Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A09Q0071

IN-FLIGHT BREAKUP OF THE RIGHT WING

AVENTURIER C-GZIR
LAC AU MIRAGE, QUEBEC
13 MAY 2009

Canada

Aviation Investigation Report

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Summary

On 13 May 2009, around 1200, Eastern Daylight Time, the Aventurier, an amateur-built, float-equipped aircraft (registration C-GZIR, serial number 001) took off from Lac Prinzèles, Quebec, for a local flight under visual flight rules. The aircraft headed south and began rolling. It then turned to the left toward Lac au Mirage, Quebec, where it crashed. Shortly after, it was found floating upside down at the surface of the water with only the floats visible. No one saw the aircraft crash. Both occupants were fatally injured.

Ce rapport est également disponible en français.

Other Factual Information

At around 1200, [1] the aircraft took off from Lac Prinzèles, which is located in the municipality of Lac Bouchette, Quebec, for a day of fishing in the area. About 3 km south of Lac Prinzèles, the aircraft headed south and turned east toward Lac au Mirage (see Appendix A – Approximate Flight Path).

Around 1215, there was a loud impact noise. Shortly after, the aircraft was found floating upside down at the surface of the water. No one witnessed the crash.

At 1200, weather conditions at Roberval Airport, which is 18 nautical miles north of Lac Prinzèles, were good for visual flight, with a few clouds at 4500 feet, visibility of 40 statute miles, winds from the south-southwest at 11 knots and a temperature of 20°C. The altimeter setting was 30.25 inches of mercury, indicating the presence of high pressure in the region. The weather forecasts for the remainder of the day indicated similar conditions.

The owner/pilot had obtained his private pilot's licence in December 1982 and had accumulated nearly 4500 flying hours, most of which on float-equipped aircraft. His most recent medical examination took place on 18 October 2007 and was valid until 01 November 2009.

The pilot met the recency requirements for carrying passengers, which are set out in the *Canadian Aviation Regulations* [2] (CARs) as he had conducted six flights prior to the occurrence. However, the investigation was not able to determine whether the recurrent training requirements [3] had been met, because no recurrent training documents were found. Furthermore, Transport Canada (TC) does not keep this type of data on private pilots. The pilot recency requirements were not a factor in the occurrence flight.

The aircraft's weight and balance could not be calculated with certainty, as no documents reflecting its existing configuration could be found. The total estimated take-off weight was 2055 pounds, which includes the weight of the modified aircraft, the weight of a full tank of fuel and the weight of the occupants and their luggage. The maximum authorized take-off weight was 2200 pounds.

The Aventurier C-GZIR was built in 2003 from parts of an advanced ultralight Club Aéronautique Delisle Inc. (C.A.D.I.) model that had been involved in an accident in July 2002 (see Photo 1). The fuselage and tail were re-used after they were modified and repaired, as were certain parts of the flight controls. The flaps were 82 inches long and the ailerons were 72 inches in length. The wings were each 178 inches long and had been built with new ribs and coverings.

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1 All times are Eastern Daylight Time (Coordinated Universal Time minus four hours).

2 Paragraph 401.05(2)(*b*).

3 Paragraph 401.05(2)(*a*).

The coverings were made from 6061-T6 aluminum 0.016 inches thick, which meets construction requirements of the original plan for for wings on ultralight aircraft, C.A.D.I. model for which the maximum allowable take-off weight is 1232 pounds. At the time it was built, the aircraft was mounted on wheels. Rubber floats were later installed and then replaced by aluminum floats in 2004.

Photo 1. C-GZIR before extension of the wings**.**

The front and rear spars were made in Alma, Quebec, by Produits Aviatech, using 6061-T6 aluminum 0.040 inches thick. As with the wing covering, this meets the requirements of the original plans for the wings on C.A.D.I. ultralight models for which the maximum allowable take-off weight is 1232 pounds. The final inspection was performed by a Minister's Delegate - Recreational Aviation (MD-RA) on 12 December 2003. Despite some anomalies observed by the MD-RA, a Special Certificate of Airworthiness was issued on 29 September 2004. Some of the anomalies were still present at the time of the accident.

The new owner had purchased the aircraft in 2005. He had the engine [4] rebuilt at an approved overhaul shop. During the winter of 2006, the wings were extended by 30 inches on each side, for a total length of 208 inches each. The flaps and ailerons were also extended and measured 101.5 inches and 81.5 inches, respectively. These modifications have been made in order to improve the aircraft's performance and to reduce stall speed.

