Regulatory Instrument

Civil Aviation Directorate

Malta Transport Centre, Triq Pantar, Hal Lija, LJA 2021 Malta Tel: +356 2555 5000 Fax: +356 21239278 info.tm@transport.gov.mt
www.transport.gov.mt

Regulatory Instrument issued in terms of Article 5 of the Air Navigation Act, Chapter 641 of the Laws of Malta

Instrument No.:	**002/2024**
Title	**UAS Swarm Shows**
Date of Entry into Force:	**10 April 2024**
Version:	**1.1**

Table of Contents

1 REVISION HISTORY

Note: Changes made since the previous published edition are notified in red underline.

1.1 FIRST EDITION

This is the first edition of this document.

Version No.	Date	Amendments
1.0	10/04/2024	First edition
1.1	04/06/2024	Amendments based on MTIP feedback

2 FOREWORD

The aim of this document is to enable Unmanned Aircraft System (UAS) operators to understand the requirements that must be met as part of an application for operational authorisations related to rotary wing UAS swarm operations in visual line of sight (VLOS). The basis for this document is the CAP 722E published by the UK CAA and is intended to serve as a guideline for UAS Swarm Operators wishing to conduct UAS Swarm shows in the Maltese islands.

This document is a regulatory instrument and part of the Maltese Air Navigation Act. It is intended to be the sole reference document in absence of any regulation as such provided by EASA and has been compiled by the UAS inspector and approved by the DG.

To this end, all documentation and licenses/qualifications/experience listed required from the UAS Operator and/or remote pilot needs to be submitted to TM-CAD with evidence as and when required.

The latest version of this document will always be made available on the TM website.

For any enquiries please contact drones.aviation@transport.gov.mt

3 INTRODUCTION

3.1 POLICY

UAS operating in the Maltese islands must ensure that the risk imposed by such operations is ALARP (as low as reasonably practicable), as defined by the SAIL (Specific Assurance and Integrity Levels) levels in EASA UAS regulations which are the result of the conducted SORA (Specific Operations Risk Assessment).

It stands to reason that drone swarms, in which multiple unmanned aircraft (UA) are controlled collectively rather than individually, present a higher risk than individual drone operations not least because the malfunction of a single drone may cause repercussions on other drones within the swarm.

It should be noted that this document covers drone swarms with rotary wing UA within VLOS. Operations of swarms involving fixed wing UA, or flight beyond visual line of sight (BVLOS), result in a higher level of risk and are outside the scope of this document. In these cases, UAS operators should contact TM-CAD directly to discuss further.

It should also be noted that these are drone swarm light shows, and no material, whether pyrotechnic or otherwise, is to be dropped from the drones.

3.2 EDITORIAL PRACTICES

In this document the following editorial practices apply:

- 'Must' / 'must not' indicates a mandatory requirement.
- 'Should' indicates a strong obligation (in other words, a person would need to provide clear justification for not complying with the obligation).
- 'May' indicates discretion.
- 'Describe' / 'explain' indicates the provision of logical argument and any available evidence that justifies a situation, choice, or action.

Requirements that must be included within the OA are underlined within the text of Chapter 2 and Appendix A. For example:

'The remote pilot(s) **must** be competent to carry out UA swarm operations.'

4 REQUIREMENTS

Any operator wishing to conduct any swarming flights in the Maltese islands, including those for testing and development, must be in possession of a valid Operational Authorisation issued by the TM-CAD.

To obtain this OA, the Operator must contact TM-CAD and after a preliminary meeting to discuss the operation(s), if both parties decide to progress with this TM-CAD will provide the operator with a Centrik account. The Operator will then submit the Request for a Specific Operation, together with the requested documentation which is specified below:

1. An Operations Manual highlighting the Operations and Procedures of the Operator.

2. A Management System Manual, which may be a separate document or part of the Operations Manual.

3. A Specific Operations Risk Assessment (SORA) for the specific operation i.e. drone swarm show.

4. An Operational Authorisation request form based on the EASA template.

In parallel, the Operator must also ensure they have a valid EASA UAS Operator Registration and third party insurance, and register on tmcad.idronect.com.

Subsequently, they need to submit flight requests for each drone swarm operation, specifying the area, altitude, date/time and uploading the respective risk assessment.

4.1 VOLUME 1 - OPERATOR REQUIREMENTS

Besides a valid EASA UAS Operator registration and third party insurance, unless for R&D purposes, the Operator must have demonstrated experience of operating drone swarm shows within EASA Member States.

