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Flight control system for civil small and light multicopter unmanned aircraft system (UAS) — General requirements

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Foreword

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This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 16, *Unmanned aircraft systems*.

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Flight control system for civil small and light multicopter unmanned aircraft system (UAS) — General requirements

1 Scope

This document specifies the composition, functional and performance requirements of flight controls for civil multicopter unmanned aircrafts (UAs) with the maximum take-off mass (MTOM) less than or equal to 25 kg corresponding to unmanned aircraft systems (UAS) at levels I, II, III and IV as graded in ISO 21895 which does not include fully autonomous flights.

The flight control system in this document consists of flight control unit, navigation unit, fault diagnosis and management unit, flight planning, flight recorder, etc. This document is applicable to the design and manufacture of other UA flight control systems or subsystems.

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*

3 Terms and definitions

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

3.1
attitude control mode
flight control system mode that controls the attitude of the aircraft, but not the position of the aircraft

3.2
hover state
function or mode of keeping the position and height of an aircraft relatively unchanged in position mode without receiving any external control instructions

4 Abbreviated terms

AGL	above ground level
C2	command and control
FCS	flight control system
GNSS	global navigation satellite system
ICAO	International Civil Aviation Organisation

IMU	inertial measurement unit
MTOM	maximum take-off mass
RNP	required navigation performance
RTK	real time kinematic
RPS	remote pilot station
UA	unmanned aircraft
UAS	unmanned aircraft system

5 Systems and functions

5.1 System composition

The FCS of multicopter UAS usually includes aircraft motion control unit, navigation unit, fault diagnosis and management unit, power management unit and flight recorder. The typical information flow of the FCS is described in Figure 1.

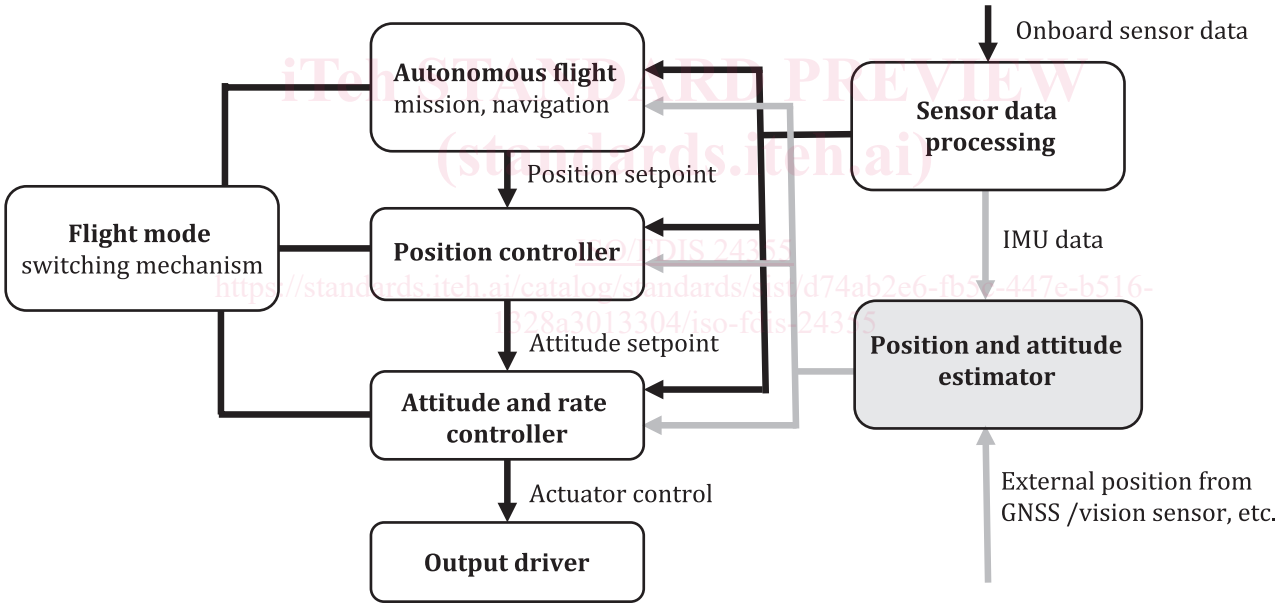

Figure 1 — Typical information flow of the FCS

5.2 Flight control unit

5.2.1 Angular velocity control

The FCS shall have the following angular velocity control functions:

