# FINAL REPORT

of civil aviation safety investigation

<table>
<thead>
<tr>
<th>Occurrence Type</th>
<th>SERIOUS INCIDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>Private</td>
</tr>
<tr>
<td>Operator</td>
<td>Private</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>HALLEY KFT</td>
</tr>
<tr>
<td>Aircraft</td>
<td>APOLLO FOX</td>
</tr>
<tr>
<td>Country</td>
<td>ROMANIA</td>
</tr>
<tr>
<td>Registration</td>
<td>YR-5160</td>
</tr>
<tr>
<td>Location</td>
<td>Balta – Verde airfield, Craiova</td>
</tr>
<tr>
<td>Date and time</td>
<td>16.06.2016 / 13:03 LT</td>
</tr>
</tbody>
</table>

**No.** : I17-04  
**Date:** 14.03.2017
1. HISTORY OF OCCURRENCE

On 16.06.2016 the owner of Apollo Fox aircraft, registered YR-5160, planned a private flight with it from Craiova “Balta-Verde” Aerodrome, Dolj County. He took out the aircraft from the hangar and begun to do the checking before flight. After reaching the engine ground performance, the aircraft started to roll towards the aerodrome grassy runway in order to take-off. After an almost 40 meters rolling the left main landing gear attaching screws broke and the aircraft slightly inclined on the left side till the wing touched the ground.

After noticing this situation the pilot immediately shut down the engine.

Fig. 1 - YR-5160 Immediately after the incident occurrence
The aircraft was slightly damaged having the left landing gear detached from fuselage structure, the left flaperon damaged and the left wing suspension system deformed.

![Fig. 2 – Left main landing gear detached](image1)
![Fig. 3 – Left flaperon](image2)
![Fig. 4 – Left wing suspension system](image3)

### 2. ADDITIONAL INFORMATION

The investigation commission arrived at the accident site took the landing gear attaching bolts in order to expertize them.
In figure 5 it can be noticed that the main left landing gear is independent from the right one. Regarding the landing gear attaching system, each main landing gear has two attaching points, as follows:

- the one in the arm exterior end is clamped with a screw with nut, that crosses the fuselage near its axis;
- the other end is clamped through a tightening bridle with two bolts screwed in the metallic structure elements under the fuselage canvas, being secured against unscrewing with a safety wire between the bolts.

From images in figure 5 it can be noticed that both landing gear arms were not deformed, observing only the detaching from the fuselage of the left main landing gear. The clamping bridle of the main left landing gear was not damaged.

A very important thing that the investigation commission noticed was that the bridle attaching screws were replaced by the operator, and the manufacturer original attachment solution was changed.
In order to determine the screws quality the investigation commission performed a metallographic expertise.

In Fig. 6 it is presented the broken nut bolt.
It is noticed that the breaking occurred without a preliminary deformation, at the beginning of threaded area (Fig. 6 – a), b)). On the bolt surface, along its longitudinal axis there are two different areas with friction marks: area 1 towards screw end, brighter in color and shinier and area 2 towards the nut, darker and matt. Considering that the fuselage is made of metallic structure covered with canvas, it is likely that both areas entered in contact with a metallic structure element.

The images of screw breakage surfaces (Fig. 6 - c)) reveal, even at macro level, the three different area which are characteristic to a fatigue breakage: area 1 (breakage crack formation), from the screw threaded surface to the nut beginning zone, area 2 (slow propagation of the crack), with the largest surface having a delicate rough shape, with some darker spots, area 3 (sudden breakage), opposite from area 1, with irregular and discontinued aspect of the surface. Also in this case it is not observed any deviation from circular form, on any of the components.

The nut is auto blocking, without any unscrew marks. The washer (Fig. 6 - d)) shows evident friction marks, with local deterioration of its coating and the hole is slightly oval, leading to the idea that the bolt gained in time a relative play from the components it fixed. This movement is also confirmed by the darker mark on the screw surface, this having almost 3 mm width (Fig. 6 - b)).

In Fig. 7 are presented stereomicroscopic aspects of screw breaking surface.
The three fatigue breaking areas highlighted in Fig. 7 – c) are detailed observing the dark grey spots, as well as the shining points, as a consequence of local friction between the surfaces resulted from slow breakage propagation. There are also observed discontinuities in screw material.

The qualitative and quantitative microstructure aspects of the steel were studied, both in longitudinal section and in cross-section. It was noticed that on the longitudinal section it appears a decarburization with a depth of almost 120 microns, which is not allowed.

Also, the entire structure of the section is deficient, of Widmanstatten type (with acicular ferrite network!), resulting from inadequate cooling during the screw manufacturing process. In the entire steel volume are dark grey elongate endogenous inclusions of MnS type, in some areas disposed in rows, more or less continuous. Their dimension reach also 200 microns in longitudinal section and 16 microns respectively in cross-section, which is not allowed for this steel class.