The advised minimum flight hours before first submission is 20h.

4.1.1 Remote pilot competence

The remote pilot(s) must be competent to carry out UA swarm operations.

Explain why the operator is satisfied that the remote pilot(s) is competent enough to comply with the conditions of an authorisation.

Explain how the qualifications and experience of the remote pilot(s) ensure they are competent to carry out the swarming operations.

4.1.2 Support crew competence

The support crew must be competent to support UA swarm operations.

Explain how the qualifications and experience of the crew ensure they are competent to support swarming operations. An example of a support crew member is a visual observer who keeps a lookout for other airspace users.

Explain the minimum composition of the flight crew/ground support crew including any additional support pilots, observers, crowd marshals etc and explain how the number of flight crew/ground support crew scales with the number of aircraft included in the operational volume.

4.1.3 Line of sight

The swarm operation must be carried out within VLOS.

Application for approval of a BVLOS swarm operation is outside the scope of this document.

4.1.4 Dimensions of the flight volume

The planned flight of the swarm must remain within the flight volume.

The upper limit of the flight volume must be kept as low as possible and only be as high as necessary to accommodate the planned flight of the swarm.

The horizontal dimensions of the flight volume must be sufficient to accommodate the planned flight of the swarm.

The flight volume must encompass the entire swarm and its planned movement, with sufficient allowance for any operational movement around the flight path.

State how the dimensions of the planned flight volumes will be calculated for each operation. Include calculations for how the Contingency Volume and Emergency Buffer Zones will be created.

4.1.5 Swarm height

The height of the swarm must be monitored and accurately measured.

The height of the swarm should be based on the height of the highest individual UA at any time during the flight.

Explain how the swarm height is measured and monitored during the flight, and how accuracy is assured.

4.1.6 Airspace

Appropriate airspace must be used for the swarm operation.

The Risk Assessment must contain all the information listed below:

- State the dimensions and location of the flight volume.
- State the dimensions and location of the contingency volume and emergency buffer.
- State the class of airspace where the swarm is to be conducted.
- State whether any additional permission is required to operate in the proposed airspace; for example, if the operation is within an FRZ (Flight Restricted Zone).
- Explain how any additional permission will be applied for.
- State any coordination procedures with any relevant parties.

4.1.7 Notification

All swarm flights must be notified in advance to TM-CAD who will ensure that any required NOTAMs (NOtices To AirMen) are issued accordingly.

4.1.8 Weather conditions

The swarm operation must only be conducted in the appropriate weather conditions.

State the weather limits for the operation and explain how the weather will be monitored during the operation.

4.1.9 Go/no-go criteria

Go/no-go and abort criteria must be clearly defined for the swarm operation. State the go/no-go criteria for the operation.

4.1.10 Emergency abort

The decision to abort the swarm must be made quickly and reliably enough, in response to an emergency, to prevent harm to people.

State who will make real-time decisions to abort the flight and what qualifies them to make the decision. This person must be physically present at the site of operation while the swarm is in flight.

Explain how the decision to abort will be made quickly and reliably to effectively intervene in an emergency to prevent harm.

State the abort conditions which, if reached, would lead to an immediate and safe termination of the operation. Explain the abort procedures which are in place to enable this decision.

State that the abort decision will always be free from commercial or contractual pressure.

4.1.11 Operating procedures

Operating procedures must be clearly defined for the swarm operation.

The OA must state and explain the operating procedures as necessary, including the:

- normal operating procedures

- lost C2 link procedures and protocols
- contingency procedures, including:
  - UA excursion from the flight volume
- emergency procedures, including:
  - aircraft incursion into the operational volume
  - UA excursion from the operational volume
- uninvolved third parties crossing the crowd line and entering the sterile ground area
- emergency response plan (ERP).

4.1.12 Illumination of take-off, landing and nominated recovery areas
The take-off, landing and nominated recovery areas must be sufficiently illuminated. Use of recovery areas is recommended.

Explain how the take-off, landing and any nominated recovery areas are sufficiently illuminated to ensure safe operation of UA when using the areas.

4.1.13 Insurance
The insurance policy must provide adequate cover for swarming operations. Include copies of the relevant insurance documents.

4.1.14 Projection or dropping of articles
No projection or dropping of articles is allowed.

4.1.15 Overflight of uninvolved third parties
The swarm must not overfly uninvolved third parties.

Explain how the overflight of uninvolved people will be avoided.

