Australian Government
Australian Transport Safety Bureau

Collision with terrain involving Aeroprakt A22 LS, 24-7390

Mt Jack Station, New South Wales, 1 November 2017

Technical analysis of control cables
AE-2018-018

Background

On 1 November 2017 at approximately 0930 Eastern Daylight Savings Time (AEDT) the pilot of an Aeroprakt A22 LS “Foxbat” registered 24-7390 was on approach to land at Mt Jack Station, New South Wales. During landing, the pilot experienced a right hand rudder control failure, with the aircraft turning sharply to the left. The aircraft impacted the ground off the runway, coming to rest inverted with substantial damage.

In early 2018, Recreational Aviation Australia (RAAus) provided the ATSB with sections of the rudder control cables and the forward pulleys for analysis to ensure that they met the required specifications.

The aircraft was built in 2011 and had 1749 hours on the airframe. Under the requirements of the Aeroprakt manual, the control cables for this type of aircraft should be inspected every 200 hours and be replaced immediately if any deformation or fractured wires are found within in the cable.

A22 LS “Foxbat” Rudder Control System

Image: Aeroprakt, annotations ATSB

- Forward pulley
- Rudder Control Cables
- RH Control Cable
- LH Control Cable
- Fractured Cable
- Damaged Cable

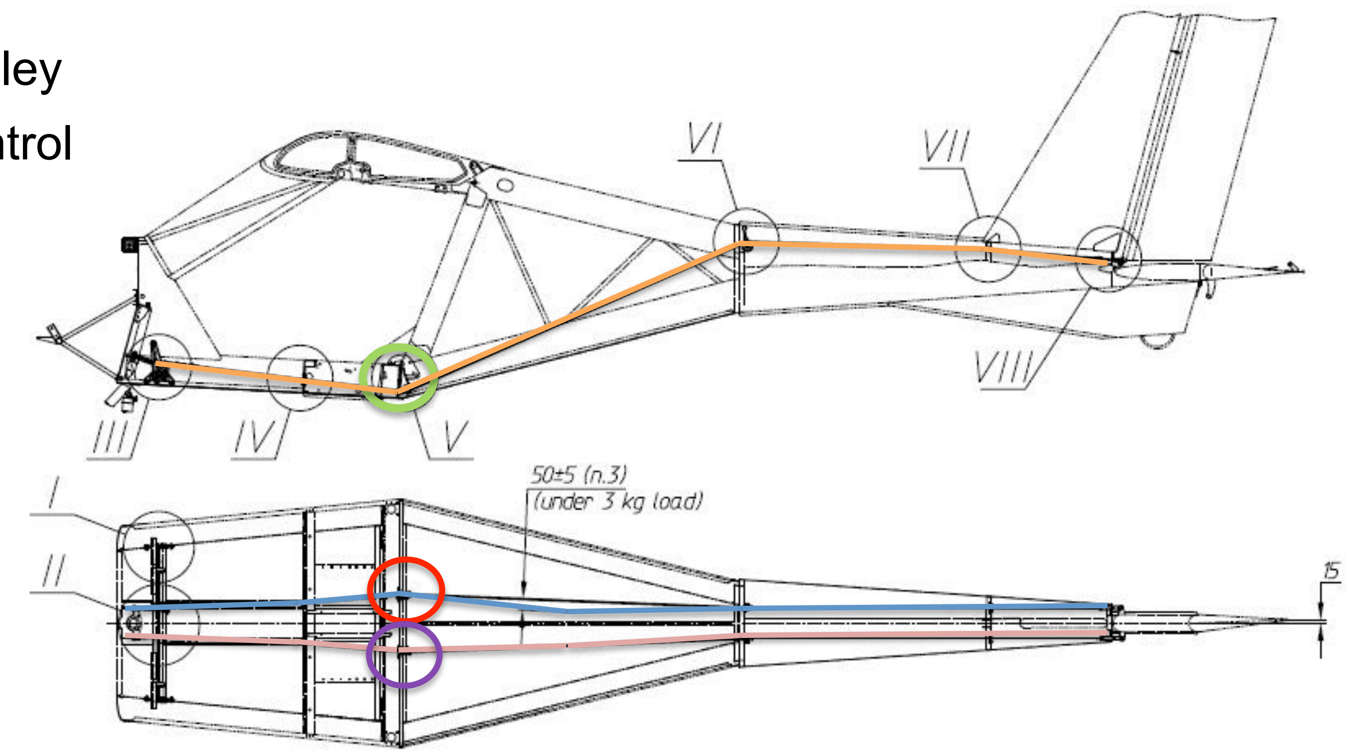


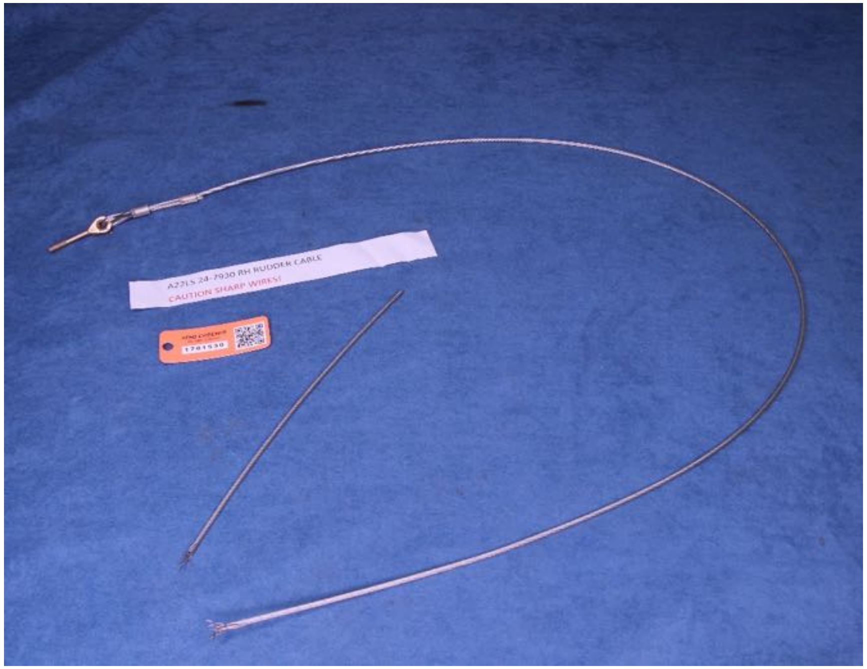
Figure 1

Scope

