GHANA
CIVIL AVIATION AUTHORITY

ADVISORY CIRCULAR
AC 28-003

Guidelines on Presentation of an RPAS Concept of Operations (CONOPS) to GCAA

SECTION 1 GENERAL

1.1 PURPOSE

The purpose of this advisory circular is to provide guidance to the RPAS Operator and Manufacturer on development and presentation of an RPAS Concept of Operations (CONOPS) to the Ghana Civil Aviation Authority (GCAA).

1.2 STATUS OF THIS ADVISORY CIRCULAR

This AC is an original issuance.

1.3 APPLICABILITY

This advisory circular is applicable to all Ghana Remotely Piloted Aircraft Systems (RPAS) Operator Certificate Holders as well as those Operators and Manufacturers identified under the Ghana Assessment of Risk for RPAS Operators (ARRO) Methodology.

1.4 RELATED DIRECTIVES

The following Directives are directly applicable to the guidance contained in this advisory circular—

- Ghana Civil Aviation Directives Part 28
- Ghana Civil Aviation (Flight Standards) Directives Part 1
- Ghana Civil Aviation (Flight Standards) Directives Part 9

1.5 RELATED READING MATERIAL

(1) ICAO Manual on Remotely Piloted Aircraft Systems (RPAS) (Doc 10019)
(2) ICAO Annex 2

1.6 DEFINITIONS AND ABBREVIATIONS

Please refer to Ghana Civil Aviation Directives Part 28 and or Part 1 for Standardized Terminology"

SECTION 2 OPERATIONAL INFORMATION

2.1 ORGANIZATION OVERVIEW

2.1.1 OPERATIONS

2.1.1.1 COMPANY STRUCTURE

(1) This section describes how your organization is defined, to support safe operations. This should include:

(a) structure of organization and management; and

(b) responsibilities and duties of the RPAS operator

2.1.1.2 CREW

(1) Describe the responsibilities and duties of personnel. Describe all positions and people involved, for functions such as:

(a) remote pilot (including flight team composition according to nature of operation, complexity, type of RPAS, etc.); and

(b) support personnel (like observers, launch crew, recovery crew, etc.)

(2) Operation of different types of RPAS: details of any limitations to the types of RPAS that a pilot may operate if appropriate.

(3) Crew medical qualification requirements: details of the required medical qualifications necessary for the pilot or support crew, according to the types of RPAS and roles employed by the operator.

2.1.1.3 RPAS CONFIGURATION MANAGEMENT

Describe how the organization manages changes to the RPAS design.

2.1.1.4 OTHER POSITION(S) AND OTHER INFORMATION

Describe here any other position defined in the organization, or any other relevant information.

2.1.2 OPERATIONS

If the organization is responsible for the design and/or production of the RPAS, describe the design and/or the production organization.

2.2 RPAS OPERATIONS

2.2.1 TYPES OF OPERATIONS

(1) Detailed description of the CONOPS: describe what types of normal operations the operator intends to carry out. The detailed description should contain all information to get a detailed understanding of **how**, **where** and **under which limitations or conditions** the operations shall be performed. Relevant charts and any other information helpful to visualize and understand the intended operation should be included in this section.

(2) Provide specific details on the type of operations (e.g. VLOS, BVLOS), the population density to be overflown (e.g. away from people, sparsely populated, crowds) and the airspace requirements (e.g. segregated area, fully integrated, etc.)

(3) Describe the level of involvement of the crew and automated or autonomous systems during each phase of the flight.

2.2.2 STANDARD OPERATING PROCEDURES

Describe the standard operating procedures (SOP) applicable to all operations for which an approval is requested. A reference to the applicable Operations Manual (OM) is acceptable.

2.2.3 NORMAL OPERATING STRATEGY

(1) The Normal Operation Strategy should contain all the safety measures, such as technical or procedural measures, crew training etc., that are put in place to ensure that the RPAS can fulfil the operation within the approved limitations, and so that the operation remains in control.

(2) Within this section, it should be assumed that all systems are working normally and as intended.

(3) The intent of this chapter is to get a clear understanding of how the operation takes place within the approved technical, environmental, procedural limitations.

2.2.4 ABNORMAL OPERATION

Describe the contingency procedures in place for any malfunction or abnormal operation.

2.3 MAINTENANCE

(1) Describe the organization of maintenance.

(2) Describe the general maintenance philosophy of the RPAS.

(3) Describe the maintenance procedures for the RPAS.