a) respond to angular velocity commands in pitch, roll and yaw directions based on navigation information;

b) control the UA angular velocity to reach the target angular velocity within the allowable time;

c) when the angular velocity control command is zero, the system should maintain current attitude angle unchanged.

NOTE Angular velocity control is also called rate control in many cases.

5.2.2 Attitude control

The FCS shall have the following attitude control functions:

a) adjust the aircraft attitude to the target value in a certain time according to the attitude angle command;

b) withstand the unexpected change of aircraft attitude angle caused by external forces during the flight.

5.2.3 Velocity control

When equipped with navigation sensors for velocity measurements/estimation, the FCS shall have the following velocity control functions:

a) adjust the aircraft velocity to the target value in a certain time according to the velocity command;

b) withstand the unexpected change of aircraft speed caused by external forces during the flight.

5.2.4 Position control

When equipped with navigation sensors for position measurements/estimation, position control should have the following functions:

a) control the aircraft to the target position;

b) keep the position of the aircraft when the position control command remains unchanged.

5.3 Navigation unit

5.3.1 General

This subclause applies to the FCS with navigation capability.

5.3.2 General requirements

The navigation unit shall have the following functions:

a) calculate all or some of other values such as the longitude and latitude, altitude, acceleration, ground speed, vertical speed, heading, pitch, roll and other navigation information of UA;

b) sensor calibration;

c) diagnose sensor faults;

d) provide angular rate, orientation and acceleration information, such as IMU information;

e) provide continuous altitude information, such as barometric altitude information;

f) provide positioning information, such as GNSS information.

5.3.3 Optional function

The navigation unit should have the following functions:

a) provide AGL information, such as ultrasonic AGL information;

b) provide relative positioning information;

c) interfacing with geo-fencing information;

d) monitor environmental information such as temperature, air pressure and magnetic field;

e) estimate the accuracy of navigation information (e.g. in the form of covariance);

f) alignment or calibration function to improve the performance of the sensor;

g) manage critical sensor redundancy;

h) receive position of other aircraft;

i) flight-path deviation warning from pre-programmed flight-path for automatic or semiautomatic mode;

j) receive key information during the departure phase from the vertiport infrastructure.

NOTE Information exchanges between the UA and the vertiport are standardised in ISO 5491.

5.3.4 Flight management

5.3.4.1 General requirements

Flight management shall have the following functions:

a) manual control mode, semi-automatic and automatic control switching;

b) identify whether the UAS is on the ground or in the air;

c) provide the remaining endurance time or distance in real-time;

d) fault detection of components;

e) protective measures such as flight envelope limits and flying altitude limitations;

f) provide effective control and maintain smooth flight process.

5.3.4.2 Take-off management

UAS take-off phase management should have the following functions:

a) detect the status of safety-related modules such as sensors, energy sources and power units and the flight restriction area before take-off, and send warnings and prevent the take-off;

b) the take-off point position, home point position and altitude information should be recorded when the position information is known;

d) monitor the key environmental information of take-off point (such as temperature, altitude, geomagnetic interference) and take protective measures in case of poor environment.

5.3.4.3 Navigation management

UA navigation management should have the following functions:

a) when automatically planning a flight mission, the constraints of energy, flight environment, flight capability and other factors should be considered.

b) for the system have UTM interface, support the UAS remote pilot to plan the flight as a sequence of way points defined in 2, 3 or 4 dimensions, considering the intended mission as well as constraints of energy, ground and airspace environment, flight capability and other factors;

NOTE 1 The fleet manager of the UAS remote pilot can use the operational plan preparation (OPP) service in ISO 23629-12.

c) provide effective control and guide the unmanned aircraft through subsequent waypoints along the pre-planned flight path.

