KÖZLEKEDÉSBIZTONSÁGI SZERVEZET

TRANSPORTATION SAFETY BUREAU

FINAL REPORT

2006-254-4

SERIOUS INCIDENT

KALOCSA

22 July 2006

F-PIFS
SOUBRANE ACRO 200

The sole objective of the technical investigation is to reveal the causes and circumstances of aviation accidents, incidents or irregularities and to initiate the necessary technical measures and make recommendations in order to prevent similar cases in the future. It is not the purpose of this activity to apportion blame or liability.

This present investigation was carried out on the basis of

- Act XCVII of 1995 on aviation,
- Annex 13 of MTCW (Ministry of Transport, Communications and Water) Decree 20/1997. (X. 21.) on the declaration of the annexes of the Convention on International Civil Aviation signed in Chicago on 7th December 1944,
- Act CLXXXIV of 2005 on the technical investigation of aviation, railway and marine accidents and incidents (hereinafter referred to as Kbvt.),
- MET Decree 123/2005 (XII. 29.) on the regulations of the technical investigation of aviation accidents, incidents and irregularities;
- In absence of other related regulation of the Kbvt., the Transportation Safety Bureau of Hungary carried out the investigation in accordance with Act CXL of 2004 on the general rules of administrative authority procedure and service,
- The Kbvt. and the MET Decree 123/2005 (XII. 29.) jointly serve the compliance with the following EU acts:
    a) Council Directive 94/56/EC of 21 November 1994 establishing the fundamental principles governing the investigation of civil aviation accidents and incidents, with the exception of its Annex;
    b) Directive 2003/42/EC of the European Parliament and of the Council of 13 June 2003 on occurrence reporting in civil aviation, with the exception of its Annex I and Annex II.
- The competence of the Transportation Safety Bureau of Hungary is based on the Kbvt. until 31st December 2006 and on Government Decree 278/2006 (XII. 23.) from 1st January 2007 respectively.

Under the aforementioned regulations

- The Transportation Safety Bureau of Hungary shall investigate aviation accidents and serious aviation incidents.
- The Transportation Safety Bureau of Hungary may investigate aviation incidents and irregularities which - in its judgement - would have resulted in accidents in other circumstances.
- The technical investigation is independent of any administrative, infringement or criminal procedures.
- In addition to the aforementioned laws, the ICAO DOC 6920 Manual of Aircraft Accident Investigation is applicable.
- This present Final Report shall not be binding, nor shall an appeal be lodged against it.

Persons participating in the technical investigation did not act as experts in other procedures concerning the same case and shall not do so in the future.

The IC shall safe keep the data having come to their knowledge in the course of the technical investigation. Furthermore the IC shall not be obliged to make the data – regarding which the owner of the data could have refused the disclosure of the data pursuant to the relevant act – available to other authorities.

Abbreviations

BME	Budapest University of Technology and Economics (Budapesti Műszaki Egyetem)
CAVOK	„Ceiling and Visibility are OK"
IC	Investigating Committee
ICAO	International Civil Aviation Organization
Kbvt	Act CLXXXIV of 2005 on the technical investigation of aviation, railway and marine accidents and incidents
MAA	Military Aviation Authority
MET	Ministry of Economy and Transport
MTCW	Ministry of Transport, Communications and Water
NTA DAT	National Transport Authority - Directorate for Air Transport (CAA of Hungary)
TSB	Transportation Safety Bureau

Synopsis

Occurrence category	Serious incident
Type of the aircraft	SOUBRANE ACRO 200
Manufacturer	Soubrane Franck, France
Registration mark	F-PIFS
Serial No.	01
Owner	private owner
Operator	private person (owner)
Date and time of event (UTC)	22 July 2006. 10:45 LT
Location	Kalocsa airfield, Bács-Kiskun County
Number of injured	none
Damage to vehicle	Reparable
State of registry	France
Registering authority	Civil Aviation Authority of France

The pilot was invited to perform a demonstration flight at Kalocsa airfield. After descent at a glide angle of 30 degrees he increased the speed to 320-350 km/h in horizontal flight then pulled the aircraft with a load factor of 5,5g. During the manoeuvre the pilot felt a strong vibration. This vibration was caused by the left aileron the outer two-third of which was torn off the wing, the remaining one-third was stuck forming a right angle with the wing. As the ailerons extend along cca. 66 percent of the wingspan, the undamaged right aileron was sufficient for control of the aircraft which landed successfully without further problems.