2.4 PERSONNEL TRAINING

2.4.1 GENERAL INFORMATION

Brief description of the processes and procedures that the operator uses to develop and maintain the necessary competence for all staff involved in operations.

2.4.2 INITIAL TRAINING AND QUALIFICATION

Description of the processes and procedures that the operator uses to recruit and qualify all staff involved in operations. Particularly, the licensing and rating requirements for remote operators (if any) or, if license is not required, how their qualification is carried out, should be described.

2.4.3 PROCEDURES FOR MAINTENANCE OF CURRENCY

Describe which processes and procedures the operator uses to ensure that the remote operators or other operational staff acquire and maintain the required currency to execute the various types of duties. Some elements may be required by the applicable regulations, some elements could be specific to the individual operator and the mission.

2.4.4 FLIGHT SIMULATION TRAINING DEVICES (FTSD)

(1) Is the operator using FSTD for acquiring and maintaining the practical skills?

(2) What are the opportunities and restrictions in connection with such training?

2.4.5 TRAINING PROGRAM

Provide a reference to the applicable training program(s) for all staff involved in operations. This might simply be a reference to the program as required by regulation or, if the operator has developed a specific program, a reference to the operator's training program.

2.5 SAFETY

2.5.1 SAFETY MANAGEMENT SYSTEM

(1) Describe how safety is integrated in the organization. What Safety Management System is in place?

(2) Any other safety related information?

2.5.2 EMERGENCY RESPONSE PLAN

Describe the ERP in place. See AC 28-002.

SECTION 3 TECHNICAL INFORMATION

3.1 RPAS DESCRIPTION

(1) Applicants using commercially available, off the shelf small, light or large RPAS, are required to satisfy 3.1.1 below.

(2) Applicants using RPAS other than those specified in paragraph (a) of this section are required to satisfy 3.1.2 below.

3.1.1 OFF THE SHELF SMALL AND LIGHT REMOTELY PILOTED AIRCRAFT (RPA)

3.1.1.1 TYPE OF AIRCRAFT

State the make, model and serial number of the RPAS

3.1.1.2 TECHNICAL DATA

List manufacturer technical specifications of the RPAS

3.1.2 REMOTELY PILOTED AIRCRAFT (RPA) OTHER THAN OFF THE SHELF SMALL AND LIGHT RPA

3.1.2.1 AIRFRAME

Describe in detail the physical characteristics of the aircraft (mass, center-of-mass, dimensions, etc.). Include photos, diagrams and schematics, whenever deemed necessary to support the description of the RPA.

(a) Dimensions

i. For fixed-wing aircraft, specify wingspan, fuselage length, body diameter etc.

ii. For a rotorcraft provide length, width and height, propeller diameter etc.

(b) Mass

i. Describe all relevant masses such as Empty Mass, Maximum Takeoff Mass (MTOM), etc.

(c) Center of mass

i. Define the center of mass location and limits.

3.1.2.2 MATERIALS

Describe the main materials used and where they are used in the RPA. Highlight any new materials (new metal alloys or composites) or combinations of materials (composites "tailored" to designs).

3.1.2.3 LOADS

(1) Describe the capability of the airframe structure to withstand expected flight loads and provide test data/ or analysis to show that it is flutter-free throughout the flight envelope.
(2) Include any loads or stress test data or analysis that demonstrates positive structural margins of safety during flight.

3.1.2.4 SUB-SYSTEMS

Identify and describe any sub-systems such as a hydraulic system, environmental control system, parachute, or brakes.

3.1.2.5 AIRCRAFT PERFORMANCE CHARACTERISTICS

Describe the performance of the aircraft within the proposed flight envelope. Specifically, address at least the following items:

(a) Performance:
- i. Maximum altitude
- ii. Maximum endurance
- iii. Maximum range
- iv. Maximum rate of climb
- v. Maximum rate of descent
- vi. Maximum bank angle
- vii. Turn rate limits

(b) Airspeeds:
- i. Slowest speed attainable
- ii. Stall speed (if applicable)
- iii. Nominal cruise speed
- iv. Max cruise speed
- v. Never exceed airspeed

3.1.2.6 ENVIRONMENTAL LIMITATIONS

Identify any performance limitations due to environmental and meteorological conditions. Specifically, address the following items:

(a) Wind speed limitations

i. Headwind

ii. Crosswind

iii. Gusts

(b) Turbulence restriction

(c) Rain, hail, ashes resistance or sensitivity,

(d) Minimum visibility conditions, if applicable

(e) Outside Air temperature (OAT) limits

(f) In-flight icing:

i. Does the proposed operating environment include operations in icing conditions?

ii. Does the system have an icing detection capability? If so, what indications, if any, does the system provide to the operator (if an operator is in the loop), and/or how does the system respond?

iii. Describe any icing protection capability of the RPA. Include any test data that demonstrates the performance of the icing protection system.