The person who made the modifications had neither engineering knowledge nor an Aircraft Maintenance Engineer licence. These qualifications were not, however, required by regulations. No technical entry had been made in the journey log or in the aircraft technical log, as is required by Section 571.03 of the CARs. Also, none of the changes had been inspected by TC. Significantly modifying the aircraft without informing the minister can invalidate the Special

[4] Avco Lycoming O-320-A2B.

Certificate of Airworthiness, since "such changes may require re-evaluation to confirm that the aircraft continues to comply with the applicable standards." [5]

A weight and balance report at the time of construction in 2003 stated that the aircraft weighed 1037 pounds on wheels and that the centre of gravity was within prescribed limits. The maximum allowable take-off weight was established at 2200 pounds. The weight and balance report was amended when new aluminum floats were installed and the empty weight increased to 1185 pounds. However, no change was made in the weight and balance report after the wings were extended.

At the time of the accident, C-GZIR had a total of 350 flying hours. The pilot/owner performed routine maintenance and annual inspections in accordance with regulations. No anomaly was mentioned in the log. The aircraft was placed in the water on 06 May 2009, one week before the accident on 13 May 2009. The occurrence flight was the seventh of the season.

The aircraft was recovered two days after the occurrence by a specialized team under the supervision of two TSB investigators. It was upside down in about 2 m of water. After it was removed from the water, it was noted that the left wing was folded above the main cabin and that the right wing had detached from the fuselage and was found a few metres from the main wreckage. It was impossible to establish integrity of the flight controls, given the extent of the damages.

Part of the front cabin had been torn off under the force of the impact, and the engine was partly detached. The flap selector was in the up position, while the engine control was locked in a position equivalent to the cruising flight position. The ACK Technologies emergency locator transmitter (ELT) was found detached from its mounting and in the off position. However, the Trenton Search and Rescue Centre, Ontario, reported receiving a signal from the crash area up to the time the ELT was recovered. An internal short-circuit of the ELT, caused by immersion in water, could have caused the transmission of this signal. C-GZIR's two front seats were equipped with lap belts and shoulder straps; neither the pilot nor the passenger was wearing his shoulder straps at the time of the accident.

The engine and propeller were examined, and the damage confirms that the engine was producing power at the time of impact. The aircraft was taken to the TSB laboratory in Ottawa, Ontario, for examination.

The results of the examination at the TSB laboratory confirm that the right wing broke in flight at the strut attachment point, thus blocking the right aileron in the raised position. As a result, the left wing rose, and the aircraft turned right and became uncontrollable. Compression damage along the entire length of the leading edge of the left wing confirms that the left wing was still attached to the fuselage at the time of impact, unlike the right wing. Damage to the fuselage is consistent with an impact with the surface of the water on the right side. The fact that there is little damage to the tip of the right wing confirms that it broke off before impact with the water. All other damage to the aircraft is consistent with overload stress. No sign of

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[5] Subsection (61) (xi) of Part VII, Continuing Airworthiness, Appendix A of the Exemption from Chapter 549 of the *Airworthiness Manual – Amateur-Built Aircraft*, published by the Minister on 23 April 2002.

fatigue was detected on the other parts that failed; no attachment was missing or had become loose. Therefore, the folding of the right wing was not caused by pre-existing damage, either to the wing struts, their attachment fittings or the fuselage.

Unlike the right wing, the left wing had been reinforced at the strut attachment point. According to the assembly reports, both wings were built from new material in 2003. There is reason to believe that the left wing was damaged prior to the accident and that it was repaired or even replaced:

- The left wing had one rib more than the right wing;
- The two spars of the left wing were reinforced at the strut attachment point; and
- The top of the left wing had a covering of 6016-T6 aluminum 0.020 inches thick, while all the other coverings were 0.016 inches thick.

It could not be determined when or by whom the reinforcement work had been done on the left wing as there was no record of such in the aircraft logs.

The front and rear spars on both wings were of 6061-T6 aluminum 0.040 inches thick. The front spar had dimpled lightening holes, while the rear spar lightening holes were not dimpled. Lightening holes allow spars to be lighter, while dimpling makes the assembly more rigid, providing increased strength. This construction method is also used for ribs. The rear spar, with no dimpling, did not have the rigidity and strength of the front spar.

