Airborne data acquisition system and flight experiment order for small uav aerodynamic characteristics investigation

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Background. Small-sized unmanned aircraft type aerial vehicle experimental aerodynamic research via flight experiment is needed for their development and manufacturing acceleration because of the increasing role of small UAVs in modern world and, therefore, rising required quantity of such aircrafts. There are lots of papers [1–6] connected with experimental aerodynamic characteristics investigation, using Airborne Data Acquisition Systems (ADAS) consisting of a microcontroller and a set of sensors which are intended for large aircrafts, but not small UAVs.

Aim. ADAS and flight experiment order development for small UAV aerodynamic characteristics research.

Methods. ADAS consists of the Arduino Nano 33 BLE microcontroller, BNO055 absolute orientation sensor, BMP180 barometric pressure altimeter and MPXV7002DP dynamic pressure sensor and mounts on small UAV (fig. 1, 2).

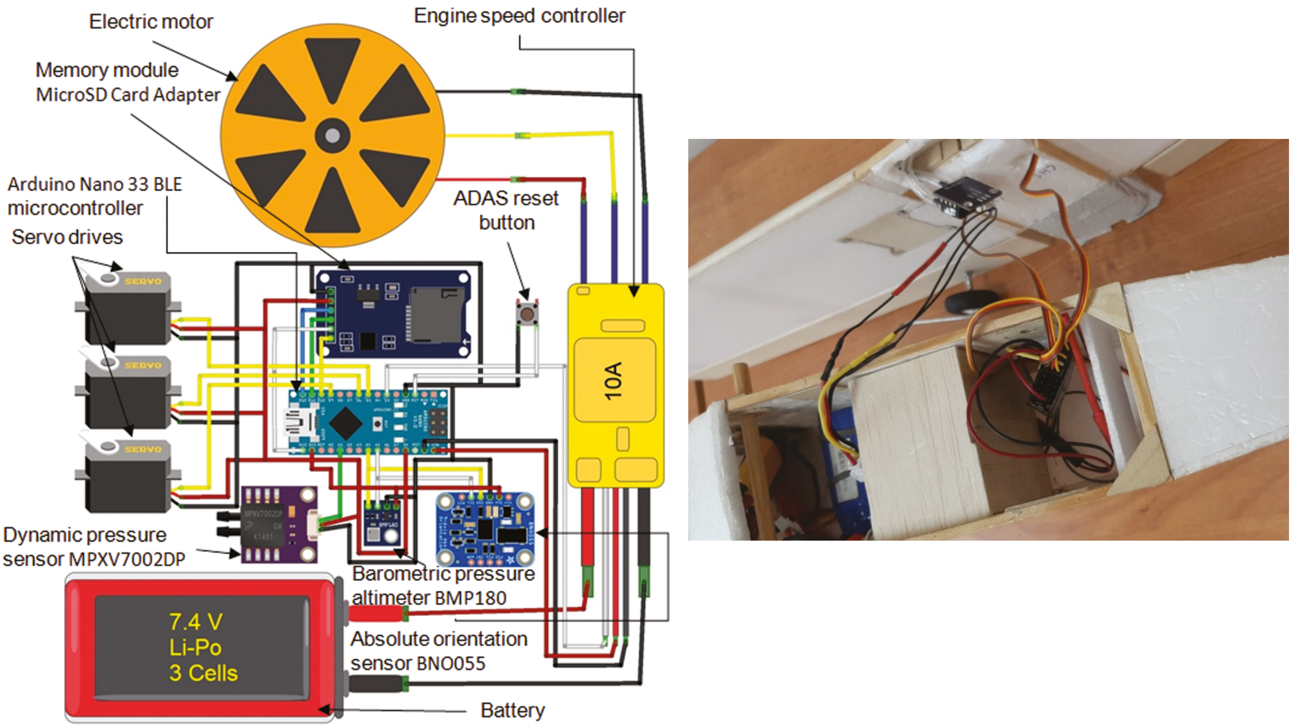

Fig. 1. Visual ADAS scheme drawn with Fritzing software and ADAS inside the small UAV

