



MINIMUM OPERATIONAL PERFORMANCE STANDARD FOR GEOCAGING

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CHAPTER I

GENERAL

1.1 PURPOSE AND SCOPE

This document contains Minimum Operational Performance Standard for the Geocaging function of Unmanned Aircraft Systems. This standard specifies the minimum performance expected from this Geocaging function, without prescribing its design and implementation as far as possible.

NOTE: *In the rest of the document, the word "Function" will be used to mean the object of this specification, and equipment to identify the entity implementing this Function in whatever form.*

Compliance with this standard is recommended as one mean of assuring that the Function will perform its intended sub-functions satisfactorily under all conditions normally encountered in routine aeronautical operation and will comply with applicable regulations.

The document is structured as follows:

Chapter 1 of this document provides information required to understand the need for the Function characteristics and tests defined in the remaining chapters. It describes typical Function applications and operational objectives and is the basis for the performance criteria stated in Chapter 2 to Chapter 4. Definitions essential to proper understanding of this document are also provided in Chapter 1.

Chapter 2 contains general design requirements.

Chapter 3 contains the minimum performance specification for the Function, defining performance under standard operating conditions.

Chapter 4 prescribes the environmental test conditions, which provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those, which may be encountered in actual operations.

Chapter 5 describes recommended test procedures for demonstrating compliance with Chapters 3 and 4.

Chapter 6 specifies normally the performance required of the installed Function. Ground and flight tests for the installed Function are included when performance cannot be adequately determined through testing under standard test conditions. In the present case, no difference has been made for performances and testing. Chapter 5 includes all testing requirements, whatever mean used.

Chapter 7 lists normally some considerations for Aircraft Operational Performance Characteristics. Nothing has been identified in the present case.

Operational performance standards for functions or components that refer to equipment capabilities that exceed the stated minimum requirements are identified as optional features. Performance requirements and associated test procedures should be developed for these optional features.

1.2 APPLICATIONS

Any regulatory application of this document in whole or in part is the sole responsibility of appropriate government agencies.

1.2.1 Mandating and Recommending Phrases

"Shall"

The use of the word "Shall" indicates a mandated criterion; i.e. compliance with the particular procedure or specification is mandatory and no alternative may be applied.

"Should"

The use of the word "Should" (and phrases such as "It is recommended that...", etc.) indicate that though the procedure or criterion is regarded as the preferred option, alternative procedures, specifications or criteria may be applied, provided that the manufacturer, installer or tester can provide information or data to adequately support and justify the alternative.

1.3

DESCRIPTION OF FUNCTION

The Geocaging function is an UAS function that helps the remote pilot to prevent the UA from exiting out of a volume defined on purpose for this operation.

This function operates in both horizontal plane and vertical axis, otherwise noted.

The Geocaging function has three grades defined to accommodate different levels of risk in case of exit.

The Geocaging function will provide, depending on the grade, one or several barriers to the exit.

These barriers can be alerts to the remote pilot that will perform the adequate actions or, optionally, can be automatic actions.

A flight termination system can be included in the Geocaging function to achieve the required safety objective, specifically for High grade, but this is not a preferred or imposed solution.

A **functional block diagram** is provided in the **FIGURE 1** below, where dashed lines show the optional variants of implementation (automatic actions).