4.1.16 Swarms for public display – sterile ground area
A sterile ground area must be in place for the operation.

Uninvolved third parties must not be present in the sterile ground area.

The sterile ground area is the entire ground or water area covered by the flight volume, the contingency volume and the emergency buffer.

State the dimensions and location of the sterile ground area.

4.1.17 Swarm for public display – crowd line position
A crowd line must be established outside of the sterile ground area for the operation. A crowd line is applicable to any number of uninvolved people.

Based on the sterile ground area description, the crowd line must be outside the emergency buffer.

The crowd line must never be less than 50m from the operational volume. State the position of the crowd line.

4.1.18 Swarm for public display – crowd line marking and monitoring
Uninvolved third parties must not be permitted to cross the crowd line when the swarm is in flight.

Explain how the crowd line will be marked and how its observation will be enforced. Explain how you will respond if uninvolved third parties cross the crowd line.

4.2 VOLUME 2 – SYSTEM SPECIFICATIONS

4.2.1 UA type

The swarm must only be comprised of rotary wing UA. State the type of UA to be used in the swarm.

4.2.2 Number of UA in the swarm

The number of UA in the swarm must be no more than necessary to complete the operation.

The number of UA in the swarm is important; as the number increases, so does the swarm's potential to harm people. It also increases the potential for RF interference, C2 spectrum issues and loss of control or fly-away events.

While the number of UA within the swarm will not necessarily increase the amount of energy transferred to a person if the swarm were to crash, it would affect the likelihood of a person being struck.

State the number of UA to be used in the swarm.

4.2.3 UA speed

The highest speed of an individual UA must be no greater than necessary to complete the operation.

State the highest speed of the individual UA in the swarm.

4.2.4 UA mass

The mass of an individual UA must be no greater than necessary to complete the operation. State the mass, including payload, of the individual UA in the swarm.

4.2.5 UA kinetic energy

The kinetic energy of an individual UA must be no greater than necessary to complete the operation.

Kinetic energy is increased with higher UA speed. Kinetic energy is also increased with greater UA mass.

State the kinetic energy of the individual UA in the swarm at their highest speed.

4.2.6 UA size

The size of the UA must be no larger than necessary to complete the operation. State the size of the individual UA in the swarm.

4.2.7 Swarm coordination protocol

The swarm must be effectively controlled.

State how the UA in the swarm establish and maintain communication with each other through an RF channel. For example, is it a 'lead' and 'follower' configuration, a mesh system, or a pre-defined waypoint configuration?

Describe how individual UA in the swarm avoid one another and obstacles.

4.2.8 Intra-swarm collision avoidance and movement

All UA in the swarm must remain separated from each other during the operation. Explain the collision avoidance and movement co-ordination technologies between UA.

4.2.9 Whole system single points of failure

All single points of failure must be identified and mitigated.

State all single points of failure and explain how these points are mitigated.

4.2.10 Known failure modes

All known failure modes must be identified and mitigated.

State all known failure modes and explain how these are mitigated.

4.2.11 ADS-B (Automatic Dependent Surveillance Broadcast) dual frequency receiver

The remote pilot should use technical means to supplement visual lookout.

The remote pilot should be aware of other ADS-B equipped aircraft close to the operation.

An ADS-B dual frequency receiver operating on 978MHz and 1090MHz should be used and must be in the same place as the swarm.

ADS-B receivers may be airborne, or ground based and must be in the immediate vicinity of the swarm.

One ADS-B receiver may be used for the entire swarm.

If an ADS-B receiver is used, describe how it will be used to monitor ADS-B equipped aircraft nearby.

Describe the use of any third-party web-based application to supplement visual lookout and explain its limitations in terms of reliability and coverage.

If an ADS-B receiver is not used, explain why.

4.2.12 C2 link

An effective C2 link must be maintained between the command unit and the swarm. State how a C2 link between the command unit and the swarm is assured.

Describe how the C2 link works and the risks of it being lost during the operation.

Describe all technical mitigations designed to prevent the loss of the C2 link. For example, any redundancy provided within the system through the use of independent C2 links.

4.2.13 C2 link frequency

Any interference on the C2 link frequency must not present an intolerable risk of the loss of the C2 link.

State which C2 frequency or frequencies will be used.

Explain how potential RF interference is assessed prior to and during the operation. A calibrated spectrum analyser or equivalent signal monitoring system should be used before and during flight.