3.1.2.7 PROPULSION SYSTEM

(1) Principle: Describe the propulsion system and its ability to provide reliable and sufficient power to takeoff, climb, and maintain flight at expected mission altitudes.

(2) Fuel-powered propulsion systems

(a) What type (manufacturer and model) of engine is used?

(b) How many engines are installed?

(c) What type and capacity of fuel is used?

(d) How is the engine performance monitored?

(e) What status indicators, alerts (such as warning, caution and advisory) messages are provided to the operator?

(f) Describe the most critical propulsion-related failure modes/conditions and their impact on system operation.

(g) How does the RPA respond, and what safeguards are in place to mitigate the risk of engine power loss for each of the following?

i. Fuel starvation

ii. Fuel contamination

iii. Failed signal input from the control station

iv. Engine controller failure

(h) Does the engine have in-flight restart capabilities? If so, describe the manual and/or automatic features of this capability.

(i) Describe the fuel system and how it allows for adequate control of the fuel delivery to the engine and provides for aircrew determination of fuel remaining. Provide a system level diagram showing the location of the system in the aircraft and the fuel flow path.

(j) How is the fuel system designed in terms of safety (fire detection and extinguishing, reduction of risk in case of impact, leak prevention, etc.)?

(3) Electric-powered propulsion systems

(a) Provide a high-level description of the electrical distribution architecture. Include items such as regulators, switches, buses, and converter, as necessary.

(b) What type of motor is used?

(c) How many motors are installed?

(d) What is the max continuous power output of the motor [Watt]?

(e) What is the max peak power output of the motor [Watt]?

(f) What current range does the motor have [Amps]?

(g) Does the propulsion system have a separate electrical source? If not, how is the power managed with respect to the other systems of the RPA?

(h) Describe the electrical system and how it distributes adequate power to meet the requirements of the receiving systems.

(i) Provide a system level diagram showing electrical power distribution throughout the aircraft.

(j) How is power generated on-board the aircraft (for example, generator, alternator, batteries)?

(k) If a limited life power source such as batteries is used, what is the useful life of the power source during normal and emergency conditions? How was this determined?

(l) How is information on battery status and remaining battery capacity provided to the operator (if one is in the loop) or watchdog system?

(m) If available, describe the source(s) of backup power in the event of loss of the primary power source.

i. What systems are powered during backup power operation?

ii. Is there any automatic or manual load shedding?

iii. How much operational time does the backup power source provide?

iv. Include the assumptions used to make this determination.

(n) How is the propulsion system performance monitored?

(o) What status indicators and alerts (such as warning, caution and advisory) messages are provided to the operator?

(p) Describe the most critical propulsion-related failure modes/conditions and their impact on system operation.

(q) How does the aircraft respond, and what safeguards are in place to mitigate the risk of propulsion system loss for each of the following?

i. Low battery

ii. Failed signal input from the control station

iii. Motor controller failure

(r) Does the motor have in-flight reset capabilities? If so, describe the manual and/or automatic features of this capability

(4) Other propulsion systems

Provide a description to a level of detail equivalent to the fuel and electrical propulsions sections above.

3.1.2.8 FLIGHT CONTROL SURFACES AND ACTUATORS

(1) Describe the design and operation of the flight control surfaces and servos/actuators. Include a diagram showing the location of the control surfaces and servos/actuators.

(2) Describe any potential failure modes and corresponding mitigations.

(3) How does the system respond to a servo/actuator failure?

(4) How is the operator (if one is in the loop), or watchdog system alerted of a servo/actuator malfunction?

3.1.2.9 SENSORS

Describe the non-payload sensors equipment on-board the aircraft and their role.

3.1.2.10 PAYLOADS

Describe the payload equipment on-board the aircraft. Describe all payload configurations that significantly change weight and balance, electrical loads, or flight dynamics.

3.2 RPAS CONTROL

3.2.1 AVIONICS

3.2.1.1 APPLICABILITY

This section is applicable to Applicants utilizing RPAS other than off the shelf small, light or large RPAS.

