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Flight performance of civil small and light fixed-wing unmanned aircraft systems (UAS) — Test methods

Performance de vol des aéronefs sans pilote (UAS) civils petits et légers à voilure fixe — Méthodes d'essais

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Foreword

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Introduction

Fixed-wing unmanned aircraft systems (UAS) have rapidly increased and are widely used in agriculture, surveying, monitoring, public security, and so on. However, the test methods for the flight performance of fixed-wing UAS vary worldwide and are yet to be harmonized.

This document provides flight performance test methods of civil fixed-wing UAS to verify the manufacturer's declared specifications. The test items selected in this document are those considered to affect fixed-wing flight performance significantly. Acceptance criteria are not included due to consideration that regulations can vary in different countries.

Flight performance of civil small and light fixed-wing unmanned aircraft systems (UAS) — Test methods

1 Scope

This document specifies the test requirements and methods for verifying the specified flight performance items of civil fixed-wing unmanned aircraft systems (UAS).

This document is applicable to the category of civil small and light fixed-wing UAS, which applies to maximum take-off mass (MTOM) level I through V according to ISO 21895.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 21384-4, *Unmanned aircraft systems — Part 4: Vocabulary*

ISO 23665, *Unmanned aircraft systems — Training for personnel involved in UAS operations*

ISO 2533, *Standard Atmosphere*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21384-4 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 General requirements

4.1 Test purpose

This test aims to verify that a fixed-wing UAS's flight performance indicators satisfy its design specifications.

4.2 Test outline

A test outline shall be prepared, which should include but not be limited to the following:

a) test basis;

b) test purpose;

c) the quantity and technical status of the test article and apparatus;

d) test plan (objective, applicable standards/specifications, number of test flights, methods and requirements, instrumentation, conditions, acceptance criteria);

e) test and measurement requirements;

f) test termination and resumption;

g) data processing principle;

h) test organization and task allocation;

i) security assurance.

4.3 Test requirements

4.3.1 Technical documents

The following documents should be prepared before the test:

a) design documents, figures and interface file which are relevant to the test;

b) operator's manual.

4.3.2 Test article

The test article shall meet the following requirements.

a) The test article shall conform to the requirements specified in 4.3.1.

b) There shall be sufficient test articles to complete each flight test. The allowable number of test articles as per criteria shall include the number of statistical repetitions of flights to be completed by each test article.

c) The flight testing shall take place across the range of the test article's centres of gravity and mass envelope.

d) The test article's flight control system (FCS), as well as its sensor, shall have been properly calibrated.

4.3.3 Test apparatus

All the measuring devices used in flight tests shall have been properly calibrated and shall be within the valid period of calibration.

4.3.4 Personnel

The test personnel shall have the appropriated level of experience and training for the specific test articles in accordance with ISO 23665.

4.3.5 Management of the test article

The management rules after the test article enters the site are as follows.

a) After the test article enters the site, the operation shall be implemented in accordance with the test management rules of the test unit.

b) After the test articles are handed over, they shall not be adjusted and debugged without consent. The operation is organized and implemented by the test unit; and the clients provide technical support.

4.3.6 Flight test conditions

The flight test shall be conducted under the following conditions.

a) There shall be no considerable obstructions between the ground measurement and control facilities and the test article. Clear radio communication shall be maintained throughout the test; and there shall be no significant electromagnetic interference at the test site.

b) The meteorological conditions during the test shall meet the standard atmospheric conditions.

c) The test field and airspace shall meet the flight test requirement.

4.3.7 Test termination and resumption

The termination and resumption principles are specified as follows.

a) The test shall be terminated in any of the following conditions.

   1) Key indicators of the test article are ineligible.

   2) The test article does not operate normally due to unrepairable faults.

   3) Unacceptable changes occur in the external environment.

b) Additional tests shall be conducted in any of the following situations.

   1) Individual test items fail; the cause has been found and corrected.

   2) The original design is changed due to maintenance and repair.

   3) The test article is replaced with the components or devices that affect technical performance.