The purpose of this examination was to identify the mode of failure in the right hand (RH) cable, determine the serviceability of the left hand (LH) cable, and to ensure that the componentry met the manufacturer's specifications.

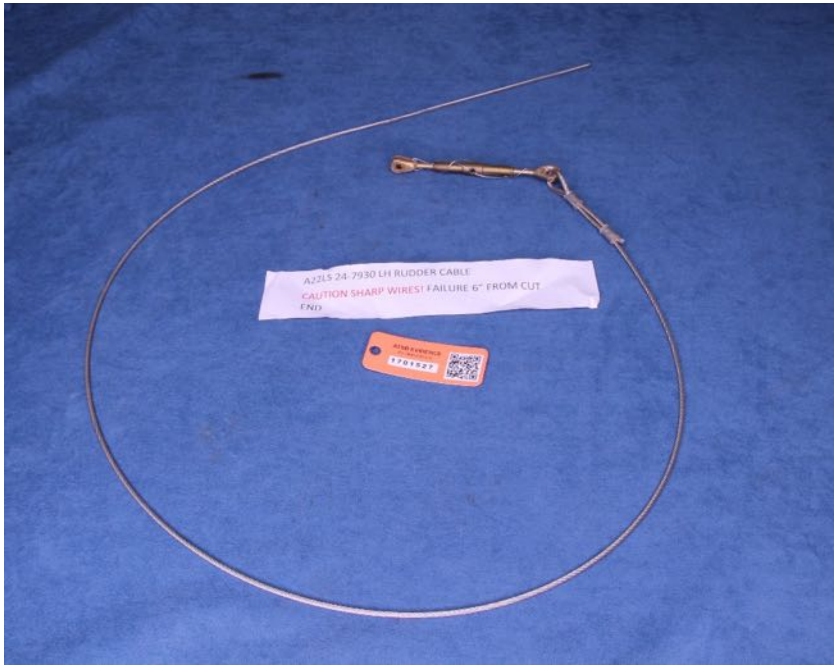
Other factors affecting serviceability were not examined, e.g. rigging and maintenance practices.

Rudder Cable Sections



RH Rudder Control Cable

Figure 2



LH Rudder Control Cable

Figure 3

Right Hand rudder cable

Following the accident, the right hand rudder control cable (Figure 2) was found completely fractured. The cable was cut for transport beyond the point of fracture and was provided to the ATSB for analysis.

- It was determined that the fracture occurred the approximate position of the forward pulley (see Figure 1).
- Microscopic examination revealed that approximately 65% of the wires in the cable had fractured in fatigue, with the remainder failing in overstress.
- Based on the amount of fatigue it is likely that the cable would have been unserviceable at the last 200-hourly inspection, as per the Aeroprakt maintenance manual section 12.7 (see next slide).

Figure 4 shows an image of the fractured end of the cable taken during the microscopic examination. Figures 6 and 7 show examples of wires that have fractured in fatigue and overstress.

AEROPRAKT-22LS Airplane Maintenance Manual A22LS-AMM-02

Section 12.7

Inspect the cable for wear in the areas where it passes through fairleads and pulleys.

If any cable wire is broken the cable must be replaced. Contact the manufacturer for the required technical support.

