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Federal Department of the Environment,
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Federal Office of Civil Aviation FOCA
Safety Division - Flight Operations

FOCA GM

Operation Manual

UAS Swarm

Scope	Guidance for drawing up an OM for UAS swarms
Applies to	UAS Swarms Operators
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Table of Contents (ToC)

0 Introduction

All Guidance Material (GM) is intended to assist the operator in administrative matters. The administrative requirements and processes contained therein will facilitate liaison with the Federal Office of Civil Aviation (FOCA). The GM is a tool for the operator which eases the process of obtaining required and defined authorisations issued by the FOCA. Use of the GM will help to establish compliance with FOCA requirements and will lead the operator through the administrative authorisation process.

0.1 Terms and Conditions

Most frequent abbreviations used by EASA are listed here: easa.europa.eu/abbreviations.

0.2 Purpose

The purpose of this GM is to provide guidelines for drawing up an Operation Manual for UAS swarm operations with regard to the UAS swarm PDRA. This GM is valid for operations of the specific category.

0.3 Scope

UAS swarm operations shall take place within the limitations defined in the form “Authorisation request for the operation of UAS swarms”.

0.4 Operator responsibilities

The applicant bears overall responsibility for the operation. Specifically, the applicant must ensure compliance with all requirements of the standard application procedure as well as any other requirements associated with the authorisation. The applicant may name an employee and instruct said employee to carry out the operation. Overall responsibility remains with the applicant.

0.5 Document control

Applicants should include an amendment record at the beginning of the document to record any changes and checks. This is critical to ensure appropriate document control.

Amendment/Revision/Issue Number	Date	Amended by	Signed
A,B,C or 1,2,3 etc…	DDMMYYYY	Name of person carrying out the amendment/revision/issue number	Signature of the person carrying out the amendment/ revision/issue number

Any changes to the OM may require further assessment and approval by the competent authority before further operations can be conducted.

1 Organisation overview

1.1 Responsibilities and associated duties

Describe the responsibilities and duties of the UAS operator and personnel, describe all positions and people involved.

1.2 Safety

Describe the role of safety in the organisation and the Safety Management System (SMS) that is in place.

1.3 Staff training

Describe the programmes in place to train all staff involved in operations.

1.4 Maintenance

Describe the maintenance instructions and procedures. A maintenance log system should be available and a list of maintenance staff authorised to carry out maintenance drawn up and kept up to date. A record of all relevant qualifications and training completed by the staff should be established and kept up to date. A record of the Control Software Versions should be available.

1.5 Crew

This section should describe:

a) staff responsibilities and duties, including all the positions and people involved, for functions such as:

   1) the remote pilot (including the composition of the flight team according to the nature of the operation, its complexity, the type of UAS, etc.); and
   2) support staff (e.g. visual observers (VOs), launch crew, recovery crew);

b) the procedure for multi-crew coordination if more than one person is directly involved in the flight operations;

c) the operation of different types of UAS, including details of any limitations to the types of UAS that a remote pilot may operate, if appropriate; and

d) details of the operator’s policy on crew health requirements, including any procedures, guidance or references to ensure that the flight team is appropriately fit, capable and able to conduct the planned operations.

2 Operations

2.1 Type of operations

Detailed description of the ConOps: the applicant should describe what type of operations the UAS operator intends to carry out. The description should contain all the information needed to obtain a detailed understanding of how, where and under which limitations or conditions the operations will be performed. The operational volume, including the ground and air risk buffers, needs to be clearly defined. Relevant charts/diagrams and any other information helpful to visualise and understand the intended operation(s) should be included in this section.

The applicant should describe the level of involvement (LOI) of the crew and any automated or autonomous systems during each phase of the flight.

2.2 Standard operating procedures

Describe the standard operating procedures (SOP) applicable to all operations for which an approval is requested. UASs and the Ground Control Station are to be inspected according to the manufacturer instructions.

Procedure to assess the area of operation: The operational volume and the buffers should be assessed by means of a pre-mission checklist. The pre-mission checklist should include as a minimum:

a) an assessment of the people in the operational volume and the ground risk buffer. Only people directly involved in the operation of the UAS are allowed to be present. These people should be fully aware of the risks involved in the UAS operation and have accepted these risks. They should furthermore be informed of and be able to follow relevant effective emergency procedures and contingency plans.

b) an assessment of the class of airspace and other aircraft operations. Coordination with local airports/heliports (5km radius) if necessary. Includes assessment of the chart: https://map.geo.admin.ch/?topic=aviation&bgLayer=ch.swisstopo.pixelkarte-grau&layers=ch.bazl.einschraenkungen-drohnen&X=189554.62&Y=664804.11&zoom=1&catalogNodes=1379&layers_opacity=0.6&lang=de

c) an assessment of the surrounding area and airspace, including, for example, the proximity of restricted zones and potential activities by other airspace users;

   Includes an assessment of the Daily Airspace Bulletin: https://www.skybriefing.com/

d) an assessment of nearby obstacles (high voltage lines, buildings and so on): The operational volume and the ground risk buffer should not contain areas with obstacles unless under the control of the applicant. The flight should be planned accordingly.

e) an assessment of roads and railways: The operational volume and the ground risk buffer should not contain areas with roads and railways unless closed or under the control of the applicant.

f) where UAS visual obervers (VOs) are used, an assessment of the compliance between visibility and planned range, the potential terrain obstruction, and the potential gaps between the zones covered by each of the UAS VOs.

