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Unmanned aircraft systems — Training for personnel involved in UAS operations

Aéronefs sans pilote — Formation du personnel impliqué dans l'exploitation d'UAS

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Contents

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at https://www.iso.org/members.html.

Introduction

Unmanned aircraft (UA) have been rapidly increased in number, application and type within recent decades. UA are commonly utilized for filming, agricultural spraying, inspection, security activities and are expected to be also employed for transportation.

However, the required knowledge, attitude and skill levels for personnel who are involved in unmanned aircraft system (UAS) operations need to be clearly defined. When unskilled persons operate a UA, the risk of a serious accident will increase. Discrepancies in qualification criteria among countries or organizations will also prevent the international exchange of workers and aircraft.

This document helps to ensure that personnel who are involved in UAS operations receive appropriate education and obtain essential knowledge and skill. Training organizations and individuals qualified according to this document will be internationally recognized. It will enhance the international operation of UAS, enable personal exchange, and encourage international trade.

The main body of this document defines the procedures for the operation of a training organization, which is the entity that delivers training to trainees. The requirements for a specific course (VLOS UAS remote pilot-in-command) are located in Annex A. It is envisioned that further courses will be defined later and that these will be added as additional annexes in the future.

Unmanned aircraft systems — Training for personnel involved in UAS operations

1 Scope

This document describes the procedures for training personnel who will be involved in the operation of unmanned aircraft systems (UAS).

This document defines:

a) knowledge, skill, attitude and qualification criteria that are needed for UAS pilots and training organizations that provides training to trainees of UAS remote pilots and other personnel involved in UAS operations;

b) training curriculum and contents for specific learning courses;

c) qualification and confirmation criteria for the training organizations;

d) general procedures for providing training of UAS personnel. The requirements for a specific course as described in the annexes can be more restrictive in some cases.

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 21384-3:2019, *Unmanned aircraft systems — Part 3: Operational procedures*

ISO 21384-4:2020, *Unmanned aircraft systems — Part 4: Vocabulary*

ISO 21895, *Categorization and classification of civil unmanned aircraft systems*

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 terminological databases for use in standardization at the following addresses:

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

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

3.1
national aviation authority
government statutory authority in each country that oversees the approval and regulation of civil aviation

3.2
visual observer
remote crew member who, by visual observation of the remotely piloted aircraft, assists the *remote pilot* (3.3) in the safe conduct of the flight

3.3
remote pilot
person charged by the operator with duties essential to the operation of an unmanned aircraft and who manipulates the flight controls, as appropriate, during flight time

Note 1 to entry: The definition is adapted from Reference [6].

3.4
visual line-of-sight operation
VLOS
operation in which the *remote pilot* (3.3) or unmanned aircraft observer maintains direct unaided visual contact with the unmanned aircraft system

Note 1 to entry: The definition is adapted from Reference [5].

4   Abbreviated terms

AGL	above ground level
ATC	air traffic control
ATS	air traffic service
ATZ	aerodrome traffic zone
Baro-VNAV	barometric-vertical navigation
BVLOS	beyond visual line-of-sight
CRM	crew resource management
CTR	control zone
EVLOS	extended visual line-of-sight
FIR	flight information region
GNSS	global navigation satellite system
GPS	global positioning system
ICAO	International Civil Aviation Organization
IFR	instrument flight rules
NOTAM	notice to airmen
SD card	secure digital card
TEM	threat and error management
VFR	visual flight rules

5 Training organization

5.1 Responsibilities

The training organization shall designate each different person who will be responsible for at least each of the following areas:

a)   training and assessment;

b)   safety.

5.2 Documentation for staff members

The training organization shall maintain, at least, the following documentation for all staff members delivering training services:

a)   name, address and date of birth;

b)   training/qualification, experience; and

c)   duties assigned to the individual staff member.

The service provider shall have documentary evidence that all staff members hold relevant and current qualifications for their duties. Proof of qualifications shall be updated at least every two years and made available to the clients upon request.

5.3 Display of certificate

The training organization shall display a current certificate of accreditation (when applicable) showing that it meets the requirement of this document in a position visible to members of the public entering the premises.

5.4 Records

The training organization shall retain, at least, the following records of trainee training and certification in paper or electric format for a minimum of 7 years:

a)   trainee name;

b)   trainee address;

c)   trainee email address;

d)   trainee telephone number;

e)   trainee date of birth;

f)   course(s) taken;

g)   pass or fail and date; and

h)   instructor details.

The training organization should follow the general protocols for data management outlined in ISO 15489-1 as far as possible.

5.5 Emergency procedures and equipment

For all locations where UAS are to be operated, the training organization shall ensure the availability of the following:

a) a first aid kit suitable for the planned activities;

b) a communication system suitable for alerting emergency services;

c) firefighting equipment;

d) identification of an evacuation location for personnel; and

e) a means for contacting the appropriate air traffic control (ATC), e.g. telephone, radio.

5.6 Introductory information

The training organization shall provide the following information to trainees:

a) conditions regarding the responsibilities of each party related to commencement, delivery and termination of the service;

b) consequences for the training organization and the trainee should either party choose to cancel the service;

c) prerequisites and any qualification requirements in order to obtain the service (e.g. prerequisite certifications);

d) equipment requirements;

e) costs;

f) insurance requirements;

g) any legislation and legal requirements relevant to the specific kind of service;

h) limitations of eventual qualification;

i) scope of the training course;

j) course procedures;

k) means and methods for assessment and criteria for successful completion;

l) that records of their personal data will be kept, and that these records may be passed on to a central training authority or national aviation authority;

m) specification of duration, matters and contents delivered in the course; and

n) specification of language or languages of the course delivery.