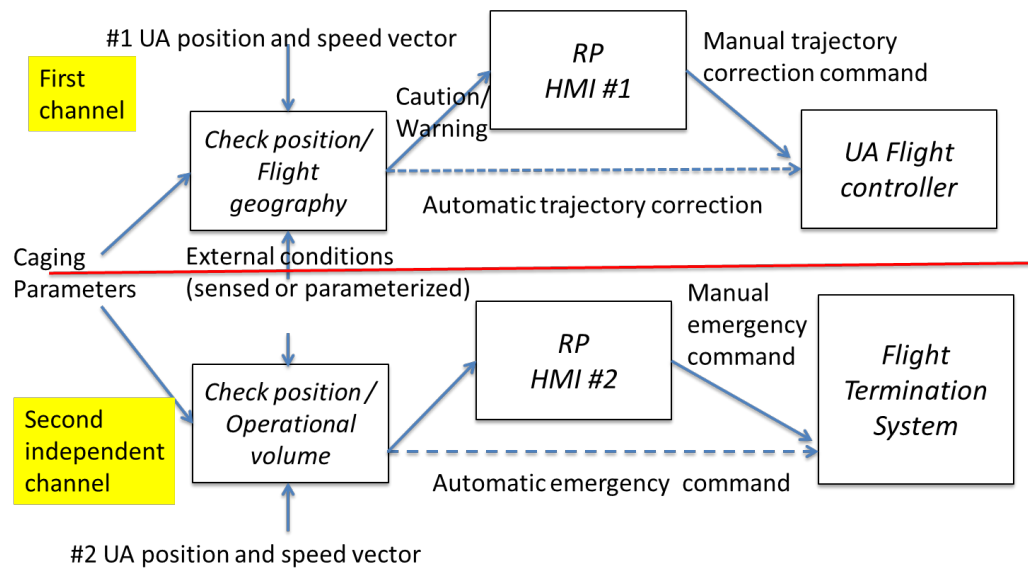


FIGURE 1: GEOCAGING FUNCTIONAL BLOCK DIAGRAM

Two independent channels are represented in this figure, which corresponds to the High grade function implementation. Low and Medium grades may need only the first channel. The first channel is typically realized within the nominal flight control and command system of the UAS, provided this has the required performance and reliability to keep the UA in the Flight geography plus Contingency volume.

The second channel is typically realized via an independent Flight Termination System, its activation corresponding to Emergency when the UA cannot be kept in the Contingency volume with the first channel only.

But these mentions of nominal UA control system and FTS are only examples. Nothing in this standard precludes other implementations, provided that they meet its performances and safety objectives. In particular, there could be implementations where the FTS is replaced by a second flight control channel which takes over control of the UA and keep the UA in the required volume while continuing the flight. This would not be strictly speaking an emergency situation but the requirement of defining an 'Emergency' buffer to accommodate its exact effect would still apply.

However, in order to limit the complexity of this document, it will be mentioned essentially the FTS type of solution for the rest of the text.

Principle of operation:

In the first/Contingency channel, there is a comparison between the UA position and speed vector with regard to the limit of the Flight geography. The Flight geography corresponds to the volume intended normally for the flight. A Caution alert or an automatic command is sent by the Function to prevent from exiting the Flight geography. If the Flight geography limit is however trespassed, a Contingency warning alert and/or an Automatic Contingency command is sent to perform a Contingency manoeuvre in

order to come back as soon as possible in the Flight geography. The Contingency volume is the volume needed to accommodate these Contingency manoeuvres.

The reliability of the Contingency channel is not only the reliability of the Contingency warning alert or automatic command, but includes also the reliability of anything necessary to perform the Contingency manoeuvre (e.g.: the UA flight controller, the RPS).

In High grade, there is a second independent channel which compares the current UA position and speed vector, and generates an Emergency warning alert then manual Emergency command or an automatic Emergency command in order to keep the UA in the predefined overall volume, meaning the Flight geography + the Contingency volume + the Emergency buffer provisioned to accommodate effects of Emergency on trajectory.

The reliability of the second/Emergency channel is not only the reliability of the Emergency warning alert or automatic command, but includes also the reliability of anything necessary to perform the Emergency action (e.g.: the FTS, the remote control of the FTS if any).

In some implementations, position and speed vector assessment in one or both channels might be made only visually by the remote pilot or observers, without dedicated sensors. The accuracy of such visual assessment shall be estimated and taken into account as for any position sensor.

The [FIGURE 2](#), in Appendix 1, can also be used to support the above explanations.

1.4 COMPOSITION OF EQUIPMENT

The Geocaging function consists in a set of hardware and /or software components inside the UAS, either in the remote pilot station and/or on board the UA itself, which is loaded with Geocaging parameters such as threshold setting for alerts or triggers, geometrical definitions relative to the pre-defined volumes and other factors relative to the UAS and the operational conditions.