Check the cable tension. To do that, apply 30 N (6.7 lb) side load towards the other cable of in the middle of the cable portion between the pulley supports behind the luggage container. The cable sag must be equal to 50±5 mm (2±0.2 in). If necessary adjust the cable tension using the turnbuckles. Lock the turnbuckles with safety wire after that.

Recommended special tools: none.

Necessary parts/materials: none.

Right Hand rudder cable fracture

Figure 4

Figure 5

Released Under Section 61
of the TSI Act 2003

Fatigue Vs Overstress

Overstress

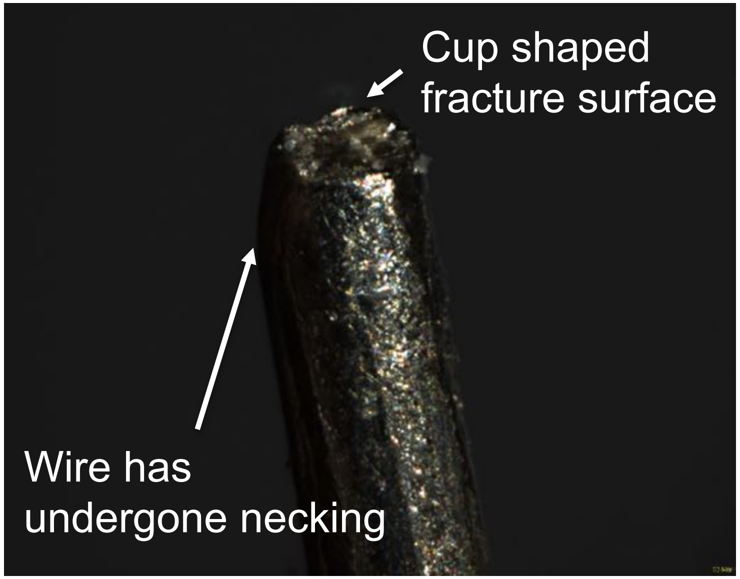


Figure 6

Fatigue

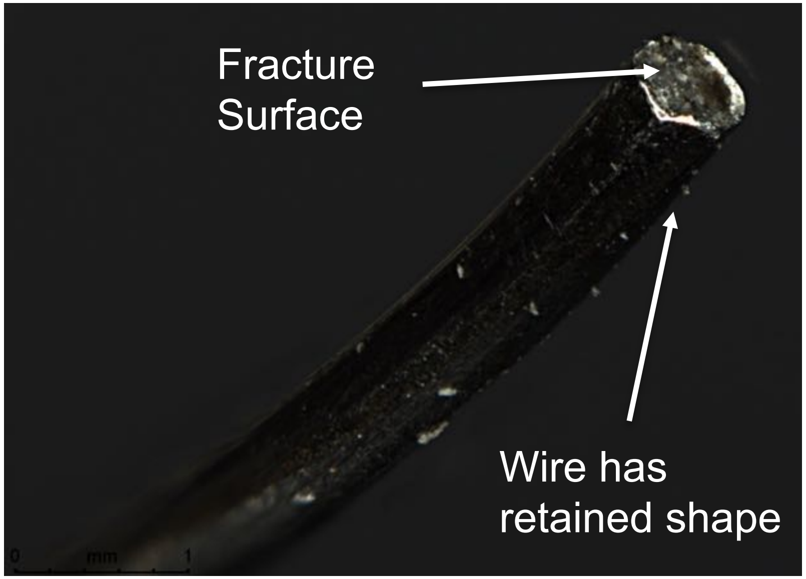


Figure 7

Released Under Section 61
of the TSI Act 2003

Left Hand rudder cable

The left hand rudder cable had not completely fractured at the time of the accident. Figure 3 shows the cable section provided to the ATSB, which was also cut for transport.

- Local deformation of the wires (see Figures 9 and 10) was observed at the approximate position of the forward pulley, the same area where the RH cable had fractured.
- Running a hand along the wire revealed a number of sharp and deformed areas, indicating fractured or deformed wires within the cable.
- Microscopic examination of these areas revealed a number of wires with fatigue fractures as shown in Figure 9 and 10. As with the RH cable, under the requirements set out in the maintenance manual this cable was unserviceable, and likely would have been unserviceable at the last inspection.