6 Training resources

6.1 Teaching aids

The training organization shall provide the necessary resources for training such as instructors, trainee reference materials, facility equipment.

6.2 Instructor requirements

Instructors shall be competent to deliver the training in accordance with the specific requirements detailed in Annex A.

6.3 Theoretical training

6.3.1 Theory knowledge delivery methods

Required theory knowledge can be introduced using instructor-delivered sessions, via internet, virtual reality, applications or any similar mechanisms as long as the trainee can subsequently prove mastery of the required information.

6.3.2 Theory presentations

In case theory teaching is conducted by training organization instructor-delivered sessions, it shall be conducted in an environment such as a dedicated classroom that is free from significant distractions to learning. This shall provide trainees with sufficient working facilities and training aids (e.g. writing surfaces, reference materials, computers, visual or audio materials) to ensure that trainees are able to understand the information being presented.

6.4 Flight training

6.4.1 Training environment

Where the training organization provides flight training, it shall secure an appropriate flight training airspace. The training environment shall be suitably designated and equipped for trainees. The airspace shall be designated as a reserved airspace for training, if possible.

The training organization shall ensure the training environment is appropriate and safe, including taking reasonable steps to consider such factors as:

a) potential conflict with other aircraft;

b) risk to third parties, including to members of the public; and

c) ensuring the area is cleared of any unnecessary hazards to trainees, instructors and other personnel involved in the training operations.

Electromagnetic interference including from other communications and sources in the environment (e.g. other emitter, power lines) should be prevented as far as can be reasonably achieved.

NOTE   Applicable radio interference assessment methods are described in Reference [3] and Reference [4].

6.4.2 Training aircraft

The training organization shall provide appropriate unmanned aircraft of an appropriate kind, number and quality for the training courses being offered to trainees to ensure all trainees have sufficient experience and airtime with the necessary aircraft types. Dual control systems for training aircraft may be beneficial in some circumstances and may be used when appropriate.

6.4.3 Simulators

The training organization should use training simulators wherever possible and appropriate, particularly when demonstrating serious emergency actions.

6.4.4 Risk management

The training organization shall ensure that a risk assessment is conducted before each flight training activity and shall adopt procedures to ensure that all risks are controlled as far as is reasonably possible. All relevant factors shall be considered as part of this assessment including the capability of trainees, the weather conditions, likely air traffic movement and the available equipment.

7 Training content delivery

The training organization shall provide training covering the theoretical knowledge and practical skills as defined in Annex A. The quality and effectiveness of the training content shall be evaluated and maintained periodically.

Before a qualification is issued to a trainee, the training organization shall assess the trainee's knowledge and practical competence to ensure all the required competencies defined in this document have been met.

The training organization should meet the general requirements for learning services described in ISO 29993:2017, Clause 12 "Assessment of learning" and ISO 29993:2017, Clause 13 "Monitoring and evaluation of the learning service", as far as possible.

8 Final qualification

The training organization shall issue diplomas, or other means of recognition, to certify when trainees have met the requisite knowledge and practical skills as defined in Annex A. The diplomas shall include the following data:

a) trainee name;

b) trainee birth date;

c) serial number of the diploma, given by the training organization issuing the diploma:

d) course name and version information;

e) UAS classification/category covered by course;

f) issue date;

g) expiration date (if applicable);

h) training organization name;

i) qualifying instructor's name; and

j) any special endorsements, e.g. including night operations.

9 Evaluation protocols

Trainees shall be evaluated in their theoretical and practical skills to demonstrate their competency according to this document before being issued with any qualification.

Prior to final evaluation, trainees shall either complete all the training described in Annex A or, in the case of experienced but unqualified UAS pilots, demonstrate equivalent existing abilities.

Annex A
(normative)

VLOS UAS pilot course

A.1 Overview

This annex specifies requirements for UAS pilot training programs and the competencies that a training organization is expected to deliver to a trainee in order to achieve a VLOS UAS pilot certification who is able to act as remote pilot-in-command using VTOL UA in VLOS operations. The pilot shall be trained to be able to operate a VTOL UA according to ISO 21895 Grade 2, 3 or 4, and their qualification shall state which Grades of UA they can operate.

This document specifies two stages of pilot training:

a)   theory knowledge (see A.4); and

b)   practical skills (see A.5).

A.2 Competencies

A trainee who successfully completes the training course that satisfies the requirements of this document shall be able to act as the pilot-in-command (remote PIC) of an unmanned aircraft that is operated within their visual line-of-sight. If the training course is for a specific category or class of UA, this shall be specified.

A.3 Fitness to act as remote pilot-in-command

In order to operate the UAS in a safe manner, the trainee shall not have any health issues that are likely to impede their control of the aircraft. In particular, the trainee shall:

a)   be able to clearly see with naked eyes or corrected vision the aircraft at all times and be able to judge its orientation at any distance at which it is likely to be operated;

b)   be able to identify any other air users or obstructions that can pose a collision risk for the UA;

c)   be able to correctly interpret all safety critical data displayed on the UAS controller display unit;

d)   be able to hear sufficiently to be aware of the approach of other aircraft or to be warned verbally of a safety concern;

e)   not have any known condition that could cause sudden loss of consciousness or concentration;

f)   be able to handle the remote-control station and to manipulate the equipment installed therein; and

g)   be able to communicate with other crew members, operators and stakeholders.