4.4 Data processing requirement

The flight test data obtained from the actual conditions shall be corrected to the standard conditions. The factors to be considered include but are not limited to the following.

a) Unless otherwise specified, the standard atmospheric conditions shall be in accordance with the requirements in ISO 2533.

b) Unless otherwise specified, the liquid fuelled UAS shall be tested at 50 % of the maximum liquid fuel level.

4.5 Test record

A test record should include but not be limited to the following:

a) name of the test item;

b) test purpose;

c) time, place, and main test personnel;

d) altitude of the test site;

e) meteorological conditions (including weather, temperature, atmosphere pressure, relative humidity, wind direction, and wind speed);

f) type, serial number, and technical status of the test articles and apparatus;

g) mission planning (flight route, height, flight duration, etc.);

h) test acceptance criteria;

i) main problems identified during the test;

j) file management.

4.6 Test report

A test report should include but not be limited to the following:

a) test overview;

b) test items, procedures, and methods;

c) the International Standard used (including its year of publication);

d) test results, test data analysis, test acceptance criteria;

e) any deviations from the test procedure;

f) any unusual features observed during the test;

g) the date of the test.

5 Test methods

5.1 Test items

The test items are listed in Table 1.

Table 1 — Test items for fixed-wing UAS

S/N	Test item	Reference
1	Launch/take-off performance	5.2.2
2	Maximum take-off mass	5.2.3
3	Climb performance	5.2.4
4	Maximum achievable height	5.2.5
5	Maximum horizontal speed	5.2.6
6	Minimum horizontal speed	5.2.7
7	Maximum flight endurance	5.2.8
8	Turning performance	5.2.9
9	Recovery/Landing performance	5.2.10
10	Gliding performance	5.2.11

5.2 Test procedures

5.2.1 General

Tests should be conducted in "straight-line" flight mode (except for tests under 5.2.9).

5.2.2 Launch/take-off performance

The launch/take-off modes of civil fixed-wing UAS can be classified into horizontal rollout take-off, vertical take-off, catapult launch, and manually launched take-off. Allow the test article to complete the launch/take-off at the maximum take-off mass, and the following data should be measured.

a) In the case of horizontal rollout take-off, measure the ground roll time and distance, take-off time and distance, lift-off speed, etc.

b) In the case of vertical take-off, measure the offset distance from the take-off point, determine the maximum head, cross and tail wind (limits) for vertical take-off.

c) In the case of manually launched/take-off, measure the minimum distance between the test article and the ground.

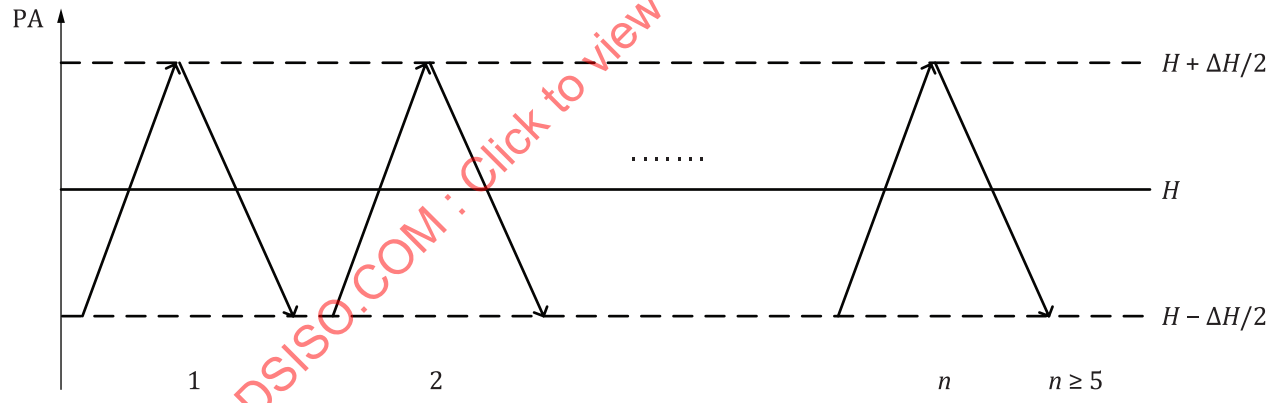
At least 5 tests should be performed.