Left Hand Rudder cable fractures

Fatigue fractured wires

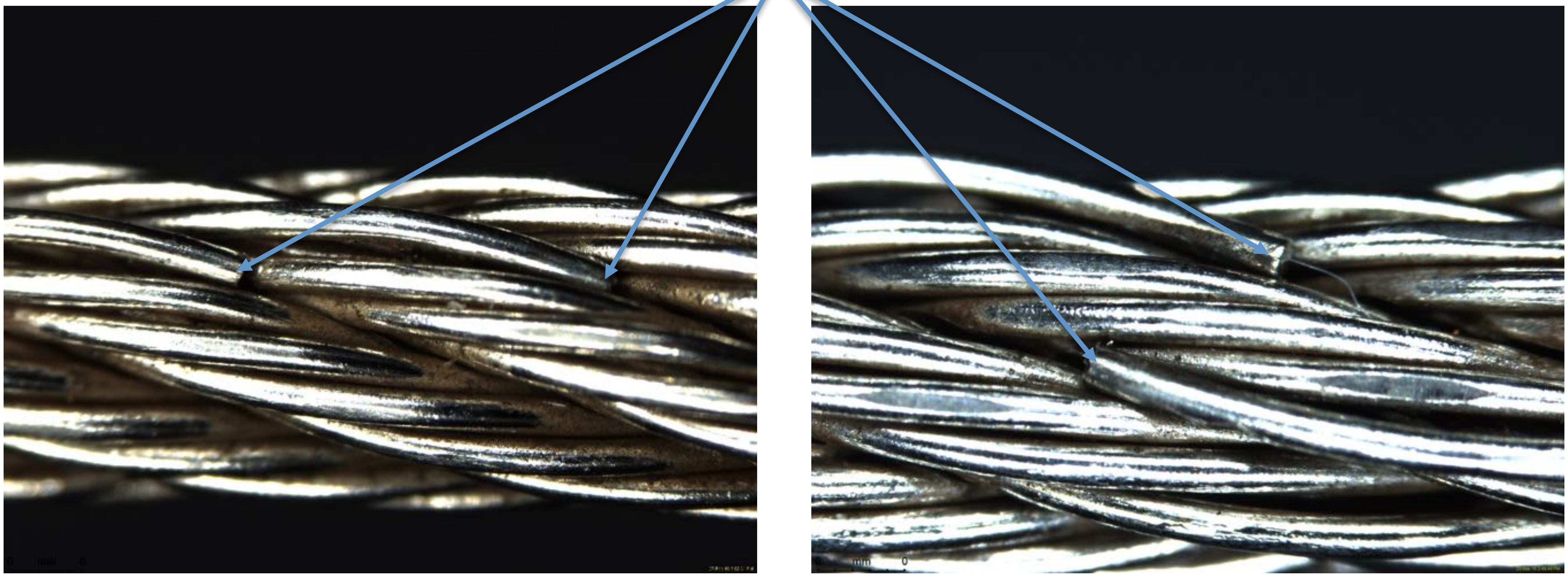
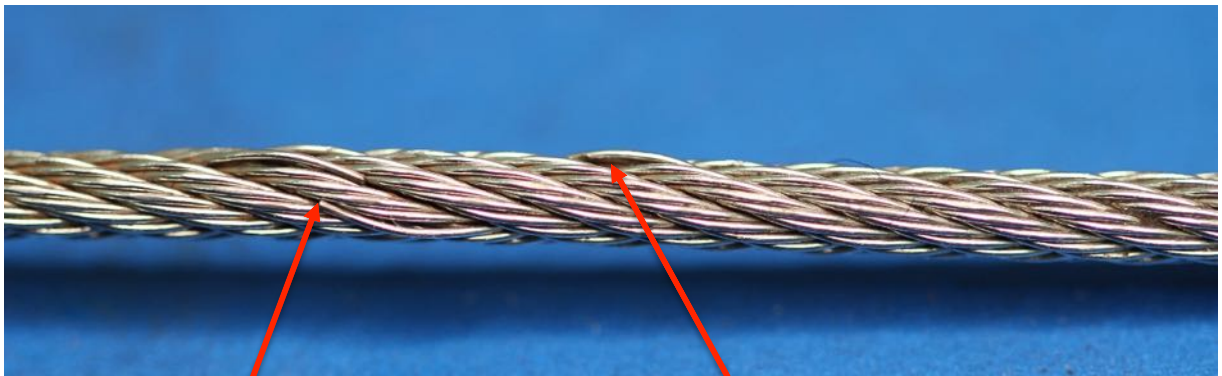


Figure 8

Left Hand rudder cable deformation



Fractured Wire

Local Deformation

Figure 9

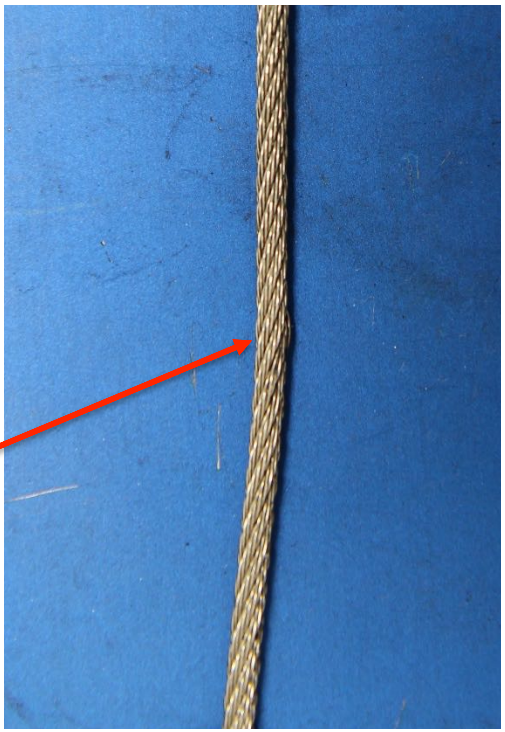


Figure 10

Cable Wear

Wear was observed on both cables which may have contributed to the fatigue fractures observed. These can be seen in Figure 11 and are described below.