3.2.1.2 GENERAL

Provide an overall system architecture diagram of the avionics architecture. Include the location of all air data sensors, antennas, radios, and navigation equipment. Describe any redundant system, if available.

3.2.2 NAVIGATION

(1) How does the RPAS determine its location?

(2) How does it navigate to its intended destination?

(3) How does the operator or RPAS respond to instructions from?

   (a) Air Traffic Control, if applicable

   (b) Visual observer, if any,

   (c) Another crew member?

(4) Describe the procedures to test the altimeter navigation system (position, altitude)

(5) How does the system identify and respond to a loss of the primary means of navigation?

(6) Is there a backup means of navigation?

(7) How does the system respond to a loss of the secondary means of navigation, if available?

3.2.3 AUTOPILOT

3.2.3.1 APPLICABILITY

This section is applicable to Applicants utilizing RPAS other than off the shelf small, light or large RPAS.

3.2.3.2 GENERAL

(1) How was the autopilot system developed? Which industry or regulatory standards were used in the development process?

(2) Is the autopilot a commercial off-the-shelf (COTS) product? If so, name the type/manufacturer and provide the criteria that was used in selecting the COTS autopilot.

(3) Describe the procedures used to install the autopilot. How is correct installation verified? Reference any documents or procedures provided by the manufacturer and/or developed by your organization.

(4) Does the autopilot employ input limit parameters to keep the aircraft within defined limits (structural, performance, flight envelope, etc.)? If so, what are these limits? How were these limits defined and validated?

(5) What type of testing and validation was performed (software-in-the-loop (SITL) and hardware-in-the-loop (HITL) simulations)?

3.2.4 FLIGHT CONTROL SYSTEM

(1) Describe how the control surfaces (if any) respond to commands from the flight control computer/autopilot.

(2) Describe the flight modes (i.e. manual, artificial-stability, automatic, autonomous)

(3) Flight Control Computer/autopilot:

(4) Are there any auxiliary controls? Does the flight control computer interface with auxiliary controls? And how are they protected against unintended activation?

(5) Describe the flight control computer interfaces required to determine flight status and to issue appropriate commands.

(6) On which operating system are the flight controls based?

3.2.5 CONTROL STATION (CS)

(1) Describe or diagram the CS configuration. Include screen captures of the control station displays.

(2) How accurately can the operator determine the attitude, altitude (or height) and position of the RPA?

(3) How accurate is the transmission of critical parameters to other airspace users/ATC?

(4) What critical commands are safeguarded from inadvertent activation and how is that achieved (for example, is there a two-step process to command "kill engine")? What kind of inadvertent input could the operator enter to cause an undesirable outcome (for example, accidentally hitting the "kill engine" command in flight)?

(5) Are any other programs running concurrently on the ground control computer? If so, what precautionary measures are used to ensure that flight-critical processing will not be adversely affected?

(6) What are the provisions taken against a CS display or interface lock-up?

(7) What alerts (such as warning, caution and advisory) does the system provide to the operator (for example, low fuel or battery, failure of critical systems, operation out of control)?

(8) Describe the means of power to the CS, and redundancies if any.

(9) What are the procedures in place in case of CS loss of primary and secondary power (if any)?

(10) If a "Handover" is envisaged between two or more control stations, describe the process to ensure that only one control station has control over the RPA. Also describe the procedure to alert the ATC of commencement and cessation of the handover.

3.2.6 DETECT AND AVOID (DAA) SYSTEM

3.2.6.1 OBSTACLE CONFLICT AVOIDANCE

Describe which system/equipment is installed, if any, for obstacle collision avoidance.

3.2.6.2 WEATHER ADVERSE CONDITIONS AVOIDANCE

Describe which system/equipment is installed, if any, for adverse weather conditions avoidance.

3.2.6.3 AIRCRAFT CONFLICT AVOIDANCE

(1) Describe which system/equipment is installed for collaborative Conflict Avoidance (e.g. SSR, TCAS, ADS-B, FLARM, etc.).

(2) If the equipment is qualified, list the detailed qualification to the respective standard.

(3) If the equipment is not qualified, provide the criteria that was used in selecting the system.

3.2.6.4 NON-COLLABORATIVE CONFLICT AVOIDANCE

Describe, what equipment is installed for (e.g. vision based, PSR data, LIDAR, etc.).

3.2.6.5 STANDARD

(1) If the equipment is qualified, list the detailed qualification to the respective standard.

(2) If the equipment is not qualified, provide the criteria that was used in selecting the system.

(3) Describe any interface from the Conflict Avoidance to the flight control computer.