5.2.3 Maximum take-off mass

A payload or dummy payload is mounted to make the test article's mass reach the maximum take-off mass declared by its design specifications. Allow the test article to fly according to a prescribed typical mission profile; check whether the test article can accomplish the task.

5.2.4 Climb performance

At least 3 different flight heights should be selected within the flight envelope of the test article. For the selected test height, select 2 to 3 speeds on both sides of the designed best climb rate (including the designed best climb rate). Operate the test article to launch/take-off with the maximum take-off mass. The climb performance should be carried out with sawtooth method without wind speed or in headings perpendicular to the wind speed. Firstly, determine the test height H and the climb range ΔH (100 m ≤ ΔH ≤ 200 m). Then allow the test article to steadily climb from $H-\Delta H/2$ to $H+\Delta H/2$ at the maximum take-off power. Lastly, let the test article descend to $H-\Delta H/2$. At least 5 tests should be performed; measure the altitude, airspeed, angle of attack, climb rate, etc. The procedure of sawtooth method is shown in Figure 1.



Key

PA pressure altitude

H test height

ΔH climb range

n numbers of flight test

Figure 1 — Procedure for sawtooth method

5.2.5 Maximum achievable height

According to the data obtained from the climb performance test in 5.2.4, operate the test article using the direct climb method to climb to the designed maximum climb rate and perform stable level flight; the stable level flight should be performed for at least 30 s. Measure the altitude, airspeed, angle of attack, climb rate, etc.

5.2.6 Maximum horizontal speed

The flight test shall be conducted in a stable atmosphere. Operate the test article to accelerate linearly until to the declared maximum horizontal speed set by the fight control system (FCS); check whether the test article can level-off stably. The stable level flight should be performed for at least 30 s, considering the test field, airspace, and the model of the test articles. Measure the altitude, airspeed, angle of attack, engine speed, etc.

5.2.7 Minimum horizontal speed

The flight test shall be conducted in a stable atmosphere. Operate the test article to decelerate linearly until to the declared minimum horizontal speed set by the fight control system (FCS); check whether the test article can level-off stably. The stable level flight should be performed for at least 30 s, considering the test field, airspace, and the model of the test articles. Measure the altitude, airspeed, angle of attack, engine speed, etc.

5.2.8 Maximum flight endurance

Operate the test article to launch/take-off with full liquid fuel or full power and to perform a prescribed mission profile until the liquid fuel or electrical power reaches the safety remaining margin, operate the test article to recover or land; at least 3 tests should be performed.

For liquid fuel test article, determine fuel burn rate and extrapolate flight endurance from remaining useful fuel (or equivalent).

5.2.9 Turning performance

Operate the test article to turn left and right stably for not less than 360° with different speeds and roll angles. Measure the altitude, airspeed, angle of attack, engine speed, etc.

NOTE It is necessary to increase the engine power during the hovering to avoid altitude loss.

5.2.10 Recovery/landing performance

The recovery/landing modes of civil fixed-wing UAS can be classified into parachute recovery, net/rope/cable recovery, horizontal rollout landing, and vertical landing. Allow the test article to complete the recovery/landing process; and the following data should be measured.

a) In the case of parachute recovery, measure the distance between the parachute deployment command and the actual landing point.

b) In the case of horizontal rollout landing, measure the final approach speed, distance, and time; touchdown speed, ground roll time and distance, etc.; measure the distance between the start of pitch up (flare out) and touch down for various glide slope angles (within the ranges provided in the manual).

c) In the case of vertical landing, measure the distance between the take-off point and the landing point; determine the maximum head, cross and tail wind (limits) for vertical landing.

At least 5 tests should be performed.

NOTE For liquid fuel powered test article, the landing mass cannot exceed the limit.

5.2.11 Gliding performance

The test shall be carried out in a stable atmosphere. To ensure safety, a high altitude should be selected within the range from the test field to the maximum achievable height. Operate the test article to level-off stably; then turn off the engine (safety protection measures shall be taken); glide at the constant angle of attack (AOA) set by the flight control system (FCS); keep the blades, landing gear and flaps