Investigation data

The occurrence was reported to the duty services of TSB by the owner of the aircraft on 24 July 2006. As the aircraft was locked away safely in the hangar of the Kalocsa airfield, the possibility of tampering with the evidence was eliminated. The Investigating Committee (hereinafter referred to as IC) arrived at the scene the next day, on 25 July 2006, to perform the necessary examinations and to make a record of the data.

Composition of the IC:

- János DUSA, Investigator-in-Charge (IIC)
- György BADOVSZKY, IC member
- Zsófia OLÁH, IC member

1. Factual information

1.1. History of the flight

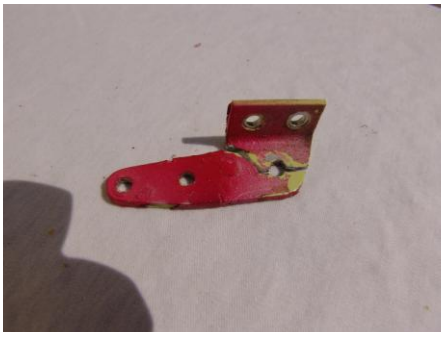
The pilot took off from Tököl airport, and upon arrival at Kalocsa airfield he started the aerobatics programme. The first element of the programme was a steep descent followed by a pull-up and a vertical roll. The pilot felt a strong vibration at the initiation of the pull-up, and the outer two-third of the left aileron broke. The remaining part twisted the 6-mm-thick dural-like hinge and the aileron part was stuck forming a right angle with the wing.
The pilot managed to bring the aircraft in horizontal flight and after cautious turns it landed on the runway. The aircraft was put in the hangar of the airfield where it remained locked until the arrival of the IC three days later.

1.2. Injuries to persons

There were no injuries.

1.3. Damage to aircraft

During the pull-up the aerodynamic forces tore the left eyelet of the center aileron bracket, broke the right eyelet at its base, and twisted the center aileron hinge (made of 6-mm-thick alloy) clockwise about 30 degrees. The outer hinge was torn out of the aileron spar, its M4 bolts and M4 washers (Φ 13mm) were simply pulled through the pinewood by the force. Once the outer hinges had been broken, the aerodynamic force broke the aileron spar next to the center hinge and turned the remaining part clockwise. Finally the inner hinge was also twisted. Therefore the left aileron and its three hinges were severely damaged.



Bracket right eyelet fracture

Bracket left eyelet fracture at its base

Fracture surface of left eyelet

Grainy structure (dynamic fracture)

The center bracket's fracture surface has a grainy, crystallic structure. The reasoning and causes that are detailed in Part 2: Analysis, together with the above fracture surface, prove a dynamic fracture; the possibility of fatigue fracture can be excluded.

The outer hinge and the aileron spar also show dynamic fracture (see below).

The anchor point of the outer hinge was torn out of the aileron spar

Damaged center hinge

Damaged inner hinge

Broken aileron spar

The left wing and the remains of the aileron

1.4. Other damage

None.

1.5. Personnel information

Pilot

Age and gender	37-year-old man
License	Cat. A pilot, valid until 4 June 2007
Medical certificate	Valid until 20 June 2007
Total flight hours	781
Number of take-offs	n/a
Flight hours on the type	47:06
Number of take-offs w/ the type	122
Number of take-offs on the day of the accident	1

1.6. Aircraft information

1.6.1. General information

Aircraft type	Soubrane ACRO 200
Registration mark	F-PIFS
Owner	private owner
Operator	private operator (owner)
Year of manufacturing	2002
Manufacturer	Soubrane Franck, France
Serial No.	01
Engine type	Lycoming IO 360 A1B6
Engine serial No.	IO 360 AB6-01
Engine power output	149 kW
Propeller type	MT-propeller EN MTV-2-B-C193-02

1.6.2. Flight data

Total flight hours	199
Total number of take-offs	n/a

1.6.3. Loading data

Amount and type of fuel on board	30 litres, AVGAS 100
Number of persons on board	1 (pilot)
Empty mass, kg	450
Maximum load, kg	150
Maximum fuel load mass, kg	42
Actual Take-Off Mass (TOM), kg	565
Maximum TOM, kg	600
Loading was within operational limits.	

1.7. Meteorological information

The weather conditions were the following: air temperature 32 ^{o}C, good visibility (over 10 kms), wind 2-3 m/s from 330 ^{o} , barometric pressure: n/a, clouds: CAVOK.

1.8. Aids to navigation

The aircraft was equipped with navigation instruments that allow VFR flights.
The navigation instruments had no effect on the course of events therefore their analysis was not required.

1.9. Communications

The aircraft was equipped with a BACKER COM radio and a BACKER TRANS transponder.

1.10. Aerodrome information

The characteristics of the aerodrome had no effect on the course of events therefore their analysis was not required.

