DronesBench Index of Health for Drones

Mauro Pompetti*, Luca Pompetti & Giuseppe Cornacchia
DPM Elettronica S.r.l.
*email: pompetti@dpmelettronica.it

KEY POINTS

The new European civil aviation legislation will be approved and ratified by the end of 2018.

This legislation will include technical and electro-mechanical requirements also for drones between 250g and 25kg.

DronesBench is a line of test benches for measuring the functioning parameters of drones.

DronesBench Index is an original index of electro-mechanical efficiency of the entire drone system.

Measurements of the DronesBench Index during the operational life of the drone ensure flight safety.

1. Introduction

Following the results of a wide phase of public and private consultation with the numerous stakeholders in the sector [1], the European Air Safety Agency passed its proposal for Community legislation on civil aviation safety [2], which includes rules for drones, to the European Parliament for approval and ratification by the European Council, with specific implementing acts expected by the end of 2018. The legislation introduces rules according to the general principle of proportionality with respect to the risk associated with flight activities and, for drones, regarding security, privacy and protection of personal data. High risk drones will require certification, while lower risk drones will have to comply with the normal surveillance mechanisms of the European market. In this context, the test and analysis bench DronesBench [3] by DPM Elettronica Srl, born in 2015 as an educational project in a professional institute of Foggia and academically validated between 2016 and 2017, arrived at the international commercial phase at the beginning of 2018. It operates in the field of electro-mechanical measurements on civil drones between 250g and 25kg, classified by the Agency as "open" category and subject at least to CE marking. In particular, the DronesBench project generated an original and precursor index, a Figure of Merit defined as the DronesBench Index [4-6], for the electro-mechanical evaluation of the drone as an overall system, rather than for individual components or subsystems. Measured at the factory, the DronesBench Index could be wirtten on the plate of the drone and periodically verified during the operating life: significant deviations from the initial measurement, would in fact indicate hidden electro-mechanical defects and therefore risk for flight. A case study [7] and comparative numbers with other drones tested in the same "open" segment illustrate the concept and its possible utility as a benchmark for the electro-mechanical efficiency of the overall drone system.

2. METHODS

DronesBench is able to measure simultaneously and without disassembling the drone: (i) the thrust provided by the drone, (ii) the instantaneous power consumed by the drone, and (iii) the instantaneous pitch, yaw and rolling angles during the test. Force measurements can be used to detect faults in the electronic speed control - engine - propeller subsystem. The values of force and instantaneous power can be used together to quantify

power efficiency. Instant pitch, yaw and roll measurements are useful for analyzing system stability. The general architecture of the DronesBench is illustrated in Fig. 1.a). It consists of: (i) a power supply for the test stand and the drone; (ii) the test bench; and (iii) the frame. The test bench is shown in Fig. 1.b). It consists of (i) a housing for the drone, in the shape of a ring where the drone under test is placed and secured by laces, (ii) a reference plane used for distance measurements, and (iii) a measurement unit. The test bench is equipped with three load cells used to evaluate the forces exerted by the drones. The measurement unit acquires the quantities supplied by the sensors on the test bench and passes them to a personal computer via a USB interface. From these measurements, we estimate the equation of the plane that relates the housing of the drone to the reference plane. In this way the vertical components of the forces are estimated, as measured by the force cells and referred to the reference plane.