Five types of load may affect a wing in flight: tension, compression, shear, bending and twisting. The loads on a wing that is supported by struts, such as on the Aventurier, are bending and shearing. More specifically, the bending loads are greater at the strut attachment points; they will tend to cause folding, while shear loads will tend to cause breakage. Since the wings on C-GZIR had been extended, their weight and size had considerably increased. Since the right wing was not reinforced, it was more vulnerable to folding and failing during flight.

Calculations were made to determine the maximum bending loads to which a wing supported by struts is subject, under the following three scenarios:

- For an ultralight aircraft wing 168 inches in length, with a maximum take-off weight of 1232 pounds, the bending load is 4020 lb/in.
- For the wing of C-GZIR when built in 2003, with a length of 178 inches and a maximum take-off weight of 2200 pounds, the bending load was 10 442 lb/in.
- For the wing of C-GZIR extended to 208 inches, with a take-off weight of 2200 pounds, the bending load was 18 506 lb/in.

Based on these calculations, the extended wing of C-GZIR could withstand a bending load some 4.6 times greater than a wing 168 inches in length of the kind normally installed on a C.A.D.I. ultralight model. Thus, if the extended wing was in normal flying conditions equivalent to 1.0 *g*,

it could withstand a bending load of some 4.6 *g* greater. It should be noted that the major parts, such as wings on amateur-built aircraft, do not have serial numbers that would make it possible to track maintenance and/or identify service life. Regulations do not require this.

According to the Light Aircraft Manufacturers Association of Canada (LAMAC), which developed the construction standards for advanced ultralights in Canada, the limit load factor for a wing is 4.0 *g* multiplied by a safety factor of 1.5, which brings the limit load factor to 6.0 *g*. With regard to construction standards for normal aircraft, Part V, Chapter 523 of the CARs sets the limit load factor at 5.5 *g*, that is, 3.7 times the safety factor of 1.5. For amateur-built aircraft, Part II, Construction Standards, Appendix A of the Exemption from Chapter 549 of the *Airworthiness Manual* states "Any materials may be used in the construction of an amateur-built aircraft, provided they are adequate for the purpose. It is recommended that established aircraft quality material and components be used." However, no limit load is specified for amateur-built aircraft in Canada.

On 28 June 2009, the right wing of amateur-built C.A.D.I. model C-GKDH folded in flight (TSB occurrence A09Q0098). The pilot managed to land the aircraft. The wing was taken to the TSB laboratory for examination. Like the C-GZIR, the front and rear spars were of 6061-T6 aluminum. However, the aluminum had a thickness of 0.051 inches, which was greater than the required thickness of 0.040 inches in the original plans for a C.A.D.I. model. The two spars had dimpled lightening holes. The wings were 184 inches long. The TSB laboratory report shows that the wings could barely withstand a force of 3 *g*.

Construction of amateur-built aircraft is governed by Appendix A of the Exemption from Chapter 549 of the *Airworthiness Manual*. According to this appendix, amateur-built aircraft refers to "an aircraft, the major portion of which is constructed or assembled individually as a unique project, either from raw materials or from a kit." The major portion means "more than 50% of the total number of items constructed or assembled during the project."

For several years now, TC has been delegating authority to monitor amateur-built aircraft in Canada to a Minister's Delegate – Recreational Aviation (MD-RA). The MD-RA program was established to provide the aviation industry with a mechanism that allows qualified individuals, other than Civil Aviation Safety Inspectors, to inspect amateur-built aircraft and issue Special Certificates of Airworthiness. The MD-RAs thus perform the administrative functions associated with the inspection program.

Candidates for MD-RA delegation of authority must be:

- builders of amateur-built aircraft;
- owners of small type certified aircraft, AMEs with experience in the maintenance of small aircraft and amateur-built aircraft, or;
- persons who have been intimately involved in the restoration of small aircraft.

Once accepted, candidates must attend regulatory, technical and administrative training sessions as well as on-the-job training. They must successfully complete a minimum of three aircraft inspections, one of which is a final inspection. The sample inspections must be representative of the scope of delegation being sought by the applicant. In this case, the MD-RA who conducted the pre-recovery and final inspections of C-GZIR was an AME.

MD-RAs see to the quality of the work and its compliance with aviation standards. They make at least one inspection during construction and note anomalies in a report, a copy of which is given to the builders. During final inspection, they again take note of anomalies and give a copy of the report to the builders. The builders must correct the anomalies and return a signed copy to the MD-RA stating that the anomalies have been rectified. Generally speaking, MD-RAs do not return for a visual check of the aircraft to verify that the anomalies have been properly corrected.

