Analysis of In-flight Loads on a PW-6U Glider using Wing Deflection and Acceleration Measurements

M. Sc. Stanisław Gajek
Warsaw University of Technology, email: stanislaw.gajek.dokt@pw.edu.pl

Abstract:

This paper aims to identify critical differences and similarities between loads during typical glider flight manoeuvres as measured by multiple sensors. This is achieved by comparing high-frequency load recordings gathered using accelerometers and an extensometer. The analysed flights were typically airfield traffic patterns consisting of winch starts, turns, level flights and landings.

The experiments were performed on a PW-6U trainer glider. The aircraft was double-seated, giving ample room for the positioning of measuring equipment. Based on previous findings, the author constructed a custom flight recorder and a wing deflection sensor in order to find the most representative flight parameters. The recorder was placed behind the aft seat, near the glider's centre of gravity. An extensometer functioning as the wing deflection sensor was attached to the wing box front wall and connected to the right wing spar using a stiff steel shaft.

The data from the custom-built devices was recorded in an onboard memory. The recorder used a sensor array consisting of accelerometers, magnetometers, gyroscopes, a barometer and a GNSS receiver. The extensometer used strain gauges arranged in a Wheatstone bridge to compensate for in-flight temperature differences. Both accelerometers and the extensometer were synchronised to minimise the time offset between measurements. The frequency of both sensors' outputs was set to 732Hz. All recordings began automatically, with minimal pilot engagement.

The article presents the results of the experiments in the form of a time analysis and a frequency analysis. A typical recorded mission is visualised using GNSS-based flight paths and load graphs. The time-based analysis mainly shows the well-known and expected differences, such as tamer loads during starts and landings, as detected by the extensometer rather than by the accelerometers. However, the frequency analysis offers a more nuanced perspective on the data gathered with both sensor types. With an increased measurement frequency, it was possible to identify the actual bandwidth of the accelerations and wing deflections during the typical manoeuvres. Particular interest is placed on the winch start as one of the most dynamic flight situations and the only set of conditions where an activity increase in the 25-30Hz band is observed. Due to the high recording time resolution, the moment of line detachment reveals interesting differences between fuselage and wing impulse responses. Moreover, during a steady flight and turns, the differences were minuscule in calm weather, whereas fast wind gusts resulted in a shift in values measured by both sensor types.

The paper concludes with a summary of the findings and proposals for developing future projects. Based on the former, a Kalman filter may be designed to give more reliable data on true in-flight dynamic loads in gliders. The presented data may also be used in the development of non-deterministic algorithms for accelerometer and GNSS-based wing deflection prediction.