- Figure 11 shows noticeable wear notches caused by relative motion of wires across each other. This wear can be a contributing factor to fatigue fractures by reducing the diameter of the wire and creating a stress concentration.
- Flat spotting on the wire has been caused by the repeated motion the cable over a pulley (Figures 11 and 12). This type of wear over time can lead to fatigue and fracture of the wire rope.

Cable Wear (RH Cable)

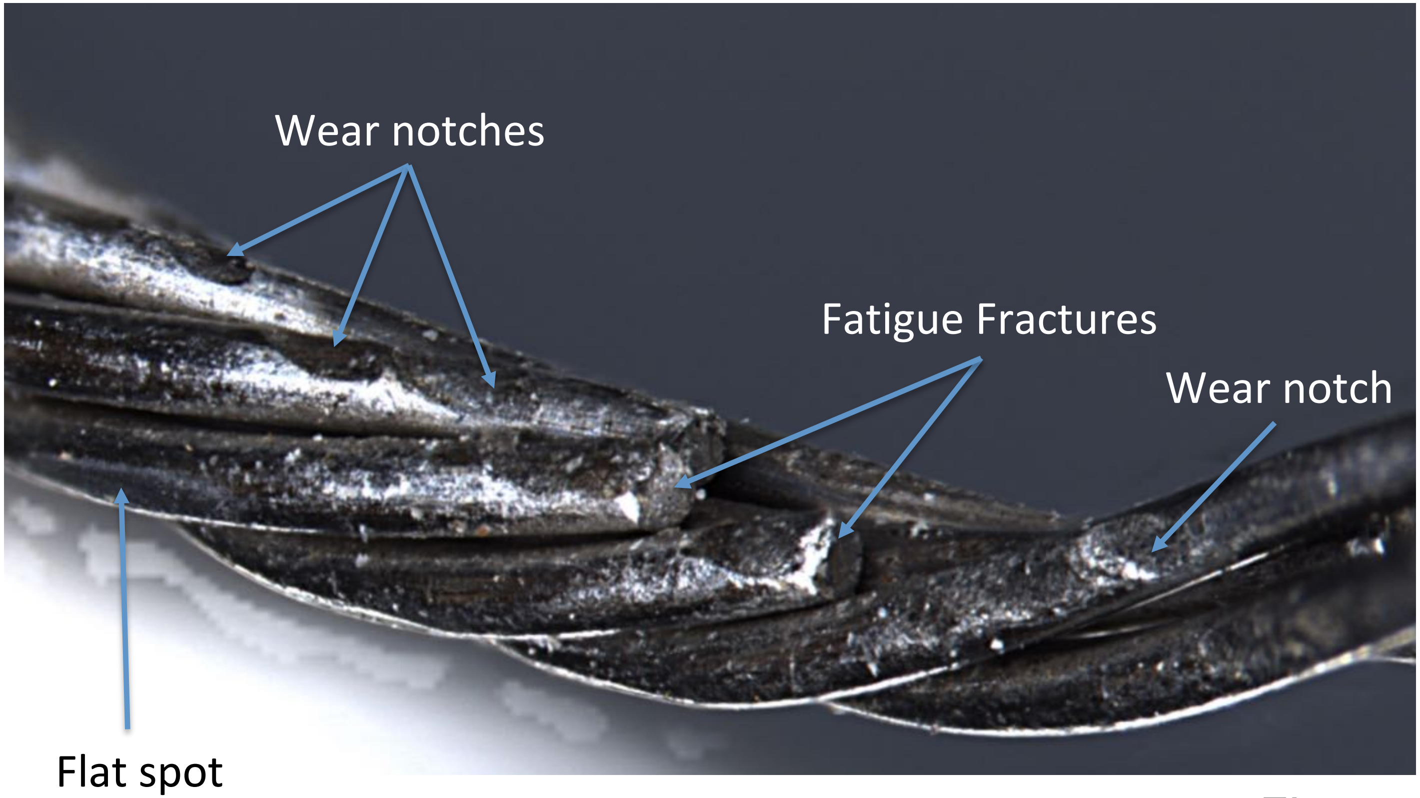
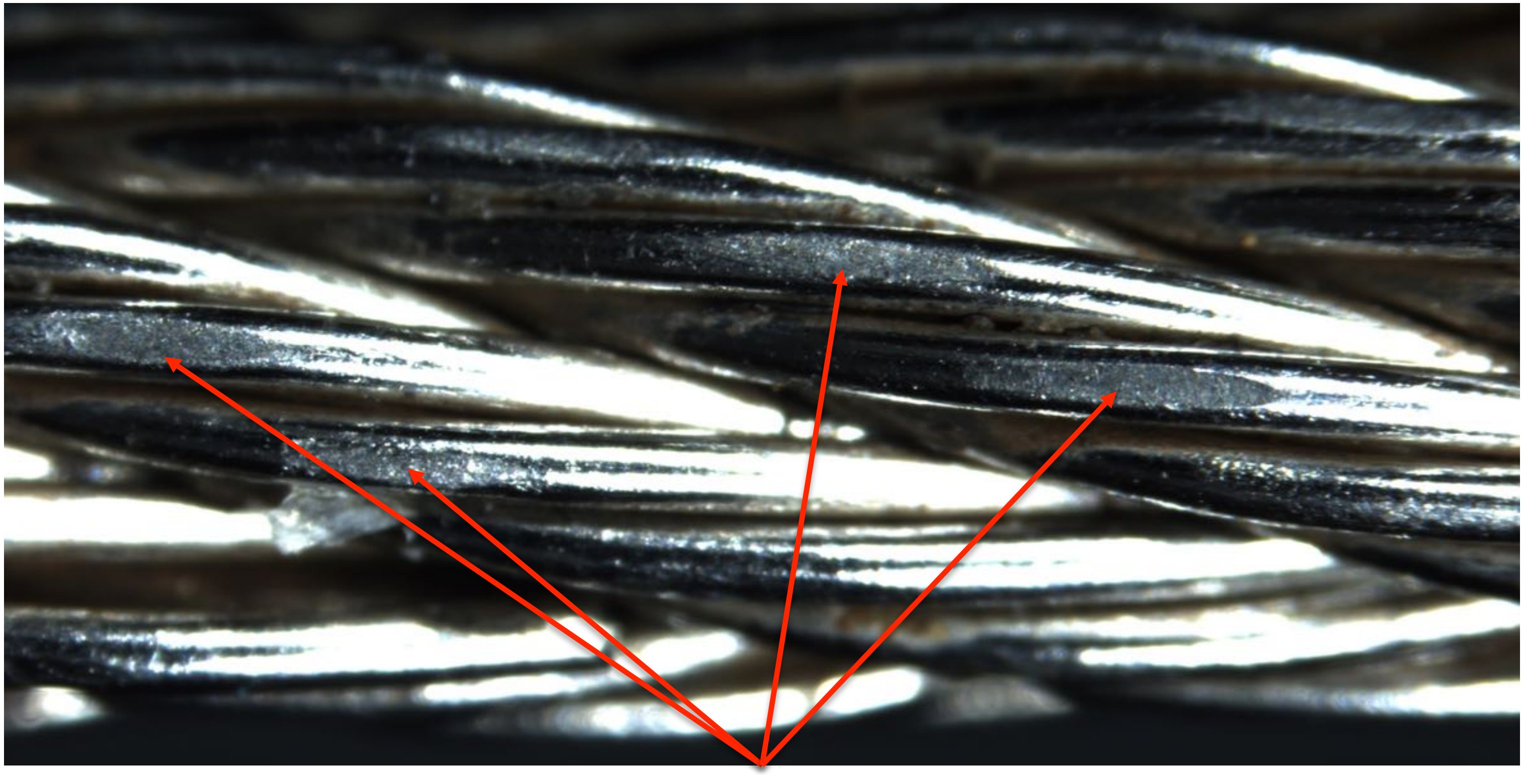


