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AEROBATIC SPECIAL IN-FLIGHT TESTS AT INSTITUTE OF AEROSPACE ENGINEERING

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Abstract: *The article provides information about real flight tests of an aircraft at Institute of Aerospace Engineering. Application of methodology is presented on attractive Red Bull Air Race aerobatic aircraft. DAQ system and sensors (used for testing response of an aircraft on control surface deflection) and control forces measurement is briefly described as well as calibration and testing procedure. Only very few results (maximum forces) are provided as the rest of data is not allowed to publish.*

Keywords: Measurement, Force, Control, Calibration, In-flight, Airplane.

1. Introduction

Aircraft testing is an inseparable part of the development of any flying vehicle regarding safety and reliability strict rules. The purpose of the tests can be divided into several groups such as: development, certification or verification tests. All of them lead to the creation of the best possible technical production. For this reason, it is necessary to give a proper attention to these experiments since the appropriate tests give a feedback to engineers. Based on the results they can refine their theoretical practices.

Each day the engineers of Aircraft Testing Facility at Institute of Aerospace Engineering (IAE) solve interesting problems linked to an industry's research and development. A lot of in-flight tests have been performed at IAE. VUT-001, VUT-061, C172T or Dornier 28, EV-55 are common aircraft tested at IAE. Test of the aerobatic special for Red Bull Air Race (Fig. 1) is different in some aspects and set up a new challenge for our team at IAE.

Fig. 1: EDGE 540V3 aerobatic airplane.

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2. In flight measurement of control stick forces at EDGE 540 aerobatic aircraft

Martin Šonka is a famous Red Bull Air Race and aerobatic pilot (sitting in EDGE 540 V3 in Fig. 1) as well as the Czech aerobatic representative in the category "Unlimited".

Travelling to Red Bull Air Race competitions is very time consuming. Moreover, weather is not always good for flight tests and thus the pilots do not have enough time for adequate training of a race track. That is the reason why the racing pilots use training flight simulators.

The simulators are important for training and pilot´s progress and set up the requirement for better mathematical model of simulation. For example, the control forces feedback can help to simulate the flight more realistic. These forces can be determined analytically, but it is preferable and more accurate to perform flight tests.

3. Measured parameters, DAQ, sensors and calibration

The aim of this measurement was to determine the control stick forces for typical aerobatic manoeuvres. The main goal was to measure deflections and forces in a control stick. It was necessary to define several flight parameters to define precise simulation model.

Acceleration and positional angles in flight were measured by inertial unit. Speed, altitude and motor parameters were taken from data log in inner data acquisition (DAQ) unit of the aircraft. It was also important to know the weight of the plane before and after the flight test. Forces in pedals were omitted (rudder control forces are less important).

The aircraft achieves load factor around 10 G during aerobatic manoeuvres, special attention had to be therefore paid to fit the measuring device Dewetron Minitaur and all sensors as potentiometers for the elevator and aileron deflections, inertial measurement unit, GPS antenna and so on. The fixing of potentiometer is shown in Fig. 2. The potentiometer is directly connected to the steel frame of fuselage. The connection to the control system is visible too.

