops the loads on the steel pin are highest and in an upward direction. The crack location at the top of the aluminium insert corresponds with a high load on the steel pin at the end of the loop and the moment when the pilot heard a cracking sound. Therefore, it is likely that the spar failed by a high load at the end of the loop. The irregularly shaped particles and the discoloration on the fracture surface close to the origin of the crack indicate that the crack grew to a certain length prior to the overload. The presence of a crack prior to the occurrence indicates that the end of the spar was highly loaded and could indicate that the aluminium insert was already detached from the GFRP material for some time prior to the occurrence. The reason for the poor adhesion was outside the scope of the investigation performed by the NLR.

Hypotheses
Three hypotheses were considered to explain the failure of the spar:

- Overloading of the design specifications as a result of exceeding the prescribed limits during the loop.
- A fault in the aircraft's design specifications or the manufacturer process.
- Overloading of the glider during exploitation in the past.

The pilot stated that he performed a loop without exceeding the prescribed limits. This could not be verified as the glider was not equipped with a data recorder and/or a G-force indicator.
The DSB did not investigate the aircraft's design specifications. The manufacturer stated that a stamp of the Polish Civil Aviation Authority (CAA) was present on the box (the lower fracture surface at the trailing edge). Formerly, the boxes were recognized as critical elements and the CAA was involved into their approval before giving permission to continue the manufacturer process. However the DSB could neither confirm nor rule out a fault in the manufacturer process.
Both wings of the glider were damaged during an off-field landing in 1994. However, it could not be proven that or when overloading of the glider had taken place in the past.

Right hand wing
Allstar PZL glider performed an inspection of the right hand wing. No damage was found in the wing; only a small area of initial delamination between the spar cup and the composite C-frame was present.

CONCLUSIONS

- The number of layers in the trailing edge C-frame and the wrapping of the spar of the left hand wing are according to design specification.
- During removal of the aluminium insert it was noticed that the aluminium insert had some freedom of movement and was not fixed to the C-frames anymore.
- With loss of adhesion between the GFRP spar and the aluminium insert the load is transferred to a small line of contact at the end of the spar and the top of the aluminium insert and a small line of contact at the bottom of the aluminium insert towards the middle of the spar. This would result in much higher local stresses in the C frames and in the wrapping at the end of the spar.
- The crack location at the top of the aluminium insert corresponds to a high load on the steel pin at the end of the loop and the moment when the pilot heard a cracking sound. Therefore, it is likely that the spar failed by a high load at the end of the loop.
- The irregularly shaped particles and the discoloration on the fracture surface close to the origin of the crack indicate that the crack grew to a certain length prior to the overload at the end of the loop. This implies that the crack already existed before the pilot initiated the second loop.
- The presence of a crack prior to the occurrence indicates that the end of the spar was highly loaded and could indicate that the aluminium insert was already detached from the GFRP material for some time prior to the occurrence.
- The cause of the detachment of the aluminium insert from the GFRP material could not be established with certainty.
- During scheduled maintenance checks (including several 1000 flight hours inspections in the past) no failures in the area of the main fitting of the spar were revealed.

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