Figure 11

Flat Spotting (LH Cable)



Flat spots

Figure 12

Comparison with Sample Cable

For comparative analysis, RAAus provided the ATSB with an exemplar cable obtained directly from the Aeroprakt Factory in Ukraine (see Figure 13). Visual and microscopic examination did not reveal any concerns with the cable such as wear, corrosion or existing damage.

A series of hardness tests were performed to obtain the approximate strength of each cable. These hardness tests (see Figure 14) did not reveal any significant deviation from the manufacturers stated properties. Most of the results were within 10% of the stated 1770 MPa strength for the cable type provided by the manufacturer.

Chemical composition samples have been sent for testing. Results are pending at the time of writing.

Comparison with Sample Cable

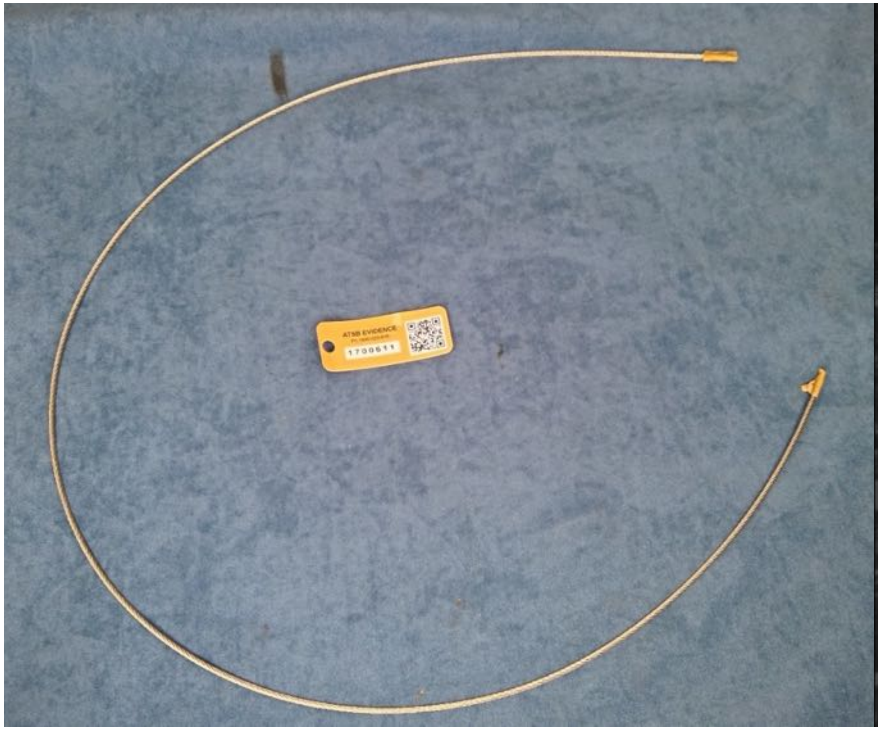


Figure 13:
Factory Cable Sample

Figure 14:
Sample Undergoing Hardness Test

Pulleys

Due to the location of the damage to both cables, both forward pulleys (see Figure 1) were examined. This revealed some wear on both pulleys (see Figures 15 - 18), but nothing of particular concern.

The pulleys were measured to ensure that they met with the specifications outlined in the manufacturer's drawings. All dimensions were within specification; however, the diameter of the pulleys in the design was below what is recommended for aircraft cables. The absolute minimum recommended for the ratio of the diameter of the pulley to the diameter of the cable is 30:1. Based on the 2.5mm diameter cable and 37mm diameter pulley the ratio in this case is approximately 15:1, which could lead to an increase in wear and a reduction in serviceable life of the cable.

It should be noted that the above ratio is for a wire rope running 180^{o} around a pulley. In this case the cable only transits 27^{o}, so the effect on service life would not be as significant.