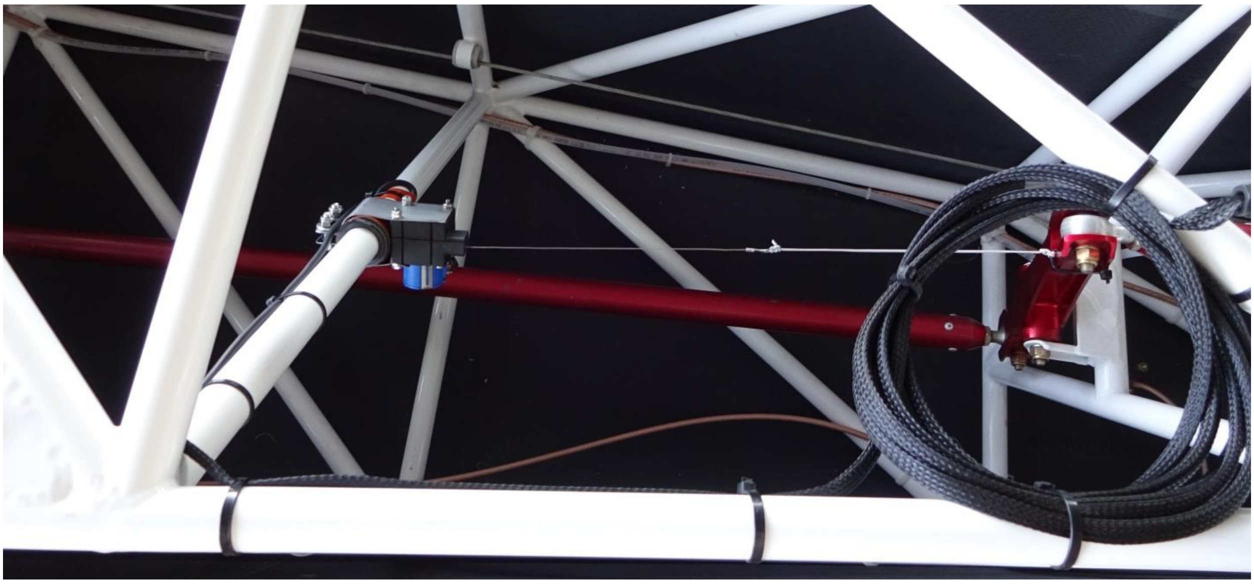

Fig. 2: Connection of elevator deflection sensor.

A lot of methods exist for forces measurement, but installation of strain gauges directly on the stick was the most convenient. To avoid all negative influences a full bridge of strain gauge was installed on control stick in longitudinal and lateral force directions. From mathematical point of view, the calibration process is searching of relation between internal load in specific cross section of the structure (strain due to bending moment on control stick) and response of strain gauge bridge located in this section (Jebáček, el al, 2015). Fig. 3 shows linear dependence of voltage (on strain gauge bridge) on force read on calibrated load cell. Coefficients of linear regression were sufficient for force stick determination. For better accuracy second order polynomial dependence was used for aileron stick force.

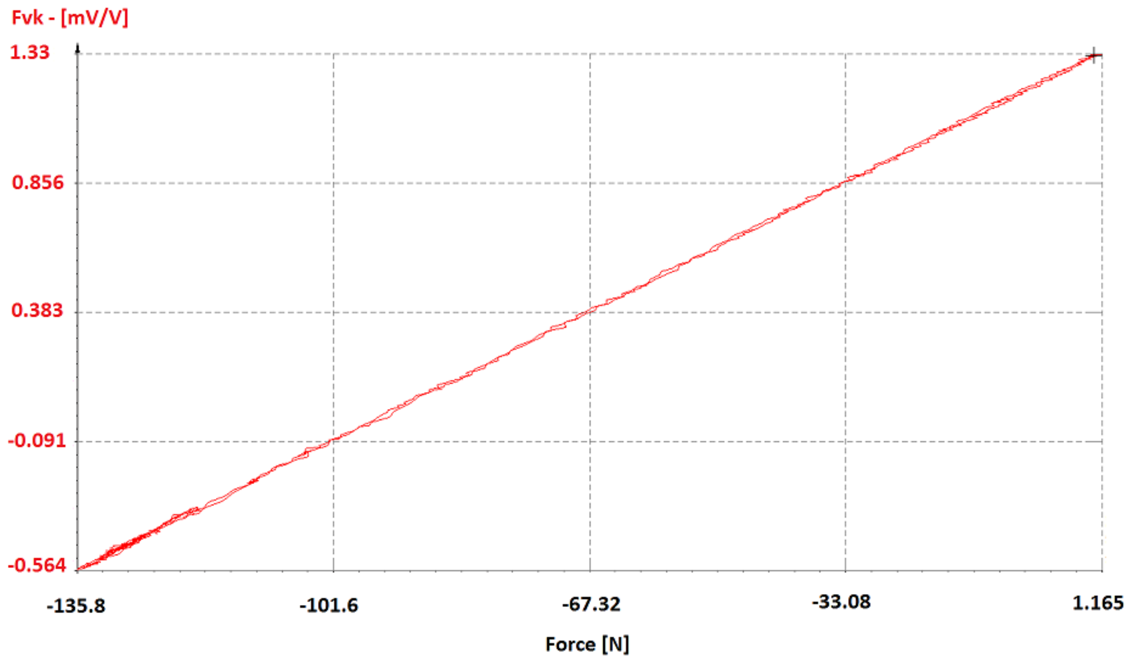

Fig. 3: Graph response - force.

Deflections were calibrated with mechanical deflection meter (Fig. 4), which is faster and more reliable than standard digital level.

Fig. 4: Calibration of control surface deflection.

4. Test procedure

All the preparations and tests had to be done within a few days, when the plane and pilot were available.

The aerobatic manoeuvres (steep turns, rolls, stalls and so on) were defined first.