Explain how the operator ensures that they are aware of any notified RF interference for the date and time of the intended flight of the swarm.

4.2.14 C2 link signal latency

The C2 link signal latency must be tolerable to maintain control of the swarm.

Describe the proof that the signal latency timing within the C2 link falls within the tolerable limit.

4.2.15 GNSS (Global Navigation Satellite System)

The planned flight of the swarm must remain within the flight volume.

GNSS must not be lost to the extent that the safe and effective control of the swarm cannot be maintained.

It is not a requirement to use GNSS. However, if GNSS is used the following information must be included:

- Describe the GNSS equipment used.

- Explain how GNSS is used in the operation and the navigational precision required.
- State the minimum number of satellites required for the operation.
- Explain how the number of satellites is monitored before and during the operation.
- Explain any use of dilution of precision indicators.

4.2.16 'Geo-caging' function

The planned flight of the swarm must remain within the flight volume.

A technical function which 'automatically' retains the swarm within a pre-defined airspace volume (sometimes referred to as a 'geo-caging' capability) must be used.

The following information must be provided:

- Describe the equipment being used to provide this capability.
- Explain how the capability is used in the operation.
- Explain how the navigational data being used accurately represents the flight volume.
- Explain how reliable it is.

4.2.17 Visual conspicuity

The swarm must be visually conspicuous.

If operating at night, conspicuity lighting must be fitted to each UA. Display lighting may be used for visual conspicuity.

If the swarm is for the purpose of public display, it is accepted that some or all UA may have their conspicuity lights off or flashing for periods of time. These periods should be minimised, and operators must demonstrate how they will mitigate the safety risk to other air users during periods when some or all UA are not displaying conspicuity lighting.

Describe how periods of flight by UA that are part of a public display and are not displaying conspicuity lighting are minimised.

State the maximum distance that each individual UA can be expected to be seen using unaided eyesight (corrective spectacles may be used).

4.2.18 Flight termination function

A flight termination function must be available to stop the swarm's flight in an emergency to prevent harm to people.

Explain the flight termination function and how it ensures safe termination of the flight if required.

Explain how the flight termination function ensures the swarm will not leave the emergency buffer.

Return to Home function is not an appropriate flight termination function for swarms.

4.3 Safety Risk Assessment

All safety risks associated with the operation must be tolerable and ALARP.

The safety risk assessment must be carried in accordance with the SORA process published by EASA in EU (Reg) 2018/947 Article 11.

4.4 Additional Application Requirements

4.4.1 Demonstration flight

A demonstration flight, observed by TM-CAD inspector(s), must be conducted.

During the application process the applicant must conduct a demonstration flight which will be observed by TM-CAD inspector(s). The demonstration flight is only required as part of the application process.

The flight must comply with the following requirements:

- The flight must be carried out in a sterile ground area.
- The flight must demonstrate the proposed operation and emergency procedures.
- Relevant equipment capabilities, particularly those which are being relied upon as safety mitigations, must be demonstrated.

4.4.2 Non-Maltese-registered Operators

All operators not registered in Malta wishing to conduct swarm operations within the Maltese islands must apply to the TM-CAD for authorisation. In these cases, operators must already be in possession of an equivalent authorisation to operate within their State of registration, granted by their respective NAA. Subsequently, as per EASA regulation requirements, the Operator is to submit these documents together with a Cross-border Application form specifying the local risks and corresponding mitigation measures.

5 VOLUME 3 – FLIGHT VOLUME SPECIFICATIONS

5.1 AIRSPACE

This chapter will help applicants create and visualise the airspace associated with the swarm operation.

Applicants must describe the airspace required for the and provide airspace diagrams.

5.1.1 Flight volume

The upper vertical limit of the flight volume must be kept as low as possible and only be as high as necessary to safely accommodate the planned swarm operation.

The flight volume must encompass the entire swarm and its planned movement, with sufficient buffer for any operational movement around the flight path. Consideration should be given to surrounding airspace, other airspace users and ground risks.

Operational movement includes UA movement for navigational changes, such as turns, and expected weather conditions.

5.1.2 Contingency volume

The contingency volume is adjacent to and surrounds the flight volume. It must be large enough to accommodate UA leaving, and manoeuvring to re-enter, the flight volume.

The contingency volume is established to cater for unexpected circumstances, such as manoeuvring the UA to avoid deteriorating weather conditions or other airspace users.