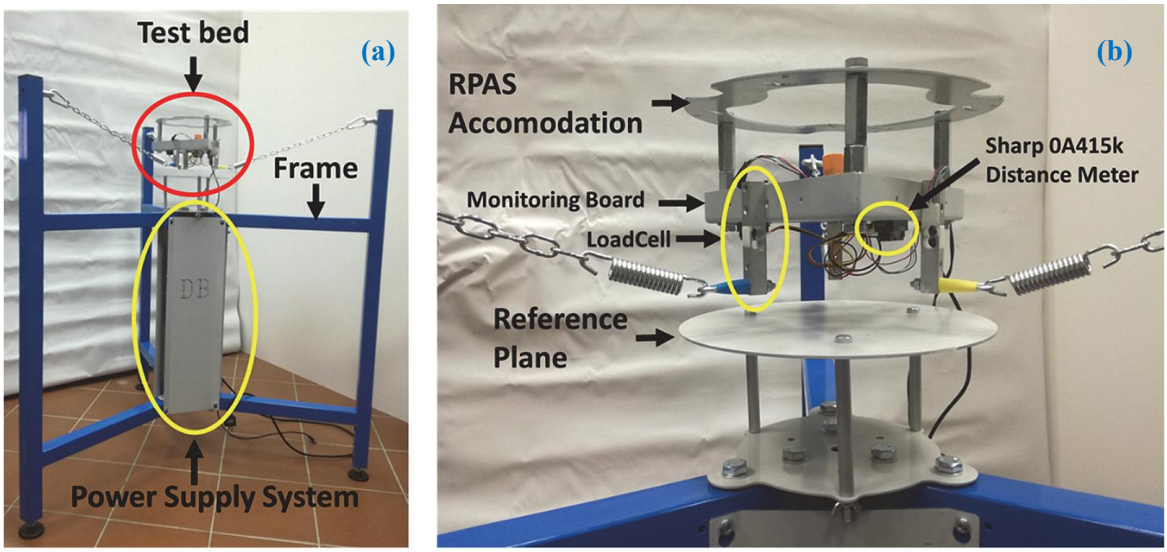


Figure 1. General architecture of the DronesBench (a) and detail of the test bed (b)

The DronesBench Index depends on the set acceleration and the speed of the propellers, so it must be evaluated at the time t_0, when the vertical thrust is equal to the weight of the drone without load. To evaluate t_0, the vertical force imposed by the test bench alone (F_1) is measured first; therefore, the vertical force imposed by the test bench and by the drone ($F_2(t)$) during take-off is measured continuously. t_0 is the instant at which F_1 is equal t $F_2(t_0)$. At the instant t_0 , the power absorbed by the battery is evaluated by measuring the voltage along the battery $V_d(t_0)$ and the current absorbed $I_d(t_0)$. The DronesBench Index, DBI, is evaluated as follows:

$$DBI = \frac{F_2(t_0)}{V_d(t_0) * I_d(t_0)} \tag{1}$$

To make it easier to determine t_0, the following rules must be followed:

1. the battery must be fully charged,
2. acceleration should be given slowly, a typical take-off time is 10 seconds. This allows the influence of dynamic forces to be reduced.

DronesBench was used to evaluate a Tali H500 commercial quadrotor drone from Walkera, with an pitch length and weight of 490 mm and 2.42 kg, respectively. The drone housing on the DronesBench and the start of the test are shown in Fig. 2a) and 2b).

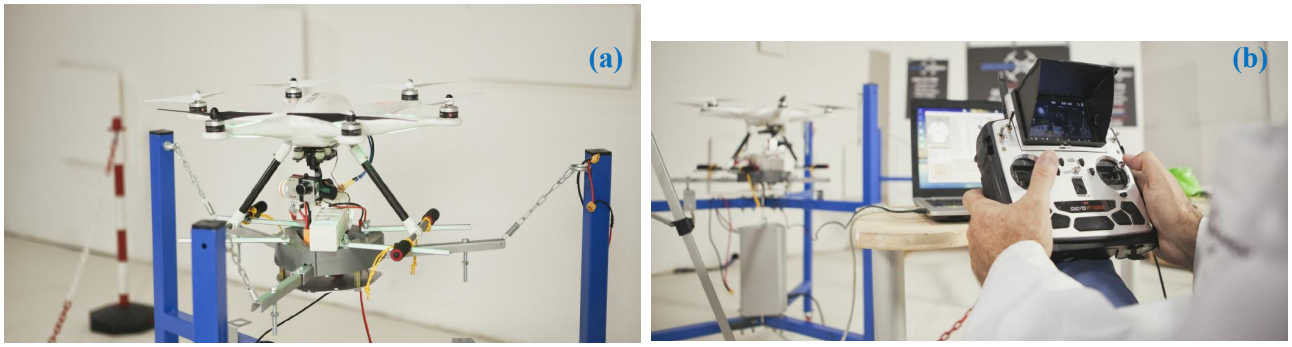
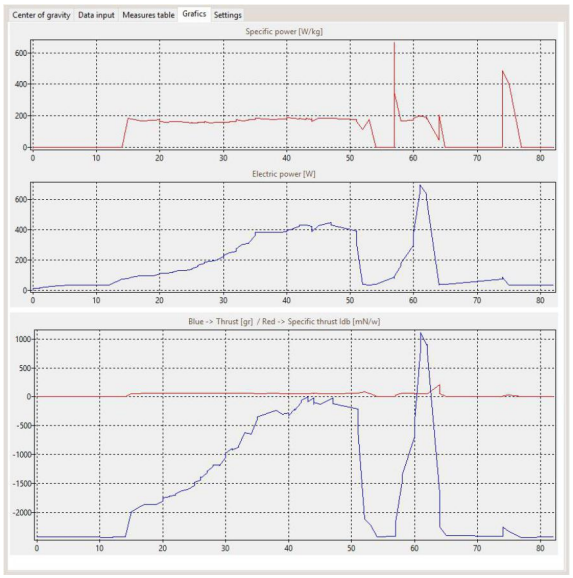


Figure 2. Drone Tali H500 secured on the DronesBench test bed (a) and ready to be tested (b)

3. RESULTS and DISCUSSION

The test was performed in 77 seconds with two acceleration variations from the minimum value to the maximum allowed by the drone.