2.2.1 Normal operating procedures

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 UAS can conduct the operation within the approved limitations, and that the operation remains under control.

The purpose of this section is to get a clear understanding of how the operation takes place within the approved technical, environmental and procedural limitations. Procedures to evaluate environmental conditions before and during the mission should be provided.

2.2.2 Contingency and emergency procedures

This section describes the contingency procedures in place for any malfunction or abnormal operation, as well as an emergency.

a) Contingency procedures: Procedures when a UAS breaches the flight geography and/or the lost link strategy in case of loss of command and control.
b) Emergency procedures: This procedure comes into force when a UAS exits the contingency volume.
c) Procedures to cope with uninvolved people entering the controlled ground area, if applicable.
d) De-confliction scheme (i.e. the criteria applied when deciding how to avoid incoming traffic). In cases where UAS VOs are responsible for detection, the phraseology to be used.

2.2.3 Emergency response plan (ERP)

The applicant should:

a) define a response plan for use in the event of a loss of control of the operation;
b) describe the procedures to limit the escalating effects of a crash; and
c) describe the procedures to be followed in the event of a loss of containment.

3 Remote crew training

3.1 General information

This section describes the processes and procedures that the UAS operator follows to develop and maintain the necessary competence for the remote crew (i.e. any person involved in the UAS operation).

The training contains as minimum following elements:

i) UAS regulation

ii) UAS airspace operating principles

iii) Airmanship and aviation safety

iv) Human performance limitations

v) Meteorology (Assessment of meteorological conditions)

vi) Navigation/charts

vii) Drone swarm knowledge

viii) Standard operating procedures and Pprocedures for normal and abnormal operations

3.2 Initial training and qualification

This section describes the processes and procedures that the UAS operator follows to ensure that the remote crew are suitably trained, and how individual skills are assessed. A record of all relevant qualifications and training completed by the staff is to be established and kept up to date.

3.3 Procedures for maintaining currency

This section describes the processes and procedures that the UAS operator follows to ensure that the remote crew maintain the required currency to carry out the various types of duties.

4 UAS description

The aim of this section is to collect all the necessary technical information about the UAS and its supporting systems. This information needs to be sufficient to address the required robustness levels of the SORA mitigations and Operational Safety Objectives.

The list below is suggested as guidance for items which may be relevant for this assessment, but the items may differ, depending on the type of UAS used in the ConOps.

4.1 Airframe

This section should include the following:

a) A detailed description of the physical characteristics of the UAS (mass, centre-of-mass, dimensions, etc.), including photos, diagrams and schematics, if appropriate to support the description of the UAS.

    1) Dimensions: for fixed-wing UA, the wingspan, fuselage length, body diameter etc.; for a rotorcraft, the length, width and height, propeller diameter, etc.;

    2) Mass: all the relevant masses such as the empty mass, MTOM, etc.;

4.2 UA performance characteristics

This section should include the following:

a) the performance of the UAS within the proposed flight envelope, specifically addressing at least the following items:

    1) Performance:

        i) maximum altitude;

        ii) maximum endurance;

        iii) maximum rate of climb;

        iv) maximum rate of descent;

    2) Airspeeds:

        i) nominal cruise speed;

        ii) maximum cruise speed; and

b) Any performance limitations due to environmental and meteorological conditions, specifically addressing the following items:

    1) wind speed limitations (headwind, crosswind, gusts);

    2) rain, hail, snow, ash resistance or sensitivities;

    3) minimum visibility conditions, if applicable;

    4) outside air temperature (OAT) limits; and

    5) in-flight icing limitations

4.3 Propulsion system

This section should include the following:

a) Principle

    A description of the propulsion system and its ability to provide reliable and sufficient power to take off, climb, and maintain flight at the expected mission altitudes.

b) Electric-powered propulsion systems

1) A high-level description of the electrical distribution architecture, including items such as regulators, switches, buses, and converters, as necessary;
2) The type of motor that is used;
3) The number of motors that are installed;
4) How the performance of the propulsion system is monitored;
5) How the UAS responds, and the safeguards that are in place to mitigate the risk of a propulsion system loss for each of the following:
   i) low battery charge;
   ii) failed signal input from the RPS; and
   iii) motor controller failure;

4.4 Payloads (if applicable)

This section should describe the payload equipment on board the UAS, including all the payload configurations that significantly change the weight and balance, electrical loads or flight dynamics.

5 UAS control segment

An overall system architecture diagram of the avionics architecture, including the location of all air data sensors, antennas, radios, and navigation equipment. A description of any redundant systems, if available.