If any UA enters the contingency volume, or the remote pilot suspects it might happen, the contingency procedures must be carried out immediately and must result in the UA re- entering the flight volume as soon as possible. The contingency procedures must be stated.

5.1.3 Operational volume

The operational volume is the zone containing the flight volume and the contingency volume.

5.1.4 Emergency buffer

The emergency buffer is airspace that is adjacent to and surrounds the operational volume.

If any UA enter the emergency buffer or the remote pilot suspects it might happen, the emergency response plan (ERP) must be carried out immediately.

5.1.5 Dimensions of the emergency buffer

The horizontal and vertical dimensions of the emergency buffer are dictated by two principles:

- It must be large enough to contain controlled manoeuvres made by the UA as part of the ERP. This includes flight termination.
- It must be large enough to contain the predicted flight path of a UA that leaves the contingency volume in any direction while suffering a total loss of propulsion and control.

5.1.6 Calculating the emergency buffer

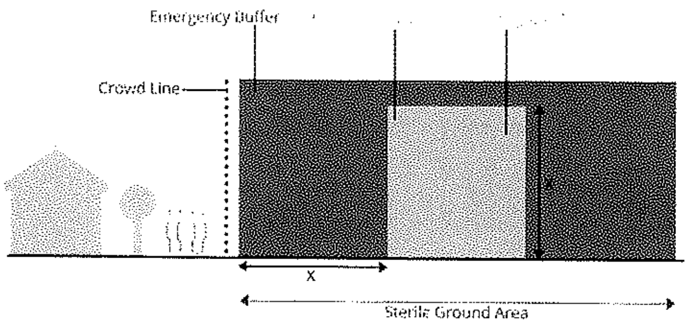
The dimensions of the emergency buffer must satisfy both principles above.

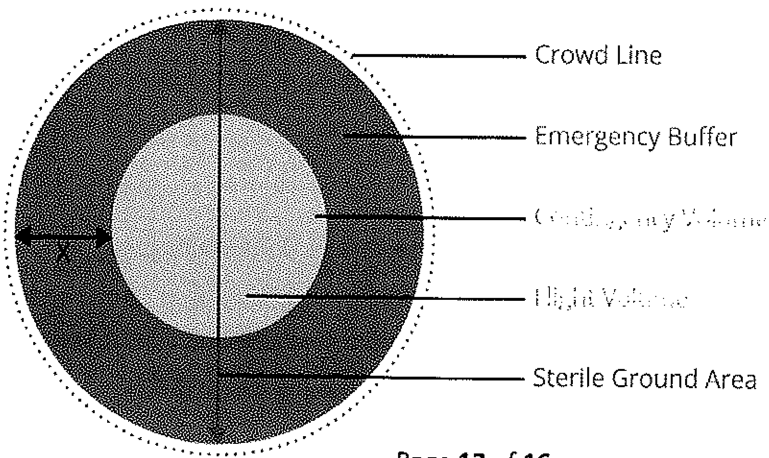
When calculating the dimensions of the emergency buffer, UAS operators must consider all the following points:

- The upper limit of the operational volume:
  - The horizontal dimensions of the emergency buffer must be at least the same as the height of the operational volume. This is the minimum distance required.
- Any technical limitations and capabilities used in the ERP.
- The speed of the UA.
- The effect of wind, and therefore any subsequent drift, on the UA.
- Any other aspects of the operation that might increase the size of the emergency buffer.

5.2 VLOS SWARM FOR PUBLIC DISPLAY DIAGRAMS

<u>Note: The diagrams are not to scale</u>





Appendix A: Summary of Requirements

5.3 OPERATOR REQUIREMENTS

The operational requirements listed below **must** be included in Volume 1.

Paragraph Number and Title	**Basic requirement for all rotary wing VLOS swarms**
4.1.1 Remote pilot competence	The remote pilot(s) **must** be competent to carry out UA swarm operations
4.1.2 Support crew competence	The support crew **must** be competent to support UA swarm operations
4.1.3 Line of sight	The swarm operation **must** be carried out within VLOS
4.1.4 Dimensions of the flight volume	The planned flight of the swarm **must** remain within the flight volume The upper limit of the flight volume **must** be kept as low as possible and only be as high as necessary to accommodate the planned flight of the swarm The horizontal dimensions of the flight volume **must** be sufficient to accommodate the planned flight of the swarm
4.1.5 Swarm height	The height of the swarm **must** be monitored and accurately measured
4.1.6 Airspace	Appropriate airspace **must** be used for the swarm operation
4.1.7 Notification	All swarm flights **must** be notified in advance to CAA Airspace Regulation Operations (AR Ops)
4.1.8 Weather conditions	The swarm operation **must** only be conducted in the appropriate weather conditions
4.1.9 Go/no-go criteria	Go/no-go and abort criteria **must** be clearly defined for the swarm operation
4.1.10 Emergency abort	The decision to abort the swarm **must** be made quickly and reliably enough, in response to an emergency, to prevent harm to people
4.1.11 Operating procedures	Operating procedures **must** be clearly defined for the swarm operation