The High grade implies a physical segregation of the first and second channel.

1.5 DEFINITIONS AND ABBREVIATIONS

Additional safety margin: any horizontal or vertical volume added after the computed Contingency volume and Emergency buffer, and before the “not to enter” volume. The present standard does not define rules for this additional safety margin. This additional safety margin is optional. It could be used to take into account various uncertainties as well as the size of the UA if significant, and the risk of projection of high energy parts.

(Emergency) Buffer: The volume beyond the Contingency volume which is computed to accommodate emergency situations. Typically, it is the volume into which the UA may enter after the triggering of a flight termination or any action engaged when the Contingency procedure has failed.

Caution Alert: For conditions that require immediate flight crew awareness and subsequent flight crew response.

C2 link: Command and Control link which connects the UA and the RPS for command and monitoring of the UA by the remote pilot.

Cage: The overall volume into which the UA shall stay. This overall volume or cage is divided in several sub-volumes: Flight geography, Contingency volume, Emergency buffer, additional safety margin.

CEP: Circle of Error Probability.

Contingency volume: The volume in which the UA may fly temporarily in abnormal situations that cause an exit out of the Flight geography. This volume is computed to accommodate manual or Automatic Contingency manoeuvres.

DAA: Detect and Avoid.

DAL: Design Assurance Level.

Emergency Flight Termination: a last resort action when the UA is no more controllable, to limit its flight excursion to the minimum, for example by cutting power on engine and/or forcing a deep dive. This feature might not be present in the UAS if the UAS is able without it to achieve the required reliability/assurance objective for the operation by other means.

FH: Flight Hour.

Flight control and command system: the sum of the remote pilot station, C2 link and UA navigation and flight control system which enables to control the UA flight.

Flight Geography: the volume in which the UA flight shall take place in normal situation.

FTS: Flight Termination System: the meaning used in this document is a system that will force the UA to come back to ground as soon and near as possible. A typical implementation is by cutting the engine power and maybe forcing the control surfaces in an adequate position.

Geocaging parameters: all the data to load in the UAS Geocaging function, complementing its resident software and hardware, and depending on the intended operation.

Geofencing: another function that helps the pilot or controls automatically the UA to prevent from entering into geographical zones which are declared restricted to this UA, for various reasons and not only for safety. It is covered by a different Eurocae MOPS.

HMI: Human – Machine Interface.

Operator: any legal or natural person operating one or more UAS.

Operational volume: Flight geography + Contingency volume.

RP: Remote Pilot: the person responsible for the safety when conducting the flight.

RPS: Remote Pilot Station, other name of the command and control station, by which the remote pilot is able to send commands to UA and monitor flight and status data from the UA (not necessarily including mission payload data).

SORA: Specific Operation Risk Analysis. It is described in the document cited as reference in chapter 1.6.

STD (or Sigma): Standard Deviation.

UA: Unmanned Aircraft: the flying part of an UAS.

UAS: Unmanned Aircraft System: the system composed of the UA and its command and control station RPS.

Warning Alert: For conditions that require immediate flight crew awareness and immediate flight crew response.

1.6

REFERENCES

AMC1 Article 11 Rules for Conducting an Operational Risk Assessment" of EASA AMC/GM to Commission Implementing Regulation (EU) 2019/947

1.7

DOCUMENT HIERARCHY

Not applicable.

1.8

OPERATIONAL APPLICATION(S)

The Geocaging function can be used to answer to the requirements set forth in SORA step #9 – Adjacent Area/Airspace Considerations. It may have other applications when it is necessary to keep the UA in a defined volume.

1.9

INTENDED FUNCTION

See 1.3 and 1.8.

1.10

OPERATIONAL GOALS

The Geocaging function is intended to be used when there is a risk in areas adjacent to the zone of operation (or overflow area), with regard to ground population or to other air traffic (e.g. to keep the drone over low population density areas or in a segregated airspace and prevent it to enter in populated areas or dense air traffic areas). The Geocaging function does not reduce the risks within the area of operation and might reduce the overall UAS reliability.