1.11. Data recorders

The aircraft did not have an on-board flight recording device. It is not required for this type of aircraft and mission.

1.12. Wreckage and impact information

The aircraft did not sustain damage other than the aileron damage during the flight.

1.13. Medical and pathological information

The pilot possessed a valid aeromedical certificate.

1.14. Fire

There was no fire.

1.15. Survival aspects

Although there was an imminent life-threatening situation due to aileron breakage, the pilot’s cool-headed corrections prevented a more serious consequence.

1.16. Tests and research

There was no need to conduct tests and research for reaching the conclusion.

1.17. Organizational and management information

The characteristics of the organizational and management environment had no effect on the course of events therefore their analysis was not required.

1.18. Additional information

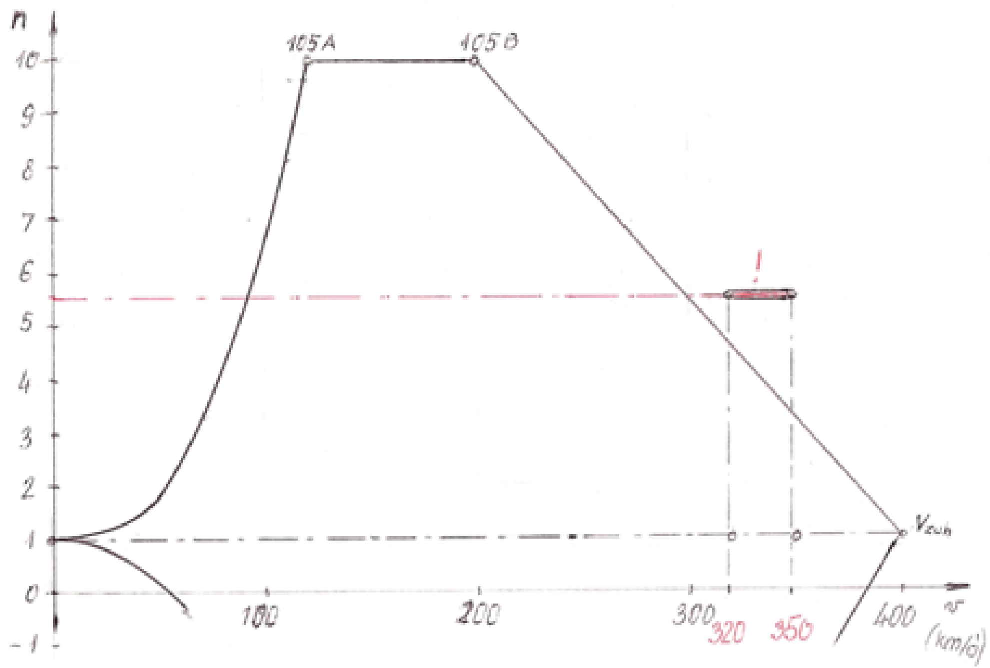
The IC requested an expert analysis from BME Faculty of Transportation Engineering. For the findings of the analysis, see the Appendix.

1.19. Useful or effective investigation techniques

The investigation did not require techniques differing from the traditional approach.