In the event that a trainee has a condition or disability that prevents them from meeting one or more of these requirements, it can be possible to achieve a safe working protocol by using a visual observer, back-up remote PIC or other additional crew member, in which case a risk assessment shall be carried out to ensure that such a protocol is effective.

A.4 Theory knowledge

A.4.1 Air law/responsibilities

A.4.1.1 Terminology

The training organization shall ensure the trainee is able to demonstrate understanding of the relevant air law and regulatory terminology.

A.4.1.2 Legislation

A.4.1.2.1 Relevant articles and definitions

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the legal framework that governs airspace in the regulatory environment or jurisdiction of operation; and

b) the legal articles or regulation relevant to UA flight in that jurisdiction.

A.4.1.2.2 Rules of the air

A.4.1.2.2.1 General

The training organization shall ensure the trainee is able to demonstrate understanding of the rules of the air relevant to UAS operation.

A.4.1.2.2.2 Avoidance of collisions ("see and avoid")

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the PIC's responsibility for "see and avoid" and how this relates to avoidance of collisions with manned/unmanned aircraft; and

b) the procedures aircraft should follow in a collision or conflict situation according to the information provided by the manufacturer.

A.4.2 UAS guidance or implementing rules issued in the jurisdiction of operation

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) guidance and/or implementing rules and their relationship with regulation;

b) details of mass categories;

c) details of categories of operation; and

d) restrictions applicable in different operating environments or standardized risk-based scenarios.

A.4.3 Incident and accident reporting

A.4.3.1 General

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the definition of "accident" as regards aviation;

b) the definition of "incident" as regards aviation;

c) the responsibility of the PIC as regards reporting incidents and accidents;

d) ensuring personnel can report incidents and aircraft proximity situations without fear of reprisals;

e) the relevant agencies for different types of reports;

f) the time limits on reporting;

g) the mechanisms for reporting;

h) the types of reportable incidents and accidents; and

i) the concepts of "hazard" and "risk".

A.4.3.2   Aircraft proximity reporting

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the definition of an aircraft proximity situation (airprox); and

b) the reporting process for aircraft proximity incidents if relevant (e.g. according to ICAO requirements in the country where the incident occurred).

A.4.3.3   Investigation handling/assistance

The training organization shall ensure the trainee is able to demonstrate understanding of how to assist agencies with any investigation as regards presentation of logs, records and documentation.

A.4.4   Insurance

The training organization shall ensure the trainee is able to demonstrate understanding of the need for insurance and be able to reference any specific national requirements or international recommendations relevant to UAS operations.

A.4.5   UAS airspace operating principles

A.4.5.1   Flight information region (FIR)

The training organization shall ensure the trainee is able to demonstrate understanding of the relevance of the following with respect to UAS:

a) overall airspace designations;

b) airspace sovereignty;

c) International Civil Aviation Organization (ICAO) definitions; and

d) national or host nation definitions.

A.4.5.2   Airspace classifications

A.4.5.2.1   General

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) airspace structure and limits;

b) difference between controlled and non-controlled airspace;

c) classes of airspace;

d) airspace restrictions;

e) likely vertical extent;

f) 3D nature of airspace;

g) IFR and VFR rules; and

h) ATS units.

A.4.5.2.2 Differing considerations

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) operating restrictions in different classes of airspace;

b) likely traffic considerations for the UAS pilot to be concerned about; and

c) responsibility of other visual flight rules (VFR) traffic.

A.4.5.2.3 Controlled airspace

The training organization shall ensure the trainee is able to demonstrate understanding of:

— how airspace ownership is assigned; and

— when liaison with air traffic control is appropriate for specific airspace types.

The training organization shall ensure the trainee is able to demonstrate understanding of the key features of the following airspace types.

a) Aerodrome traffic zone (ATZ):

1) factors to be considered when operating in liaison with airspace owners;

2) typical or likely traffic flow or operations close to airfields; and

3) how to recognize ATZs on airspace charts.

b) Control zone (CTR):

1) how to act in high-traffic areas;

2) likely traffic flow in high-traffic areas; and

3) how to recognize CTR zones on airspace charts.

c) Gliding/parachuting/ultra-light sites:

1) how to integrate with VFR traffic according to local protocols;

2) UAS handling in uncontrolled airspace, traffic flow and yielding; and

3) the importance of a good look-out given that gliders, parachutes and ultra-light emit minimal sound.

A.4.6 Airspace reservations

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the definitions, avoidance criteria and risks associated with danger areas and where to find information on them;

b) the definition of prohibited areas, their meaning for UAS pilots and where to find information on them;

c) the definition of restricted areas, their meaning for UAS pilots and where to find information on them;

d) when temporary airspace reservations can be applied, their purpose and interpretation; and

e) the significance of special activities (e.g. parachute jumps, aerobatic flights).