1.11

ASSUMPTIONS

The cage is defined on purpose for a given operation, between the operator and the authority in charge of operation approval.

The operator has to plan the flight in the Flight geography volume, taking into account the subtraction from the cage limits of the error of the position sensors used, of the Contingency volume, of the Emergency buffer and of the additional safety margin if any.

The safety of the operation with regard to the zone overflow is to be assessed considering the overall volume or cage including the buffer and not only the Flight geography.

The operator shall check the local regulation requirements for the operation in terms of Geofencing. Both UAS Geofencing and Geocaging functions can act in parallel. But the Geofencing function could be deactivated considering that the cage has been defined taking into account the Geofencing restrictions, and provided that the accuracy and reliability of the Geocaging are equal or better to those required for Geofencing.

The cage should be designed compliant with applicable airspace restrictions (for example UAS Geographical zone (Geofencing) restrictions). But it may also ignore some restrictions when subject to a specific authorization that is supposed to prevail.

1.12**TEST PROCEDURES**

The test procedures specified in this document are intended to be used as one means of demonstrating compliance with the performance requirements defined in Chapter 3. Although specific test procedures are cited, it is recognized that other methods may be preferred. These alternate procedures may be used if they provide at least equivalent assurance. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures. Users of this document should not infer performance requirements based on test Procedures.

1.13**ANTICIPATED FUTURE GROWTH**

None identified.

CHAPTER II

GENERAL DESIGN REQUIREMENTS

2.1 INTRODUCTION

This chapter establishes the general design considerations and general specification for the Geocaging function.

2.2 AIRWORTHINESS AND CERTIFICATION

Not addressed by this MOPS. It is the responsibility of the operator to ensure the compliance to all applicable regulations and to get the required approvals.

2.3 INTENDED FUNCTION

REQ001: The equipment implementing the Geocaging function shall perform its intended sub-functions, as defined by the manufacturer, and its proper use shall not create a hazard to other users of the Airspace.

REQ002: A user's manual shall state which are the sub-functions, performances and options implemented and the level of conformance to this standard, including the complexity of the cage which is managed (max number of polygons, max number of points of polygons, minimum and maximum dimensions, possibility of forbidden volume within the Flight geography volume).

REQ003: The user's manual shall enable the operator to define and load the Geocaging function with all the Geocaging parameters required to ensure the safety of the operation (Flight and Contingency volumes, buffer size, thresholds for alerts or triggers, etc.). It should also indicate the way to retrieve logged data.

2.4 FIRE PROTECTION

Not addressed by this MOPS.

2.5 OPERATION OF CONTROLS

REQ004: The equipment implementing the Geocaging function shall be designed so that controls intended for use during flight (means for the remote pilot to configure, command, control the Geocaging function) cannot be operated in any position, combination or sequence that would result in a condition detrimental to the reliability of the equipment or operation of the aircraft.

2.6 ACCESSIBILITY OF CONTROLS

REQ005: Controls that do not require adjustment during flight shall not be readily accessible to flight personnel.

2.7 EFFECTS OF TESTS

REQ006: Unless otherwise stated, the design of the equipment shall be such that, during and after the application of the specified tests, no condition exists which would be detrimental to the subsequent performance of the equipment.

2.8 FUNCTION INTERFACES

The format of the Geocaging parameters and the way to load them in the UAS function is left to manufacturer's implementation decision.

2.9 RELIABILITY, AVAILABILITY AND INTEGRITY

The respective objectives for each grade of the Geocaging function are defined in the related part of chapter 3.

2.10 MAINTAINABILITY

REQ007: A solution should be provided to facilitate the detection of the physical part or sub-assembly in default when the Geocaging function is out of order.

2.11 SOFTWARE AND HARDWARE MANAGEMENT DESIGN

The respective objectives for each grade of the Geocaging function are defined in the related part of chapter 3.