The design, drawings, engine installation and load calculations for the main structures are the exclusive responsibility of the builder. After the final inspection, the MD-RA issues a test flight permit for 25 flying hours that must be completed with no anomalies. The MD-RA then issues the Special Certificate of Airworthiness. This certificate remains valid unless TC decides otherwise, such as when a notice of change is received that could affect structural strength, performance, power plant operation or flight characteristics.

The owner of an amateur-built aircraft is wholly responsible to notify the Minister of any modifications to the aircraft. Once informed, the Minister decides whether to have the aircraft inspected before issuing a new Special Certificate of Airworthiness. The owner must also record in the aircraft's technical logs all information concerning its airworthiness.

The anomalies discovered on C-GZIR at the TSB laboratory include the following:

- The flight controls were locked with nylon nuts, whereas aviation standards require the use of castle nuts secured by a pin; this installation ensures a rotation to the attachment;

- The two front seats, which were of the kind found on pleasure boats, were mounted on office drawer slides;

- The builder had installed safety belts on the floor, but had not installed washers under the cabin covering to make the restraint system solid;

- The fuel selector had no placard;

- The front spar had dimpled lightening holes, but the rear spar lightening holes had no dimpling;

- The quality of the work done during repairs to the left wing, the spars and the wing covering was not to accepted aviation standards.

Some of these anomalies were present during final inspection of the aircraft in December 2003. With the exception of the flight controls, the anomalies were not noted down by the MD-RA.

The aviation regulations enable anyone to acquire an amateur-built aircraft, even if they did not build it. The transfer of responsibility with respect to maintenance is automatic. It was determined that the new owners were significantly lacking in their technical and regulatory knowledge.

Part VII of Appendix A of Exemption from Chapter 549 of the *Airworthiness Manual* [6] stipulate that "Changes that affect the structural strength, performance, power plant operation, or flight characteristics of an amateur built aircraft must be reported to the Minister before further flight of the aircraft; such changes may require re-evaluation to confirm that the aircraft continues to comply with the applicable standards." In this case, the new owner of C-GZIR modified the wings without consulting competent individuals or informing the Minister.

A study [7] carried out by the U.S. National Transportation Safety Board for 2005 shows that amateur-built aircraft have the highest accident rate among all general aviation aircraft: 21.89 accidents per 100 000 flying hours, of which 5.89 are fatal. Canada has 3557 amateur-built aircraft. There are no studies of the number of such aircraft that have been involved in an accident.

Analysis

The pilot was qualified for the flight. The weather conditions were favourable for visual flight and nothing suggests that conditions at the time of the event contributed to the accident.

The aircraft was assembled from parts of an advanced ultralight that had already sustained an accident. Appendix A of Exemption from Chapter 549 of the *Airworthiness Manual* requires the major portion of amateur-built aircraft to be constructed or assembled individually either from raw material or from kits. The major portions means more than 50% of the total number of items used are constructed or assembled during the project. Nevertheless, the Appendix A does not exclude the use of parts from other aircraft, damaged or not, as long as it complies with the 50% or more rule. The inspection report does not indicate the percentage of used parts that were included in the construction. The anomalies concerning the seat slides and the rear spar without dimpling, were not detected by the MD-RA at the time of the inspection during assembly or at the final inspection.

During the final inspection by the MD-RA, some anomalies were identified, notably with regard to the flight controls. An anomaly sheet was given to the builder, who attested that he had corrected the anomalies. It was determined that there was no follow-up other than a written report by the owner attesting that the anomalies had been repaired. The lack of any obligation to re-inspect the aircraft after the builder's statement meant that the MD-RA never ensured that

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6 CAR 549.23.

7 National Transportation Safety Board, *Annual Review of Aircraft Accident Data: U.S. General Aviation, Calendar Year 2005*.

the anomalies discovered had in fact been rectified. Therefore, the aircraft was put into service with anomalies that affected its airworthiness.

While the wings of C-GZIR were built from plans similar to C.A.D.I. model wing specifications, they were not built to accepted aviation standard practices for amateur-built aircraft and would already pose a risk of breaking up in flight. C.A.D.I. model wings installed on amateur-built aircraft that weigh in excess of 1232 pounds can barely withstand 3 *g* and even then, only with spars 0.051 inches thick. It was determined that many wing kits, which according to the original plans have spars 0.040 inches thick, were sold and installed on amateur-built aircraft and ultralights weighing more than 1232 pounds.