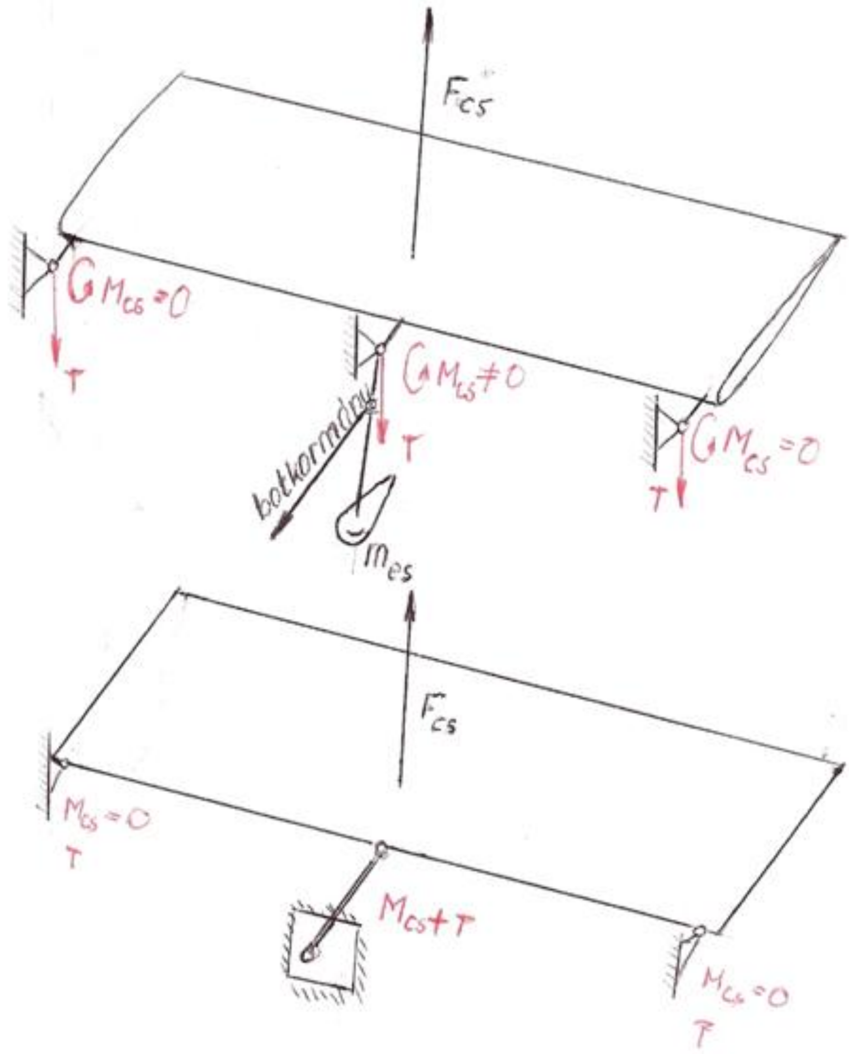
2. Analysis

The occurrence was a direct consequence of the pull-up from steep (30 degrees), high-speed (320-350 km/h) descent with a load factor of 5.5 g. The pilot substantially exceeded the speed limits listed in the Flight Manual of the aircraft for pull-up from descent (200 km/h max) as well as for vertical roll (250 km/h max). Therefore, given these speeds and load factor, the load of the aircraft exceeded the limits determined by the Flight Manual (see the velocity- load factor diagram below) that resulted in structural damage.



During the pull-up one wing was probably lower and the pilot corrected the bank with the ailerons. The correction must have been a quick, energetic action that resulted in a dynamic, hit-like load on the aileron.

The following drawing shows the anchoring and control of the aileron.



The aileron can be seen as a flat surface anchored to the wing with three hinges. When the aileron is activated, an aerodynamic force F_{cs} is generated. Because the inner and outer hinges are fitted with bearings joints, there is no momentum on those. The center hinge, however, is connected to the aileron pushrod that holds the aileron in the preset angle, therefore a bearings momentum M_{cs} can be calculated; this momentum represents a load on the anchor point of the center hinge.

Moreover, the aerodynamic force generates shearing force T on all three joints. These forces are not equal because they depend on the lift generated by the wing section. Most possibly the greatest shearing force is at the center hinge because there is the maximum of the distributed aerodynamic force.

The lower part of the above drawing shows that the center joint is rigid; this is where the momentum M_{cs} and the maximum shearing force T affect. The combination of loads resulted in the fracture of this joint.

With the fracture of the center joint the connecting flatter-weight was also lost. The system's center of gravity moved behind the rotation axis thus adding the force of inertia of mass to the inducing force. The amplitude of oscillations quickly rose, the shearing force T pulled the outer hinge anchor bolts and washers through the pinewood aileron spar. The aileron was then rotated around the inner hinge joint clockwise (seeing from the tail) and was broken at its weakest part, near the center hinge.

As for the material selection and manufacturing technology for the wing aileron assembly, the expert analysis states the following:

- The aluminium alloy which was used for the aileron hinges has a rupture strain of 350 MPa.
- The main part of the hinge is made of L-shaped die-cast alloy. The direction of the main loading force happens to be at a right angle to the filaments of the die-cast hinge, which is very unfavorable from the point of endurance of the structure.
- The die-cast technology results in longitudinal microscopic scratches on the surface that could be starting points for corrosion and fatigue cracks.

3. Conclusions

The occurrence was caused by three factors that were closely interconnected:

1. The Flight Manual is very basic and omits several parameters that are very important for the pilot. Moreover, the IC found that the pilot misinterpreted the limitations given in the Flight Manual: he believed that the speed limits were minimal speeds at which the given aerobatic element can still be completed. This misunderstanding explains why he exceeded the speed limits. The IC states that the velocity- load factor diagram should be printed in the Flight Manual of an aircraft made for aerobatics, along with the limitations derived from this diagram.