A.4.7 Obtaining information/approvals

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the interpretation and use of the aeronautical information publication (AIP) of the country where the flight will be operated;

b) the purpose, interpretation and use of aeronautical information circulars (AICs) of the country where the flight will be operated;

c) notices to airmen (NOTAMs):

    1) how to obtain and interpret NOTAMs; and

    2) how to request the addition of information regarding a UAS flight plan into a NOTAM;

d) chart interpretation:

    1) how to interpret aeronautical charts;

    2) how to interpret surface maps; and

    3) how charts and maps are amended;

e) when it is appropriate to contact other parties and the information needed, for example:

    1) air traffic control (ATC);

    2) national aviation authority;

    3) police;

    4) landowner;

    5) neighbouring property owners; and

    6) bystanders.

A.4.8 UAS operations

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the meaning of each of these terms and their operating limitations:

    1) visual line-of-sight (VLOS);

    2) extended visual line-of-sight (EVLOS);

    3) beyond visual line-of-sight (BVLOS);

    4) other terms, e.g. VFR, as defined in ISO 21384-4; and

b) how segregated airspace is established and managed.

A.4.9   Airmanship and aviation safety

A sound acquaintance with the principles of flight, the ability to operate an aircraft with competence and precision both on the ground and in the air, and the exercise of sound judgment that results in optimal operational safety and efficiency.

A.4.9.1   Good airmanship principles

A.4.9.1.1   General

The training organization shall ensure the trainee is able to demonstrate understanding of:

a)   how airmanship is a range of skills, knowledge and disciplines and is not limited to the motor skills of flying an aircraft;

b)   how airmanship principles can contribute to aviation safety and risk management in the unmanned aircraft environment;

c)   how to put into practice good airmanship principles in real operational situations; and

d)   how concepts such as threat and error management (TEM) and crew resource management (CRM) can form a part of good airmanship.

A.4.9.1.2   Aircraft safe to operate

The training organization shall ensure the trainee is able to demonstrate understanding of:

a)   the requirement to conduct appropriate maintenance checks on the aircraft;

b)   the requirement to develop a maintenance schedule to ensure the aircraft is properly maintained and safe to operate;

c)   the appropriate action when an aircraft requires repairs or maintenance;

d)   the recording of maintenance and repairs; and

e)   the need to stop the operation if the aircraft is not safe to operate at any point in the operation (go/ no go decision).

The training organization shall ensure the trainee is able to demonstrate how to conduct pre-flight checks to ensure the aircraft is safe to operate and airworthy before each flight.

A.4.9.1.3   Remote pilot fit to operate aircraft

The training organization shall ensure the trainee is able to demonstrate understanding of:

a)   how remote pilot fitness is a key part of operational safety;

b)   appropriate medical fitness levels for the remote pilot;

c)   self-check of remote pilot medical fitness before each flight and methods of accomplishing this; and

d)   monitoring of remote pilot fitness.

A.4.9.1.4   Planning

The training organization shall ensure that the trainee is able to demonstrate the basic principles of the following:

a)   planning and preparation to identify operational hazards, risks and, where appropriate, mitigating measures to perform the UAS flight successfully;

b) building situational awareness using thorough planning prior to the UAS flight;

c) determining the workload of a particular operation prior to the flight and allocating correct resources; and

d) conducting effective briefing of normal and emergency actions immediately prior to the flight to help perform the UAS flight successfully.

A.4.9.1.5   Hazard identification

The training organization shall ensure the trainee is able to:

a) identify hazards and risks at the planning stage;

b) put into place appropriate mitigating safety measures prior to the UAS flight;

c) use and generate risk assessments at an appropriate level of detail; and

d) continually assess hazards and take appropriate actions throughout the operation as the operating environment changes.

A.4.9.2   Flight safety

A.4.9.2.1   Avoiding collisions

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) maintaining situational awareness of the operating environment so that collisions with people, vehicles, vessels, structures and any obstacles are avoided; and

b) maintaining a good lookout and effective scanning technique for detecting potential conflicts.

A.4.9.2.2   "See and avoid" with respect to manned aircraft

The training organization shall ensure the trainee is able to demonstrate how to maintain an effective lookout to avoid unplanned conflicts with other aircraft.

A.4.9.2.3   Perception

A.4.9.2.3.1   Distance

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the operational difficulties with assessing distance with the eye alone;

b) using onboard sensors or other means to assess distance; and

c) making effective use of remote flight crew members, e.g. visual observer.

A.4.9.2.3.2   Height

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the operational difficulties with assessing height with the eye alone;

b) using onboard sensors to assess height; and

c) making effective use of remote flight crew members.

A.4.9.2.3.3 Speed

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the operational difficulties with assessing speed with the eye alone;

b) correctly using onboard sensors to assess speed; and

c) making effective use of remote flight crew members to determine speed and rates of closure

A.4.9.2.4 Awareness

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) maintaining situational awareness and perception of changes in a dynamic operating environment;

b) conducting a safe operation by maintaining a high state of situational awareness of all aspects of the operating environment;

c) the difficulties in the perception of change in the operating environment;

d) the dangers of focusing all attention on one task only;

e) the concept of confirmation bias; and

f) effective use of remote flight crew members to improve awareness of the entire team.

A.4.9.2.5 Go/no go decisions

The training organization shall ensure the trainee is able to demonstrate understanding that:

a) the remote pilot-in-command has responsibility to determine for when it is safe to operate;

b) the remote pilot-in-command's assessment of whether to operate or not cannot be overruled; and

c) the remote pilot-in-command holds ultimate responsibility for the flight.

A.4.9.3 Remote pilot logbooks

The training organization shall ensure the trainee is able to demonstrate understanding of effective logging of pilot records using traditional or electronic methods.