5.1 Navigation

a) How the UAS determines its location;
b) How the UAS navigates to its intended destination;
c) How the remote pilot responds to instructions from:
   1) UAS observers or VOs (if applicable); and
   2) other crew members (if applicable)
d) The procedures to test the altimeter navigation system (position, altitude);
e) How the system identifies and responds to a loss of the primary means of navigation;
f) A description of any backup means of navigation; and
g) How the system responds to a loss of the secondary means of navigation, if available.

5.2 Autopilot

a) How the autopilot system was developed, and the industry or regulatory standards that were used in the development process.
b) If the autopilot is a commercial off-the-shelf (COTS) product, the type/design and the production organisation, with the criteria that were used in selecting the COTS autopilot.
c) The procedures used to install the autopilot and how its correct installation is verified, with references to any documents or procedures provided by the manufacturer’s organisation and/or developed by the UAS operator’s organisation.

5.3 Flight control system

a) How the control surfaces (if any) respond to commands from the flight control computer/autopilot.
b) A description of the flight modes (i.e. manual, artificial stability, automatic, autonomous).

5.4 Remote pilot station (RPS)

a) A description or a diagram of the RPS configuration, including screen captures of the control station displays.

b) Information on how accurately the remote pilot can determine the attitude, altitude (or height) and position of the UA.

c) The critical commands that are safeguarded against inadvertent activation and how thisis achieved (for example, is there a two-step process to command 'switch the engine off'). The kinds of inadvertent input that the remote pilot could enter to cause an undesirable outcome (for example, accidentally hitting the 'kill engine' control in flight).

d) Any other programmes that run concurrently on the ground control computer, and if there are any, the precautionary measures that are used to ensure that flight-critical processing will not be adversely affected.

e) The provisions that are made to prevent an RPS display or interface lock-up.

f) The alerts (such as warning, caution and advisory) that the system provides to the remote pilot (e.g. low fuel or battery level, failure of critical systems, or operation out of control).

g) A description of the means to provide power to the RPS, and redundancies, if any.

5.5 Containment system (e.g. geocaging)

a) A description of the principles of the system/equipment used to perform containment functions for:

   1) avoidance of specific area(s) or volume(s); or

   2) confinement in a given area or volume (e.g. three dimensional geocaging).

b) The system information and, if applicable, supporting evidence that demonstrates the reliability of the containment system.

5.6 Command and control (C2) link segment

a) A detailed diagram that shows the system architecture of the C2 link, including informational or data flows and the performance of the subsystem, and values for the data rates and latencies, if known.

b) A description of the control link(s) connecting the UAS to the RPS and any other ground systems or infrastructures, if applicable, specifically addressing the following items:

   1) The spectrum that will be used for the control link and how the use of this spectrum has been coordinated. If approval of the spectrum is not required, the regulation that was used to authorise the frequency.

   2) The type of signal processing and/or link security (i.e. encryption) that is employed.

   3) If there is a radio signal strength and/or health indicator or similar display to the remote pilot, how the signal strength and health values are determined, and the threshold values that represent a critically degraded signal.

   4) If the system employs redundant and/or independent control links, how different the design is, and the likely common failure modes.

   5) The design characteristics that prevent or mitigate the loss of the datalink due to the following:

      i) RF or other interference;

      ii) flight beyond the communications range;

      iii) antenna masking (during turns and/or at high attitude angles);

iv) a loss of functionality of the UAS; and

v) atmospheric attenuation, including precipitation.

5.7 C2 link degradation

A description of the system functions in case of a C2 link degradation:

a) Whether the C2 link degradation status is available and in what form (e.g. degraded, critical, automatic messages).

b) How the status of the C2 link degradation is announced to the remote pilot (e.g. visual, haptic, or sound).

A description of the associated contingency procedures.

5.8 C2 link loss

a) The conditions that could lead to a loss of the C2 link.

b) The measures in case of a loss of the C2 link.

c) A description of the clear and distinct aural and visual alerts to the remote pilot for any case of a lost link (if applicable).

d) A description of the established lost link strategy presented in the UAS operating manual, taking into account the emergency recovery capability (e.g. switch to the second RPS or FTS).

e) A description of how the geo-awareness or geo-fencing system is used in this case (related to 5.5 Containment system).

f) The lost link strategy, and, if incorporated, the re-acquisition process in order to try to re-establish the link in a reasonably short time.

5.9 Safety features

a) A description of the single failure modes and their recovery mode(s), if any.

b) A description of the emergency recovery capability to prevent risks to third-parties. This typically consists of:

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

2) an automatic recovery system (ARS) that is implemented through UAS crew command or by the on-board systems. This may include an automatic pre-programmed course of action to reach a predefined and unpopulated forced landing area; or

3) any combination of the above, or other methods.

c) The applicant should provide both a functional and physical diagram of the global UAS system with a clear depiction of its constituent components, and, where applicable, an indication of its specific features (e.g. independent power supplies, redundancies, etc.)

6 External systems (if applicable)

Describe all the external systems[1] used to support the UAS operation and their respective limitations.

[1] An ‘external system’ which supports the operation is usually a system providing a function as for instance a device used during flight (e.g. anemometer, thermometer), a system to detect traffic for avoidance manoeuvers (e.g FLARM, ADS-B in) or any other system supporting the operation.