2. In the IC's opinion, should the aileron hinges and brackets have been made of aviation steel instead of aluminium alloy, the damage of the aileron could have been prevented. The pilot works as a commercial pilot at an airline, therefore he is probably not an experienced aircraft designer. The designer should have considered the consequences of substituting the steel parts with alloy. What was gained in less weight was lost in strength, because the aviation steel has four times greater rupture strain than the alloy.

3. The material selection for the aileron spar was unfavorable. Pinewood was used (cross section 40x16 mm), the distance between annual rings was ~3,2 – 3,5 mm that is considered too great; the ideal wood filament distance is 1,4 – 1,8 mm. It is probable, however, that even if the spar is made of stronger wood, it would have not sustained the stress caused by the loss of the flatter weight. In the IC's opinion, instead of standard washers, a 2-mm-thick metallic plate with a size of 35x40 mm should be placed on the spar in order to transfer the shearing force from the hinge to the aileron spar without breaking it.

4. Safety recommendations

Such occurrences are avoidable by complying with the rules and regulations.

BA 2006-254_1: The IC recommends the manufacturer to consider the expert opinion expressed in this final report regarding the material of which the aircraft was constructed, thus to use different materials for the construction of the aircraft.

5. APPENDICES

5.1. Technical expert opinion

Budapest, 25th August 2008

György BADOVSZKY IC member	János DUSA IIC	Zsófia OLÁH IC member

NOTE:

This present document is the translation of the Hungarian version of the Final Report.

Although efforts have been made to translate it as accurately as possible, discrepancies may occur.

In this case, the Hungarian is the authentic, official version.

Appendix 5.1.

Technical expert opinion

Aileron mounting eyelet fracture analysis

Budapest, 23rd September 2006.

Completed by Dr. Gyula KISS

Examination of the aileron eyelets

A one-seater powered aircraft (made in France) lost its left aileron during an aerobatic manoeuvre. I have received the task of examination of the broken aileron eyelets in order to determine the cause of fracture.

Instruments used in the analysis:

- MST-130 stereo microscope
- Zeiss-Metaval light microscope

Evaluation of the fracture surfaces

Eyelet 1

The L-shaped eyelet shows approx. 0.1-mm-deep dents right next to the bolt bores along the half of the bores' circumference. The inner painted surface of the bores are almost intact. One of the legs is broken and missing.

The fracture surface shows a stringy texture, characterictic to extrusion. The whole surface is crystallic except for at the ends where shiny parts resulted from tensile load.

The fracture was caused mostly by tension combined with bending (a slight contraction is visible).

Eyelet 2

The other eyelet shows dent marks similar to those visible on eyelet 1. The leg with one bore is broken, the missing part took away with it the lower half of the material. This fracture was also caused by tension combined with bending. (In more practical terms, the lower part of the eyelet leg was torn off.) The fracture surface is similar to those of the eyelet 1.

The semi-circular dents have been caused by the bolt washers. The shape and location of the dents indicate that there was a tension load on the other leg of the eyelet.

Metallographic analysis of the eyelets

I examined the eyelets in two different cross sections. The metallic surfaces were treated with a mordant liquid named Vilella.

In one probe, the section was parallel to the direction of extrusion, in the other it was perpendicular.

In the perpendicular cross-section the alpha-crystal borders were clearly visible, with diffuse beta-zones.The crytals of the base texture were deformed in accordance with the type of metalforming (they were rolled into the form of sheets).

In the parallel cross-section the beta-phase grains were well defined, the crystal zone borders of the base texture were blurred.

The two eyelets were made of aluminium alloy containing magnesium (and to a less extent, manganese). It is a ductile alloy; if extruded, its tensile yield strength can reach an estimated 350 N/mm2.

Summary

The fracture (tear) of the aileron mounting eyelets is a result of tensile load, combined with a less amount of bending. The semi-circular dents around the bores are evidence of that type of load.

The fracture of the eyelets was not instantaneous because the fracture surfaces demonstrate small areas of crystal wear. There were several "hits" or "collisions" before the full separation.

There is no evidence of pre-existing cracks or fatigue.

The eyelets are made of aluminium alloy with magnesium. Its L-shape was formed by extrusion, its tensile yield strength is an estimated 350 N/mm2. The main load and the texture lines are perpendicular which is unfavorable with regard to the durability of the eyelets.

I could not detect cracks or traces of fatigue on the fracture surfaces. The aluminium alloy was of good quality. These factors could not be a cause of the fracture.

Based on the abovementioned, it is most probable that the aileron mounting eyelets were designed for a less loading or, they were subject to a load greater than they were designed for.

This statement is also valid for the mounting bolts of the eyelets.

Budapest, 22nd September 2006.

Signed,

Dr. Gyula KISS