A.4.9.4 Overflight of people, crowds and gatherings

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the safety case requirements for overflights of people by a UA;

b) any national or other regulatory restrictions for overflight of people; and

c) how to obtain information regarding expected people movement, crowds, gatherings or sensitive structure and events.

A.4.9.5 Third-party liability

The training organization shall ensure the trainee is able to demonstrate understanding of the consequences of UAS operations damaging third-party property or injuring persons and the requirement for insurance.

A.4.10   Human factors

A.4.10.1 Human factors and good airmanship

The training organization shall ensure the trainee is able to demonstrate:

a)   knowledge of human factors and the threats human factors can introduce to an operation; and

b)   how knowledge of human factors contributes to aviation safety and good airmanship.

A.4.10.2 Medical fitness

A.4.10.2.1 General

The training organization shall ensure the trainee is able to demonstrate:

a)   appropriate medical fitness for the operation;

b)   assessment of medical fitness and record keeping; and

c)   awareness of regulatory requirements relating to medical fitness.

A.4.10.2.2 Crew health precautions

The training organization shall ensure the trainee is able to demonstrate understanding of relevant health precautions regarding maintaining a safe operating environment.

A.4.10.2.3 Alcohol, drugs, medication

The training organization shall ensure the trainee is able to demonstrate understanding of:

a)   appropriate organization policies regarding alcohol and drugs;

b)   the incompatibility of alcohol and drugs with UAS operations;

c)   regulatory requirements regarding alcohol and drugs; and

d)   unwanted side effects of medications and their impact on performance.

A.4.10.2.4 Medical restrictions

The training organization shall ensure the trainee is able to demonstrate understanding of:

a)   how to create organization medical restrictions; and

b)   regulatory requirements regarding medical conditions and restrictions.

A.4.10.3 Fatigue

The training organization shall ensure the trainee is able to demonstrate understanding of:

a)   the definition of fatigue and its serious effects on remote flight crew performance;

b)   how to manage flight duration and number of flights to avoid fatigue;

c)   how to manage workload through correct planning of resources prior to the flight;

d)   workload management during the flight;

e)   the effect of time of day on alertness (circadian rhythm);

f)   appropriate limitations on working and flying hours; and

g)   differences between acute and chronic fatigue and the strategies to mitigate them.

A.4.10.4 Pilot currency

The training organization shall ensure the trainee is able to demonstrate understanding of the importance of maintaining currency through:

a)   recent UAS flying experience;

b)   experience with the UAS used for training;

c)   responses to potential emergencies;

d)   experience with the anticipated task/environment; and

e)   remote flight crew experience, recency, and interactions.

A.4.10.5 Effects of weather

The training organization shall ensure the trainee is able to demonstrate understanding of:

a)   the effects of cold weather on the remote flight crew and on aircraft performance;

b)   the effects of hot weather on the remote flight crew and on aircraft performance; and

c)   the effects of humidity on the remote flight crew and on aircraft performance.

A.4.10.6 Remote and lone working

The training organization shall ensure the trainee is able to demonstrate understanding of:

a)   remote working and the associated hazards;

b)   remote working and the associated safety mitigations;

c)   lone working and the associated hazards; and

d)   lone working and the associated safety mitigations.

A.4.10.7 Crew/colleague management

The training organization shall ensure the trainee is able to demonstrate understanding of:

a)   effective team working with colleagues, including effective briefing;

b)   the content of briefing, including normal operation and emergency situations;

c)   how effective team working can be developed into crew resource management;

d)   effective briefing prior to the UAS flight; and

e)   management of multiple crew/colleagues; appointing a person to oversee this and defining their duties.

A.4.10.8 Depth perception

The training organization shall ensure the trainee is able to demonstrate understanding of:

a)   depth perception difficulties using the eye alone;

b)   using all available data to maintain an accurate mental model of the operating environment; and

c) the benefit of using observers.

A.4.10.9 Blind spot

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the need to be aware of any part of the operating environment that the remote pilot cannot see from their present position;

b) techniques to ensure the pilot's blind spot is checked; and

c) the benefit of using observers.

A.4.10.10 Training organization decision process

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the need for effective decisions in the operation;

b) different types of decision making; and

c) useful tools to aid the decision-making process in the operating environment.

A.4.10.11 Public/third parties

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) how to recognize the hazards and threats that the public and third parties can bring to an operation; and

b) the need for assertiveness to maintain operational safety.

A.4.10.12 Stress/pressure

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) how to recognize the stress and pressure that third parties, including customers and clients, can bring to an operation and the hazards and threats that these can introduce;

b) the need for assertiveness by the pilot to maintain operational safety;

c) the effect of stress on human performance; and

d) operational techniques for dealing with stress and performance degradation in stressful situations such as emergencies.

A.4.11 Meteorology

A.4.11.1 Obtaining and interpreting weather information

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) sources, original information and interpretation of weather reporting sources;

b) the use of aviation weather, limits, units and timescales; and

c) typical abbreviations and terms used in weather data.

A.4.11.2 Local weather assessments

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the need for an onsite weather assessment coupled with the forecast;

b) the signs of approaching poor weather; and

c) the signs of approaching frontal activity.

A.4.11.3 Operational envelope

A.4.11.3.1 General

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the UAS manufacturer's stated operating limits; and

b) legal/national limits.