There were also expertized the two landing gear clamping bolts secured each other with safety wire. The breaking surface is relatively uniform, showing
a directional roughness upon breakage propagation front, as the material was subjected to tensile or compression / crushing.

In terms of qualitative and quantitative aspects of steel microstructure out of which the two bolts are made, in longitudinal section, there were noticed endogenous inclusions rows of MnS type, with lengths above 1000 microns and sections of 20 microns and they are visible with the eyes. The cracks on the bolt’s thread, are cold cracks (not oxidized), having the propagation direction towards a typical heat treatment failure (“white spots”) associated with a deficient structure in rows resulted from steel hot plastic deformation. These ferrite areas (“white spots”) have considerably larger dimensions than a grain size (145,8 X 104,8 microns!), their presence itself in the structure is not allowed because it drastically decreases the mechanical steel properties.

![Fig 8 - Clamping bolt; Attack: NITAL 2%, longitudinal section](image)

Both bolts have the same defects, thus considering that they belong to the same batch and from the same manufacturer.

The investigation commission studied the aircraft logbook to check if it was complied with the manufacturer’s recommended maintenance schedule. It was found that in the aircraft logbook it was recorded the replacement of the four bridle attaching screws of the landing gear, and the 600 operation hours or 6 years inspection.

In the Aircraft Maintenance Manual it was also stated that the 600 operation hours or 6 years inspection is recommended to be carried out at the aircraft manufacturer’s plant.

The aircraft manufacturer – Halley Kft stated that they did not perform the 600 operation hours or 6 years inspection for this aircraft.

The investigation commission studied the Aircraft Maintenance Manual, checking the scheduled maintenance tasks. The commission did not identify detailed instructions of performing the recommended periodic tasks and neither the way to interpret the results obtained after the checking. Given this finding the commission...
considers that the aircraft manufacturer left the owner / user to decide how to perform these works and interpret the results.

Considering that individuals committed in ULM aircraft flights have full responsibility and assume all the risks related to manufacture, maintenance and operation / use, of this aircraft category, their access to as detailed as possible information, on how to perform maintenance works and how to interpret the results obtained after checks is very important. This would provide a high quality level in performing maintenance works and implicitly a high flight safety level.

3. CONCLUSIONS

3.1 FINDINGS

The carried out analyzes show the following:

1. The left and right landing gear attaching screws were replaced, their replacement was recorded in the aircraft logbook.
2. The entire landing gear assembly does not show evidence of mechanical damage by impact or deformation;
3. The nut screw breakage was due to fatigue;
4. The steel out of which the screw is manufactured is inadequate in terms of operation structure, and also in terms of embedding condition;
5. The breakage of the two bridle attaching bolts shows a bending breaking, as a result of sudden overload;
6. The steel out of which the bolts are manufactured is inadequate both in terms of operation structure, and in terms of embedding condition.
7. In the aircraft logbook it is recorded the 600 operation hours or 6 years inspection “as performed”.
8. The aircraft manufacturer – Halley Kft stated that they did not perform the 600 operation hours or 6 years inspection for this aircraft as recommended in the Maintenance Manual.
9. The investigation commission did not identify detailed instructions of performing the recommended periodic tasks and neither the way to interpret the results obtained after the checking.

In conclusion, as an end result of the analysis, it can be stated based on the above, that the attaching elements of the main left landing gear (a screw and two bolts) recovered after the serious incident occurrence broke as follows:

- The nut screw broke slowly, due to fatigue, due to inadequate steel and technology used in manufacturing, the breakage moment was when it reached the critical section of sudden failure;
3.2 CAUSE OF THE ACCIDENT

The serious incident occurred due to the breakage of exterior end screw of left landing gear as a fatigue consequence, based on inadequate steel and technology used for its manufacturing and on inadequate maintenance of landing gear attaching system.

3.3 SAFETY RECOMMENDATIONS:

1. It is recommended for the Romanian Air Club that when renewing the Identification Certificate for an ULM type aircraft to check the compliance with the aircraft maintenance schedule recommended by the manufacturer.

2. It is recommended for aircraft manufacturer HALLEY KFT to update the Maintenance Manual of Apollo Fox aircraft with detailed procedures on how to perform the scheduled recommended maintenance works, as well as the interpretation of the inspections / checking results.

3. It is recommended for the Romanian Air Club to consider that when an ULM owner submits the Technical Documentation in order to identify an aircraft, the Maintenance Manual of that aircraft shall contain detailed instructions of performing the scheduled works.

NOTE: As new information were transmitted to the investigation commission, the safety investigation for this event was reopened and the Final Report was modified to insert this new data. The modifications of this Report are not related to the cause of the event and the issued safety recommendations.

Note: The documents and analysis objects used for the issuance of the flight safety investigation Report are confidential and are archived at the Civil Aviation Safety Investigation and Analysis Center, according to legal provisions.