Pulleys

Outside diameter of pulley

Inside or tread diameter of pulley

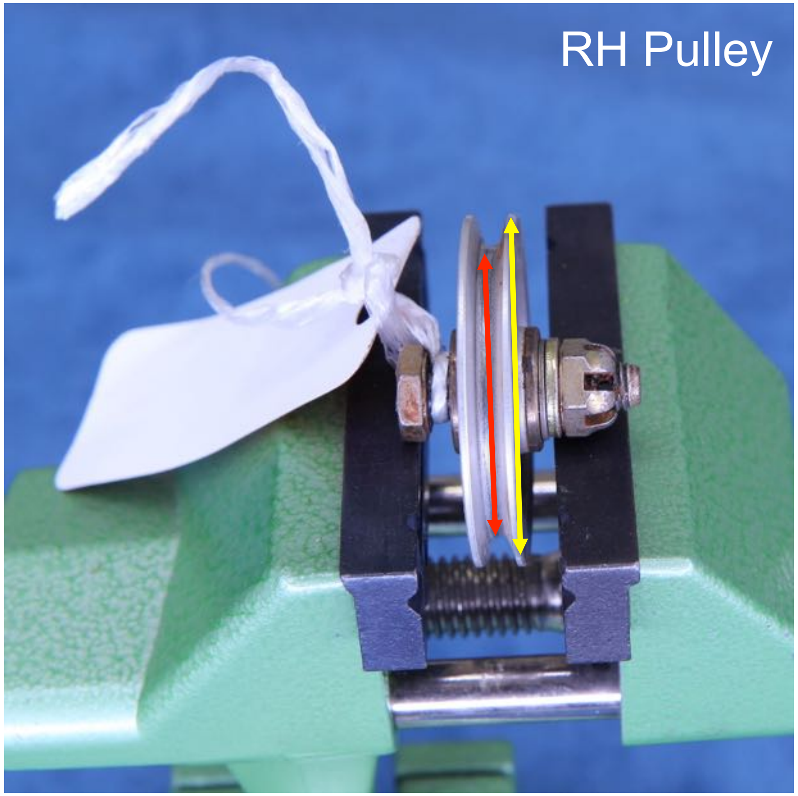


Figure 15

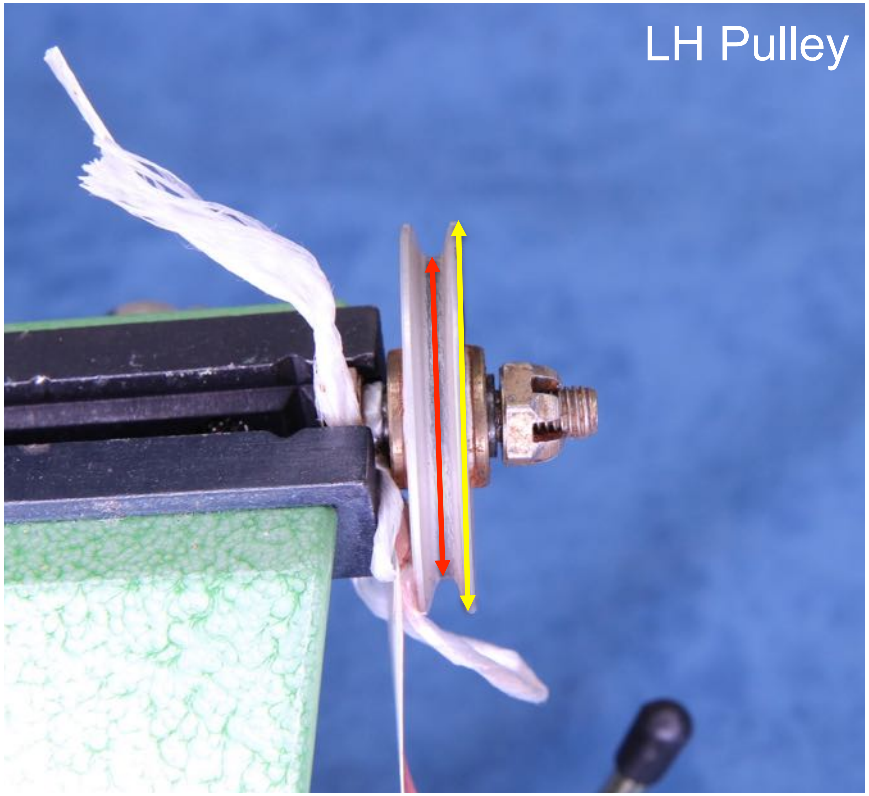
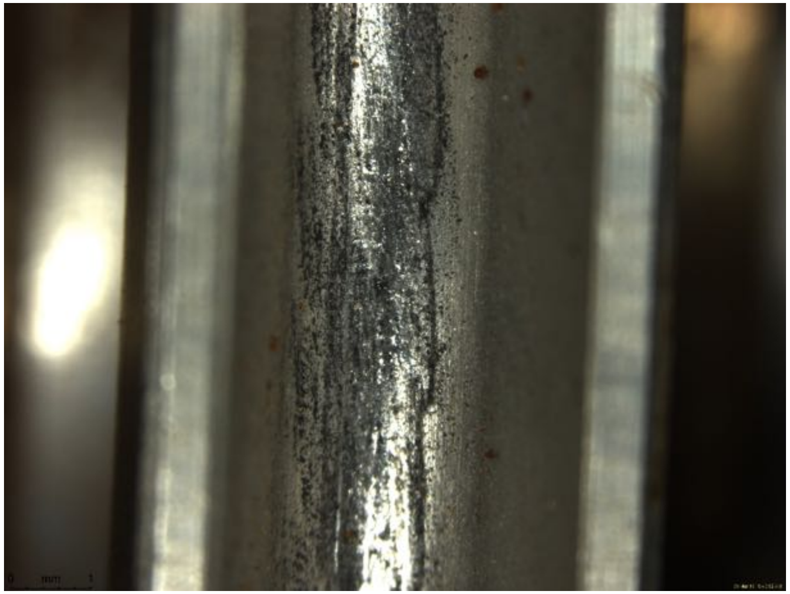


Figure 16

Pulleys

Wear on RH pulley due to cable action

Figure 17



Wear on the LH pulley due to cable action

Figure 18

Findings

- The primary cause of the RH cable fracture was fatigue, resulting in overstress of the remaining wires.
- The LH cable was unserviceable (based on manufacturer requirements) due to deformation and wire fractures that were already apparent.
- The cables and pulleys provided to the ATSB were compliant with the manufacturer's specifications *(pending chemical analysis results)*.
- Most of the fatigue would have occurred prior to the accident flight, and it is likely that some would have been present at the last 200-hourly cable inspection (1600 hours).
- Fatigue in both cables may have been accelerated by the cable running around a smaller diameter pulley than is recommended.

Safety actions

- On 2/04/2018 Aeroprakt issued a safety alert for all Foxbat aircraft with over 500 hours requiring that the rudder cables be inspected.
- Part of this safety alert instructed that cables be reversed (if found serviceable), increasing service life by spreading wear from the pulleys across the cables.

ATSB comment:

While this safety action should help to prevent occurrences like this in the future, the ATSB notes that the safety alert provides more specific guidance on rudder cable inspection than what is currently in the 200-hourly inspection procedure.