A.4.11.3.2 Effects on the UAS

The training organization shall ensure the trainee is able to demonstrate understanding of the significance of the following factors with respect to UAS operations according to the applicable conditions for the type of UAS in use and the manufacturer's recommendations.

a) wind:

   1) variation of performance with altitude;

   2) synoptic charts, and how they can be used to estimate wind;

   3) UAS behaviour in increased wind, power against wind, and the effect on aircraft and its behaviour if there is no global navigation satellite system (GNSS) support; level V typically requires a network of ground radio stations or satellite communication;

   4) UA behaviour near ground obstacles in windy weather; and

   5) UA behaviour on take-off and landing in conditions of wind shear in the surface layer;

b) ascending and descending air flows; their impact on take-off and landing performance;

c) cloud cover:

   1) the effect of clouds on the radio link;

   2) the effect of clouds on the range of visual observation of UA; and

   3) ascending and descending air flows under and in the clouds;

d) urban effects:

   1) behaviour of wind near buildings;

   2) effect of lowered pressure;

   3) likely funnelling; and

   4) areas of lee caused by buildings;

e) gradients:

   1) change in wind over a given area; and

2) causes and effects of pressure gradients;

f) masking:

1) effect of terrain;

2) urban weather masking (e.g. in lee of building); and

3) behaviour of UAS beyond masked areas;

g) icing:

1) causes and symptoms;

2) likely areas of effect, especially on battery performance;

3) performance changes;

4) avoidance of icing;

5) operational parameters of specific UA; and

6) effects on payloads and mission systems;

h) temperature:

1) effect on UAS;

2) effect on crew;

3) effect on battery performance;

4) effect on performance based on air density changes; and

5) effects on payloads and mission systems;

i) precipitation:

1) waterproofing and weatherproofing standards of UAS and the flight controller;

2) effect on visibility and crew; and

3) effects on payloads and mission systems;

j) turbulence:

1) identifying and avoiding areas of likely turbulence;

2) natural and manmade features likely to affect turbulence;

3) aircraft response; and

4) effects on mission effectiveness.

A.4.11.4 Visibility factors

The training organization shall ensure the trainee is able to demonstrate understanding of the factors affecting safe UAS operations, with particular regard to:

a) general factors:

1) changes in visibility due to moisture, pollution, dust, etc.;

2) formation of radiation, advection, upslope, precipitation and ice fog; and

3) effects on VLOS rules and limits;

b) clouds:

1) low-level clouds;

2) minimum altitude of cloud base for operations; and

3) likely weather phenomena;

c) cumulonimbus (CB) hazards (including lightning):

1) identification and hazards; and

2) when to cancel flights.

A.4.12 Navigation/charts

A.4.12.1 General

The training organization shall ensure the trainee is able to demonstrate understanding of how charts and navigation can be used to plan UAS operations in particular related to the type of UAS in use, with particular regard to the following:

a) basic map reading (e.g. land or surface maps):

1) cardinal points;

2) identifying coordinates/basic grid references;

3) features of interest to UAS pilots;

4) keys/legends; and

5) scales (e.g. 1:50 000 and 1:25 000), including appreciation of different scales and appearances and selecting best use for purpose;

b) aviation charts:

1) airspace formats;

2) aviation hazards;

3) symbology;

4) terminology;

5) plotting positions;

6) airport information;

7) keys/legends; and

8) scales (e.g. 1:50 000 and 1:25 000), including appreciation of different scales and appearances and selecting best use for purpose;

c) interpretation:

1) identification of hazards;

2) airspace designation;

3) use in planning;

4) relationship to NOTAMs; and

5) specialized charts.

A.4.12.2 Understanding of basic terms

The training organization shall ensure the trainee is able to demonstrate understanding of all relevant terms and to explain their relevance to the UAS PIC, including but not limited to:

a) nautical miles;

b) kilometres;

c) feet;

d) elevation;

e) altitude; and

f) above ground level (AGL).

A.4.12.3 GNSS (including GPS)

The training organization shall ensure the trainee is able to demonstrate understanding of each of the following terms and to explain their relevance to UAS and geo location:

a) GNSS concepts;

b) accuracy;

c) Kp index and other types of space weather effects on GNSS signals;

d) dilution of precision;

e) the use of receiver autonomous integrity monitoring (RAIM); and

f) the difference between various altitude reference systems, e.g. height above ellipsoid (HAE), height above Geoid, AGL, MSL, Baro-VNAV.

A.4.13 Aircraft knowledge

A.4.13.1 Basic principles of flight

The training organization shall ensure the trainee is able to:

a) name and describe the forces and their inter-relationship affecting flight, including lift, drag, thrust and weight;

b) explain how lift is generated using rotary and fixed wings;

c) demonstrate an understanding of a wing's angle of attack and how this can affect lift generation and efficiency;

d) explain the difference between airspeed and ground speed;

e) explain the basics of aircraft stall and stall recovery, flight modes that these phenomena can cause: stalling, parachuting, corkscrew;

f) name the basic wing and thrust components of a fixed-wing, rotary and multirotor aircraft needed to achieve aircraft lift and manoeuvre;

g) describe the manoeuvres pitch, roll and yaw;

h) with reference to an aircraft's wings and means of generating thrust, explain how rotary, fixed-wing and multirotor aircraft achieve pitch, roll and yaw;

i) explain the difference in flight characteristics between rotary and fixed wing aircraft;

j) with reference to single- and multi-rotor systems, explain torque and anti-torque controls; and

k) explain the basics of vortex ring state and how to recover from settling-with-power condition.