(4) Describe the principles governing Detect and Avoid systems installed.

(5) Describe the role of the pilot or any operator in the Detect and Avoid system.

(6) Describe the known limitations of the Detect and Avoid system.

3.3 INSTRUCTIONS FOR CONTINUING AIRWORTHINESS (ICA)

(1) Describe the set of descriptive data, maintenance planning and accomplishment instructions, developed by an RPAS manufacturer or a design approval holder in accordance with the certification basis for the aeronautical product.

(2) RPAS Operators shall provide a Maintenance Programme, designed on the basis of the ICAs, to establish the accomplishment maintenance.

(3) The Maintenance Programme is a document which describes the specific scheduled maintenance tasks and their frequency of completion and related procedures, such as a reliability programme, necessary for the safe operation of those RPAS to which it applies.

3.4 OTHER INFORMATION

3.4.1 GEO-FENCING

Describe the principles of system or equipment used to perform geo-fencing functions for:

(a) avoidance of specific area(s), or

(b) confinement in a given area.

3.4.2 GROUND SUPPORT EQUIPMENT (GSE) SEGMENT

(1) Describe all the support equipment that is used on the ground, such as launch or recovery systems, generators, and power supplies.

(2) Define the standard equipment available, and what are the backup or emergency equipment.

(3) Describe how the RPAS is transported on the ground

3.4.3 COMMAND AND CONTROL LINK (C2 LINK)

3.4.3.1 APPLICABILITY

This section is applicable to Applicants utilizing RPAS other than off the shelf small, light or large RPAS.

3.4.3.2 GENERAL

(1) Which standard(s) is the system compliant with?

(2) Provide a detailed control system architecture diagram that includes informational or data flows and subsystem performance. Include values for data rates and latencies, if known.

(3) Describe the control link(s) connecting the RPA the CS and any other ground systems or infrastructures, if applicable. Specifically address the following items:

(a) What spectrum will be used for the control link and how has the use of this spectrum been coordinated? If spectrum approval is not required, under what regulation is the use of the frequency authorized? What is the maximum power spectrum?

(b) What type of signal processing and/or link security (i.e. encryption) is employed?

(c) What is the datalink margin in terms of the overall link bandwidth at the maximum anticipated distance from the CS? How was it determined?

(d) Is there a radio signal strength and/or health indicator or similar display to the operator? How is the signal strength and health value determined, and what are the threshold values that represent a critically degraded signal?

(e) Does the system employ redundant and/or independent control links? If so, how different is the design? What are the likely common failure modes?

(f) For satellite links, estimate the latencies associated with using the satellite link for aircraft control and for air traffic control (ATC) communications.

(g) What design characteristics or procedures are in place to prevent or mitigate the loss of the datalink due to the following?

i. RF or other interference

ii. Flight beyond communications range

iii. Antenna masking (during turns and/or at high attitude angles)

iv. Loss of CS functionality

v. Loss of RPA functionality

vi. Atmospheric attenuation including precipitation

3.4.3.3 C2 Link Degradation

(1) What are the measures in case of a link degradation?

(2) What are the contingency procedures?

(3) How is the status is displayed to the operator(s) should be (e.g. Degraded/Critical/Automatic messages, etc.)?

(4) Other

3.4.3.3 C2 Link Lost

(1) What are the conditions to trigger C2 link lost?

(2) What are the measures in case of loss of the C2 link (lost link)?

(3) Describe the clear and distinct aural and visual alerts to the RPAS crew, for any case of lost link.

(4) Describe the established lost link strategy presented in the RPAS Operating Manual considering the emergency recovery capability.

(5) Describe how the geofencing system is used in this case, if available.

(6) Does the lost link strategy include a re-acquisition process in order to try to reestablish in a reasonable short time the link?

3.4.4 SAFETY MEASURES

(1) Description of the single failure modes and their recovery mode(s), if any.

(2) Describe the emergency recovery capability to prevent third party risk. This typically consist of:

(a) A flight termination system (FTS), procedure or function that aims to immediately end the flight;

(b) An Automatic Recovery System (ARS) that is implemented through RPAS crew command or by the on-board systems. This may include automatic preprogrammed course of action to reach a predefined and unpopulated forced landing area; or,

(c) Any combination of the above.

(3) Provide both a functional and physical diagram of the global RPA system with clear depiction of its constituent components and, where applicable, an indication of its peculiar features (e.g. independent power supply, redundancies, etc.)

End of Advisory Circular