Before the flight, the stick forces and control surface deflections were calibrated.

After all the preparations the aircraft was weighted and M. Šonka performed aerobatic flight plan. All data were continuously recorded during the flight in a rate of 100 samples per second.

Because the flight consisted of many manoeuvres, separated parts for evaluation of maximal forces were used. The aircraft trajectory was measured precisely and manoeuvre recognizing was carried out and required waveform of each flight manoeuvre was defined. Typical measuring window of measured parameters is in Fig. 5.

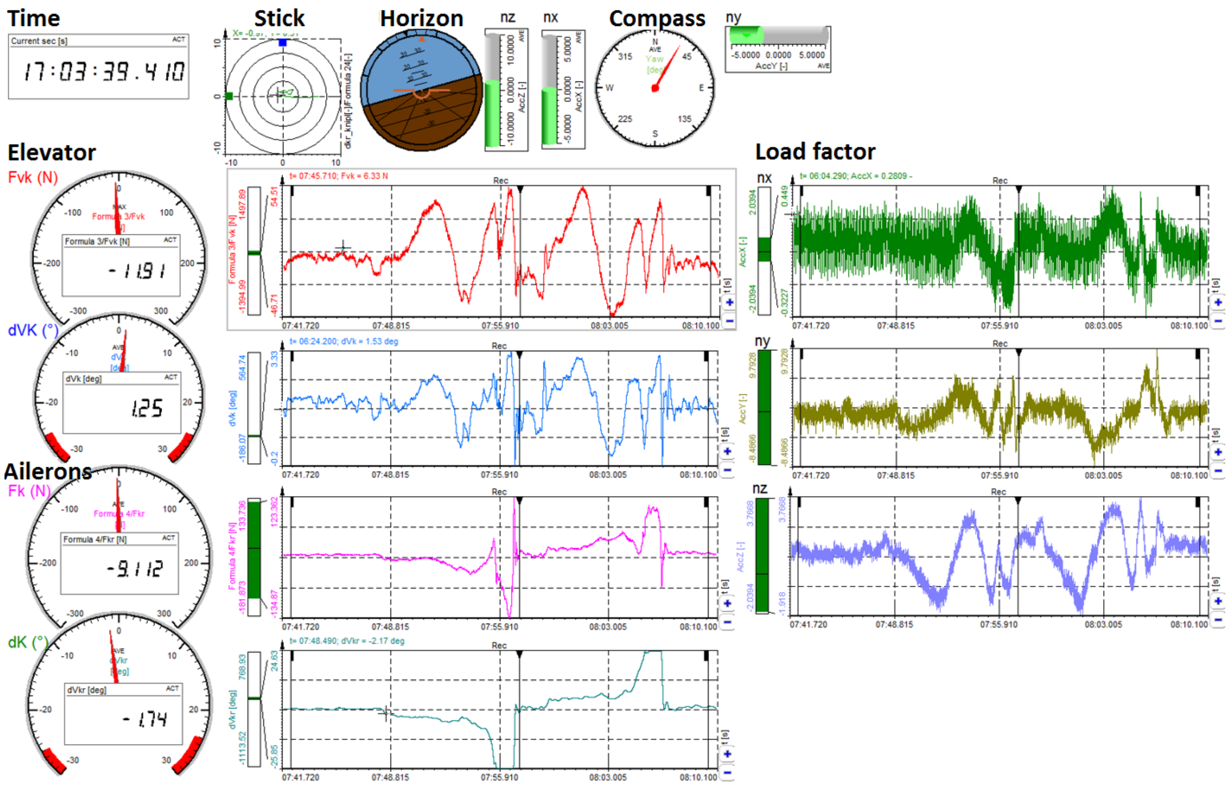

Fig. 5: Measuring window.

The maximal values 270 N in longitudinal and 209 N in lateral control system were measured.

Not only the maximal forces in control stick were defined, but also their time dependency with respect to flight conditions. This will help to get flight simulator closer to the real aircraft and improve the pilot's effective training.

5. Conclusion

The article describes practical experimental measurement of a real aircraft in flight. This procedure is standard for large transport airplanes, but it's unique for light aerobatic aircraft. Stick forces, control deflections and its dependency on flight conditions in various aerobatic manoeuvres were defined. The tests helped to understand the behaviour of an aircraft and improved mathematical model of the simulator. It can improve the placing of M. Šonka in Red Bull Air Race. Unfortunately, not all results can be published.

Dedication (Acknowledgement)

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