NOTE 2 Waypoints can be defined in two (i.e. latitude and longitude), three (plus geodetic or barometric altitude) or four (plus desired time to reach the waypoint) dimensions.

NOTE 3 The RNP in the horizontal and vertical plane is not standardised in this document.

5.3.4.4 Landing management

UAS landing phase management shall have the following functions:

a) when the remaining energy level is enough only for safety landing, the landing mode shall be immediately switched on;

b) when altitude level is less than critical value, the descent speed shall be reduced to prevent hitting the ground;

c) during landing, the position of UA should have the function to be manually adjusted to select the appropriate landing point;

d) safe landing speed should be configurable to prevent landing damage;

e) when the vertiport is include in the landing process, the FCS can receive key information during the arrival phase from the vertiport infrastructure;

NOTE Information exchanges between the UA and the vertiport are standardised in ISO 5491.

f) when the UA has limited landing space, landing accuracy shall be meet for safety landing;

g) the landing operation shall have the capability to be stopped manually.

5.4 Flight recorder

The FCS shall be able to record the following information at the specific frequency determined by the manufacturer:

a) navigation data;

b) flight control mode;

c) remote control information;

d) flight status information;

e) system fault information;

f) system warning information;

g) other required information.

5.5 Safety and emergency management

This subclause is applicable to FCS with navigation capability. When the UA encounters an emergency, to increase safety and reduce damage, the FCS should support the following functions:

a) lost link protection: when the C2 link is lost and the UA is unreachable by any communication method, the FCS should take the specified action under this situation; it should, for example, continue the mission, stop the mission, land, return to home; these actions should be software configurable;

b) emergency flight termination and/or emergency recovery: FCS shall support flight termination or recovery procedure in an emergency;

c) low battery protection: when the remaining battery is lower than the specified minimum value, the FCS should take action specified by the user or manufacturer; for example, send a warning to the remote pilot, return home or land;

d) the FCS should support the motor arm and disarm function; when the motors are in the disarmed state, they are prevented from starting by the FCS;

e) when the UA encounters GNSS failure, the FCS shall reduce the automatic control level and switch to attitude control mode or manual control mode and send warning to remote pilot with sound, light and RPS warning message, etc.;

f) the FCS shall have a maximum attitude angle limitation function to ensure the safe operation of the UA;

g) the tuning of the control parameters should consider enough gain margin to handle uncertainties and dynamic model changes due to condition variation;

h) the communication protocol of the FCS shall have methods such as package sequence number, to prevent out of order and duplicate reception of commands into the communication interface;

i) the FCS shall have the function to track and display communication errors;

j) in the case of temperature controlled IMU, if the temperature control is unable to control the temperature, the FCS shall send information to the remote pilot to indicate a reduced navigation performance;

k) the FCS shall be designed to prevent uncommanded motor start on the ground;

l) the FCS shall be designed to prevent uncommanded full throttle during the flight and send warning to the remote pilot when that happens during the flight;

m) the FCS should detect the propulsion system failure and send warning information to take action and maintain the attitude and height if possible; when the lift is not sufficient to maintain the height, the FCS shall maintain the attitude when reducing the height to minimize the loss;

n) the FCS shall have the function to manage failures or malfunctions, and generate warnings, alarms or failure messages.

5.6 Interface

The FCS manufacturer shall provide the following information in the user manual:

a) type and quantity of interfaces;

b) equipment supported by the interface;

c) relevant electrical characteristics, mechanical characteristics, interface identification and interface communication;

d) function and performance description;

e) connectors and wires.

5.7 Communication with RPS

When equipped with a ground control station, the FCS shall support the following functions:

a) change the flight state;