A.4.13.2 Command and control

A.4.13.2.1 Datalink frequencies/spectrum

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) which radio frequencies are permitted and which of these are commonly used to control UAS;

b) the risks and causes of frequency interference and the effect that this can have upon UAS in flight;

c) how to identify traffic or congestion on the frequencies used to control UAS; and

d) what actions to take in the event of frequency interference affecting control of the aircraft.

A.4.13.2.2 Manual intervention/override

The training organization shall ensure the trainee is able to demonstrate understanding of the following items according to the type of UAS in use:

a) the circumstances when it is appropriate for a pilot to intervene and take control of a UAS during autonomous flight; and

b) how to establish a switch or function on the flight transmitter to allow the pilot to intervene and gain control of an aircraft during autonomous flight.

A.4.13.2.3 Flight control modes

The training organization shall ensure the trainee is able to demonstrate understanding of the following items according to the type of UAS in use:

a) the purpose and function of a flight controller;

b) the flight modes available on typical flight controllers;

c) the differences between flight modes, with reference to position fix, aircraft stability and the nature and extent of pilot input;

d) the suitability of the various flight modes for different UAS operating tasks and environments according to the type of UAS in use; and

e) how to switch the flight controller between the various flight modes.

A.4.13.3 Limitations

A.4.13.3.1 Operational envelope

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the meaning of an aircraft's safe operating envelope, outside of which the performance and operational safety of the aircraft can be compromised during flight;

b) how to establish the safe operating envelope of UAS including the regulatory restrictions on flight parameters;

c) the key environmental conditions and location factors which can cause a UA to operate outside its safe operating envelope; and

d) the key features and components onboard an aircraft which determine the nature and extent of its safe operating envelope.

A.4.13.3.2 Stability

The training organization shall ensure the trainee is able to:

a) explain the operational safety risks of flying an unstable UAS;

b) describe what can cause flight instability in a UAS;

c) describe how the choice of flight controller modes can affect or provide aircraft stability;

d) explain what pre-flight and in-flight measures can be taken to maintain aircraft stability when in flight;

e) describe the actions to take in the event of an aircraft becoming unstable when in flight;

f) describe the difference between static and dynamic stability; and

g) describe pendular stability in multi-rotor systems.

A.4.13.3.3 Weight

The training organization shall ensure the trainee is able to demonstrate understanding of the following items according to the type of UAS in use:

a) the meaning of an aircraft's weight;

b) the significance of aircraft weight in the context of current UAS operating regulations;

c) how changes in aircraft weight can affect an aircraft's ability to achieve lift, flight stability, manoeuvrability, speed, operational endurance and flight safety; and

d) how differences in aircraft weight can affect the risk assessment of planned UAS operations and/or the method by which UAS operations are carried out.

A.4.13.3.4 Centre of gravity

The training organization shall ensure the trainee is able to demonstrate understanding of the following items related to the type of UAS in use and using the corresponding manufacturer's recommendations:

a) the meaning of an aircraft's centre of gravity;

b) how to establish an aircraft's centre of gravity;

c) the impact upon an aircraft's centre of gravity of modifying the aircraft or aircraft's payload; and

d) how changes in the centre of gravity can affect an aircraft's ability to achieve lift, flight stability, manoeuvrability, speed, operational endurance and flight safety.

A.4.13.3.5 Effect of payload on flight

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the meaning of the expression "payload" in the context of UAS; and

b) how weight, shape, dimensions and position fixing of a payload upon a UAS can affect its ability to achieve lift, centre of gravity and flight stability, manoeuvrability, operational endurance and speed in flight.

A.4.13.4 Operating guides

A.4.13.4.1 Flight procedures/basic drills

The training organization shall ensure the trainee is able to:

a) identify, design and implement appropriate pre-flight check and inspection procedures for UAS;

b) establish, document and implement procedures for the safe initiation and start-up of UAS;

c) develop appropriate in-flight procedures to test, verify and monitor the correct and safe functioning of UAS; and

d) establish the actions to take in the event of incorrect or non-functioning aircraft systems.

A.4.13.4.2 Operating UAS in indoor and confined space environments

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the nature and extent to which any national or international unmanned aircraft regulations can apply to the operation of UAS in indoor environments;

b) how indoor operation of UAS can affect GNSS (e.g. GPS) reception and the importance of correct flight mode selection;

c) the potential of increased risks of personal injury whilst operating UAS in confined spaces and how to select appropriate personal protective equipment to mitigate such risk;

d) how to plan the safe execution of indoor UAS operations, with a knowledge of the types of operational/practical risks and challenges that are faced during indoor and confined space unmanned flights;

e) how operating UAS in confined spaces can compromise aircraft lift and stability;

f) what collision protection and/or collision avoidance features or systems can be specified and installed on UAS to help with their safe operation in indoor environments, and the limitations of such features or systems;

g) how indoor and/or confined space operating environments can cause radio frequency interference and compromise the pilot's control of the aircraft;

h) how ground effect and ceiling effect influence unmanned aircraft endurance and performance; and

i) how cycling indoor environmental control systems create micro-weather effects on unmanned aircraft performance.

A.4.13.4.3 Emergencies

The training organization shall ensure the trainee is able to:

a) design procedures for dealing with emergencies arising out of UAS operations;

b) know how put emergency procedures into effect; and

c) know who to contact and notify in the event of an emergency.