The left wing was reinforced at the strut attachment point. It was not possible to determine when or by whom this wing was repaired, modified or perhaps even replaced. The major parts of an amateur-built aircraft do not have serial numbers, as it is not required by regulations. Therefore, it is virtually impossible to track maintenance or identify service life for these components.

The new pilot/owner decided to have the wings extended without consulting qualified individuals. Reinforcing the left wing without reinforcing the right wing and failing to consult a specialist and inform the Minister, demonstrate a lack of understanding of the forces at work on aircraft components in flight as well as the applicable regulations. Since the right wing had not been reinforced, it was most vulnerable to load factors and that is why it failed first.

The TSB laboratory report on C-GKDH (TSB occurrence A09Q0098) shows that the wings had two spars with dimpled lightening holes and the metal was 0.051 inches thick, which was 28% more than required by the original C.A.D.I. construction plans. Despite this, one of the wings folded. As a result, it can be concluded that spars constructed from metal 0.040 inches thick on aircraft other than ultralights do not meet airworthiness standards. Also, the fact that the rear spar on C-GZIR was not dimpled considerably reduced the rigidity of the spar, and thus the strength of the wing. Extension of the wings by 30 inches subjected them to a bending load 4.6 times higher than the force on the entire wing, and this only during normal manoeuvres and level flight.

It was determined that the responsibility for calculating the forces acting on an amateur-built aircraft is the sole responsibility of the builder, even if the builder has no engineering knowledge.

Those who inspect aircraft are not required to have a thorough knowledge of aeronautics. Construction is monitored by individuals who may have limited knowledge of engineering and/or aircraft maintenance. TC has delegated to MD-RAs the responsibility for monitoring amateur-built aircraft and has assigned full responsibility for airworthiness, drawings and engineering calculations directly to owner/builders.

The investigation determined that several individuals modified their aircraft without seeking the opinion of aviation specialists and informing TC, which is not without risk on the one hand and a contravention on the other hand.

The following TSB laboratory reports were completed:

LP078/2009 – Document Restoration
LP075/2009 – In-Flight Break-Up Analysis
LP096/2009 – C.A.D.I. Analysis (A09Q0098)

These reports are available from the Transportation Safety Board of Canada upon request.

Finding as to Causes and Contributing Factors

1. The wings of the C-GZIR had been extended, leading to a significant increase in the bending load at the strut attachment point. Unlike the left wing, the right wing had not been reinforced and broke in flight. Therefore, the aircraft became uncontrollable and crashed.

Findings as to Risk

1. The covering of the wings and the front and rear spars of the C-GZIR were made of 6061-T6 aluminum. However, the thickness of the aluminum matched the original specifications in the plans for constructing wings on ultralights, which have an authorized take-off weight of 1232 pounds. Since the C-GZIR had a maximum authorized take-off weight of 2200 pounds, the integrity of the wings was affected.

2. The lightening holes on the rear spars were not dimpled. This reduced the rigidity of the spar and thus the strength of the wing.

3. The wings were extended by a person without either engineering knowledge or an aircraft maintenance engineer (AME) licence. Therefore, the extension work did not take into consideration the increased bending load on the wing.

4. The Minister's Delegate – Recreational Aviation (MD-RA) was not required to re-inspect the aircraft after the final inspection in order to ensure that the anomalies discovered had been rectified. The aircraft could, therefore, be put to use with outstanding anomalies that affected its airworthiness.

Other Findings

1. Transport Canada (TC) does not keep records on recency requirements for private pilots. Therefore, TC is not able to confirm that a private pilot meets all the requirements for exercising the privileges of a licence.

2. The extension of the wings was a major modification, which was not reported to the Minister. Therefore, the modifications were not inspected by TC and this could invalidate the Special Certificate of Airworthiness.

Safety Action

Action Taken

On 07 August 2009, the TSB sent an Aviation Advisory (A09Q0071-D1-A1) to Transport Canada (TC). On 11 February 2010, this Advisory was replaced by A09Q0071-D1-A2. It suggested that TC may wish to inform owners, builders and manufacturers of the risk associated with installing wings designed for ultralight aircraft on amateur-built aircraft, such as the C.A.D.I. (Club Aéronautique Delisle Inc.) model. The Advisory also suggested that TC may wish to inform all builders and owners of amateur-built aircraft of the risk associated with all major modifications made to their aircraft without the approval of competent individuals and to remind them of the importance of notifying the Minister.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 17 August 2010.

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Appendix A – Approximate Flight Path