4.1.12 Illumination of take-off, landing and nominated recovery areas	The take-off, landing and nominated recovery areas **must** be sufficiently illuminated
4.1.13 Insurance	The insurance policy **must** provide adequate cover for swarming operations
4.1.14 Projection or dropping of articles	The safety risks associated with the projection or dropping of articles **must** be tolerable and ALARP
2.1.15 Overflight of uninvolved third parties	The swarm **must not** overfly any uninvolved third parties
4.1.16 Swarm for public display – sterile ground area	A sterile ground area **must** be in place for the operation
4.1.17 Swarm for public display – crowd line position	A crowd line **must** be established outside of the sterile ground area for the operation
4.1.18 Swarm for public display – crowd line marking and monitoring	Uninvolved third parties **must not** be permitted to cross the crowd line when the swarm is in flight

5.4 SYSTEM SPECIFICATIONS

The operational requirements listed below **must** be included in Volume 2.

Paragraph Number and Title	Basic requirement for all rotary wing VLOS swarms
4.2.1 UA type	The swarm **must** only be comprised of rotary wing UA
4.2.2 Number of UA in the swarm	The number of UA in the swarm **must** be no more than necessary to complete the operation
4.2.3 UA speed	The highest speed of an individual UA **must** be no greater than necessary to complete the operation
4.2.4 UA mass	The mass of an individual UA **must** be no greater than necessary to complete the operation
4.2.5 UA kinetic energy	The kinetic energy of an individual UA **must** be no greater than necessary to complete the operation
4.2.6 UA size	The size of the UA **must** be no larger than necessary to complete the operation
4.2.7 Swarm control protocol	The swarm **must** be effectively controlled

4.2.8 Intra-swarm collision avoidance and movement	All UA in the swarm **must** remain separated from each other during the operation
4.2.9 Whole system single point of failure	All single points of failure **must** be identified and mitigated
4.2.10 Known failure modes	All known failure modes **must** be identified and mitigated
4.2.12 C2 link	An effective C2 link **must** be maintained between the command unit and the swarm
4.2.13 C2 link frequency	Any interference on the C2 link frequency **must not** present an intolerable risk of the loss of the C2 link
4.2.14 C2 link signal latency	The C2 link signal latency **must** be tolerable to maintain control of the swarm
4.2.15 GNSS	The planned flight of the swarm **must** remain within the flight volume
4.2.16 'Geo-caging' function	The planned flight of the swarm **must** remain within the flight volume
4.2.17 Visual conspicuity	The swarm **must** be visually conspicuous
4.2.18 Flight termination function	A flight termination function **must** be available to stop the swarm's flight in an emergency to prevent harm to people
4.2.8 Intra-swarm collision avoidance and movement	All UA in the swarm **must** remain separated from each other during the operation

5.5 VOLUME 3 – VOLUME SPECIFICATIONS

The Operator must explain why all safety risks identified in Volumes 1 and 2 are tolerable and ALARP.

The safety risk assessment must be carried in accordance with the SORA process detailed in EU (Reg) 2019/947 Art. 11.

Title	Basic requirement for all rotary wing VLOS swarms
Safety risk assessment	All safety risks associated with the operation **must** be tolerable and ALARP

6 ADDITIONAL APPLICATION REQUIREMENTS

Title	**Basic requirement for all rotary wing VLOS swarms**
4.4.1 Demonstration flight	A demonstration flight, observed by TM-CAD inspector(s), **must** be conducted
4.4.2 Non-Maltese operators	All Non-Maltese operators wishing to conduct swarm operations within the Maltese airspace **must** apply to TM-CAD for authorization. Non-Maltese operators wishing to conduct swarm operations within the Maltese islands **must** already be in possession of an equivalent authorisation to operate within their country of registration/PPOB.

Captain Charles Pace

Director General

Civil Aviation Directorate

Transport Malta