A.4.13.5 Maintenance of systems

A.4.13.5.1 Scheduled and repairs

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) how the components which make up a UAS can be subject to damage and general wear and tear;

b) how this could compromise the performance and safety of an aircraft during flight;

c) how some aircraft components are at greater risk of damage and/or a higher rate of wear and tear than others, and identify which these are;

d) the need for the regular inspection of an operational aircraft and how and the extent to which the nature and frequency of inspection should be guided by the risk of damage and/or expected rate of wear and tear of aircraft components;

e) how to design an inspection regime of an operational aircraft, including the scope and nature of inspections, frequency and timing;

f) how to document aircraft repair and maintenance work; and

g) why it is important to maintain records of repair and maintenance work.

A.4.13.5.2 Safety of aircraft/attached items

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the importance of ensuring that an aircraft is structurally sound and all items fixed to the aircraft, such as payload, are safe before flight;

b) how a failure in the structural integrity of an aircraft or the security of any items attached to an aircraft could compromise aircraft performance and operational safety; and

c) how to design and implement procedural checks to confirm that an aircraft is structurally sound, and all components are appropriately fixed before and after flight.

A.4.13.5.3 Manufacturer's recommendations

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the operational safety importance of compliance with the manufacturer's instructions for the purposes of operation, maintenance and repair of the UAS; and

b) where to find the manufacturer's instructions for their specific UAS and its components.

A.4.13.5.4 Pre-flight assessment: "safe to be flown?"

The training organization shall ensure the trainee is able to explain how to design and implement pre-flight UAS and component checks and tests to verify that a UAS is safe to be flown.

A.4.14 Operating procedures

A.4.14.1 Pre-planning

The training organization shall ensure the trainee is able to:

a) review, evaluate and decide upon the feasibility, risk and operational safety of undertaking a particular UAS task at an operating location; and

b) ascertain whether the UAS operations can be conducted at an operating location in compliance with all current law and regulations.

A.4.14.2 Site assessment

A.4.14.2.1 General

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) the reasons for the need to undertake a site assessment before proceeding with UAS flight operations;

b) matters which need to be considered and the key components which are to comprise a site assessment;

c) the need for, and how to prepare and document, a site assessment; and

d) how to apply the findings from a site assessment to inform the safe planning and execution of UAS flight operations.

A.4.14.2.2 Establishing a safe operating environment

A.4.14.2.2.1 Hazard identification

The training organization shall ensure the trainee is able to:

a) explain the meaning of a hazard;

b) identify hazards which:

1) could affect the operational performance and safety of a UAS;

2) could impact the health, safety and welfare of UAS operational staff at the operating site;

c) plan UAS operations, taking account of the risks that hazards can pose to safety and explain how such risks could be reduced or mitigated; and

d) explain the importance of recording and documenting hazards as part of the process of planning UAS operations.

A.4.14.2.2.2 Risk assessment

The training organization shall ensure the trainee is able to:

a) select, utilize and implement an appropriate risk assessment tool for evaluating risk associated with planned UAS operations;

b) identify risks associated with planned UAS operations;

c) assess the probability and impact of risk occurrence; and

d) determine acceptable levels of risk to allow planned UAS operations to proceed safely.

A.4.14.2.2.3 Mitigating measures

The training organization shall ensure the trainee is able to:

a) design and implement appropriate risk mitigation measures into UAS operations to reduce or mitigate the probability and/or impact of risk occurrence; and

b) determine the effect of risk mitigation measures upon the probability and impact of risk occurrence and the overall risk and safety profile of planned UAS operations.

A.4.14.2.3 Site owner's permission

The training organization shall ensure the trainee is able to demonstrate understanding of:

a) when it is mandatory to notify and seek permission from a landowner in relation to planned UAS operations; and

b) whether and how operating a UAS over land and/or property without permission of the landowner could constitute trespass and/or nuisance.

A.4.14.3 Situational awareness

A.4.14.3.1 Location

The training organization shall ensure the trainee is able to:

a) ascertain the suitability of an operating site for UAS operations, both in terms of general operational safety and compliance with current law and regulations; and

b) determine the nature of, and how to secure, any operating permissions that need to be secured to allow UAS operations to proceed.

A.4.14.3.2 Aeronautical information

The training organization shall ensure the trainee is able to:

a) understand how and where to source publicly available and up-to-date information appropriate to be able to plan and manage UAS operations; and

b) read, understand and interpret airspace information sufficiently to be able to safely and in compliance with all current law and regulations, plan, manage and carry out UAS operations.

A.4.14.3.3 Aerodromes

The training organization shall ensure the trainee is able to:

a) identify the locations and explain the operational safety need for identifying the locations of aerodromes in relation to the location of planned UAS operations;

b) ascertain whether restrictions apply in relation to UAS operations around aerodromes;

c) determine when it is appropriate or mandatory to notify an aerodrome of planned UAS operations; and

d) explain how to communicate with any relevant ATS.

A.4.14.3.4 Obstructions

The training organization shall ensure the trainee is able to:

a) identify obstructions which could impact planned UAS operations;

b) explain how obstructions could impact planned UAS operations (such as risk of physical contact with UA, interruption of UAS control link and/or telemetry or causing non-compliance with current UAS operating regulations); and

c) establish and implement measures to reduce or mitigate the risk of the impact of obstructions to a level acceptable to allow planned UAS operations to proceed safely.