Fig. 2. Small UAV in flight

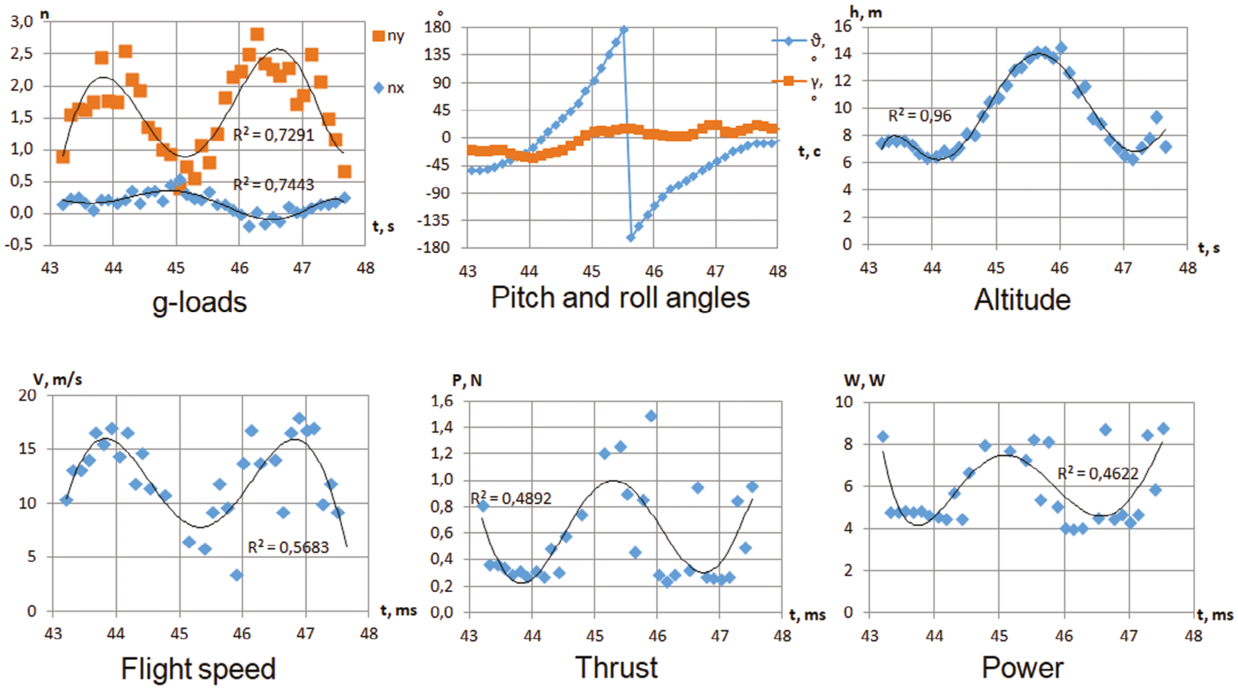

Fig. 3. Complete loop flight parameters

The ADAS registers flight parameters during the flight. The flight experiment consists of horizontal flights at different speeds at nearly zero angle of attack and demonstration flight with complete loop. The flight parameters got with the ADAS are then processed with Microsoft Excel program in order to get the aerodynamic characteristics: the coefficients of normal C_y and tangential C_x forces and aerodynamic performance in the associated coordinate system K. A series of cruising flight mode aerodynamic calculations at various angles of attack and angles of deflection of the elevator using Ansys Workbench 18.2 CFX module was conducted for measurement error estimation to compare numerical aerodynamic characteristics with experimental ones.

Results. The relative measurement error for C_x exceeds 30% due to the lack of accounting of the influence of the propeller and surface roughness in numerical aerodynamic calculation, which also affects the aerodynamic efficiency. Minimal measurement errors are about 10%. The ADAS gives adequate results at small angles of attack. Despite the fact that the aerodynamic characteristics of the UAV were not obtained in the complete loop due to the limitations of the ADAS, there is a mutual correspondence between the flight parameters (fig. 3), which is supporting evidence of ADAS performance capabilities.

The flight experiment order for ADAS function test, consisting of horizontal flights and complete loop is proposed.

Conclusion. The methodology and ADAS allows obtaining small UAV aerodynamic characteristics and can be installed on any UAV of appropriate size.

Keywords: small unmanned aerial vehicle; Airborne Data Acquisition System; aerodynamic characteristics; flight parameters; Computational Fluid Dynamics.

References

1. Миронов А.Д., Владычин Г.П., Кондратов А.А. Методы исследований на летающих моделях. Москва: Машиностроение, 1988. 144 с.
2. Корсун О.Н., Николаев С.В. Методика идентификации аэродинамических коэффициентов продольного движения самолета в эксплуатационном диапазоне углов атаки // Мехатроника, автоматизация, управление. 2015. Т. 16, № 4. С. 269–276.
3. Nikolayev S.V. Technique for assessing the stability and controllability characteristics of naval aircraft systems based on the rational combination of modeling, identification and flight experiments // Science and Education. 2015. No. 10. P. 171–193. (In Russ.) DOI: 10.7463/1015.0813316
4. Tyurina M.M., Jet convective system for measuring the altitude-airspeed parameters of rotorcraft and very light flight vehicles // Izvestiya vuzov. Aviatsionnaya tekhnika. 2007. No. 4. P. 53–57. (In Russ.) DOI: 10.3103/S1068799807040137

5. Maksimov A.K. Method of indirect measurement of aircraft aerodynamic angles using accelerometers and pressure sensors // Izvestiya vuzov. Priborostroyeniye. 2019. Vol. 62, No. 10. P. 893–899. (In Russ.) DOI: 10.17586/0021-3454-2019-62-10-893-899
6. Maksimov A.K. Estimation of errors in indirect measurement of aircraft aerodynamic angles using accelerometers and pressure sensors // Izvestiya vuzov. Priborostroyeniye. 2020. Vol. 63, No. 7. P. 634–639. (In Russ.) DOI: 10.17586/0021-3454-2020-63-7-634-639

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