The trends of specific power [W / kgf], electric power [W] and thrust [grams] with DronesBench Index [mN / W] are shown in Fig. 3. Through these graphs it is possible to give a synthetic but detailed, in-depth evaluation of the functionality of the drone, as well as any related shortcomings.

The DronesBench Index was 53 mN / W at takeoff and at 50 mN / W at maximum power, low values in this market segment. The average values from other tests on other comparable drones are in fact about 70 mN / W.

Table 1 shows the primary characteristic values of the drone in the steady state of the engines, at take-off and at maximum power. Note the 1.1 volts difference between stationary motors and maximum power, attributable to the poor quality of the battery or to its defect.

Figura 3. Graphs from the drone Tali H500 test

Parameter	Stationary Engines	Take off	Maximum Power
Voltage [volt]	23.9	23.2	22.8
Current [ampere]	1..1.5	19.2	30.4
Power [watt]	28 average	445	694
Thrust [grams]	0	2420	3530
DronesBench Index [milli newton / watt]		53	50
Specific Power [watt / kgf]		185	196

Table 1. Main parameters measured on Tali H500 drone.

The test shows that there are margins to improve the efficiency of this drone. Post test, it is suggested to use a battery with higher C (over 6) and propellers with larger pitch and diameter. The manufacturer Walkera, contacted for comment, reported that the Tali H500 drone is now out of production.

4. CONCLUSIONS

This article demonstrates how we can expand the technical boundaries of our knowledge on drones. The advantage is not only for the safety of people and things, the goal of European regulation to come, but also for builders and users. Manufacturers will be able to work in quality, classifying their products on the basis of weight, power and efficiency according to the ratio currently used for cars. The additional information will allow users to purchase their drones consciously, taking care both of the aesthetic-functional aspect and the limits of their possible uses.

The dissemination of a possible reference parameter for the electro-mechanical efficiency of the drone as an overall system, a parameter that we define as the DronesBench Index, is currently underway at the European Aviation Safety Agency and the International Institute of Engineers Electrical and Electronic. The DronesBench Index could appear on the drone plate as in Fig. 4, measured at the factory, and then periodically evaluated during the operating life of the drone by independent verification and certification organizations.

Figura 4. Drone plate sample with the DronesBench Index expressly reported

DPM Elettronica S.r.l. from Foggia, owner of the DronesBench brand, has equipped itself and is available for the study and certification of drones. The research and development department is also able to develop special benches when customer drones do not fall within a certain range of standard features. Particular attention is paid to the didactic and pedagogical aspects of the measures, as evidenced by numerous audio and video contributions at national level and the not sectorial-only fairs to which the DronesBench project has been invited to participate in the last three years. Details and videos are available on the company website [3].

REFERENCES

[1] European Aviation Safety Agency: Opinion No 01 /2018 - Introduction of a regulatory framework for the operation of unmanned aircraft systems in the ‘open’ and ‘specific’ categories, 2018
[2] European Aviation Safety Agency: Opinion No 01 /2018 - Draft Commission Regulation (EU), 2018
[3] Technical table of the DronesBench project available online at http://www.dronesbench.com
[4] P.Daponte, F.Lamonaca, F.Picariello, M.Riccio, L.Pompetti, M.Pompetti: A measurement system for testing light remotely piloted aircraft, Proc. of IEEE International Workshop on Metrology for AeroSpace (MetroAeroSpace), Padua, Italy, 21- 23 May 2017, pp. 397-402.
[5] P.Daponte, L.De Vito, F.Lamonaca, F.Picariello, S.Rapuano, M.Riccio, L.Pompetti, M.Pompetti: DronesBench: a tool for the diagnosis of drones, Proc. of IEEE International Conference on Instrumentation and Measurement (I2MTC), Turin, Italy 22-25 June 2017, pp.1-6
[6] P.Daponte, L.De Vito, F.Lamonaca, F.Picariello, M.Riccio, S.Rapuano, L.Pompetti, M.Pompetti: DronesBench an innovative bench to test Drones, Instrumentation and Measurement Magazine, Volume 20, Issue 6, pp.8-15.
[7] M.Pompetti, DronesBench calibration example, sUAS News - the business of drones, press release online since 6 Nov 2017 su https://www.suasnews.com/2017/11/dronesbench-calibration-example/