



MINIMUM OPERATIONAL PERFORMANCE STANDARD FOR GEOFENCING

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ED-269

June 2020

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CHAPTER I

GENERAL

1.1 PURPOSE AND SCOPE

This standard specifies the data model and interface protocol for the delivery of the UAS geographical zone information to UAS and users, independently of the way this information is developed and maintained.

This specification is gathered in chapter 8, 9 and Appendix 2.

The functional, performances, and test requirements contained in this document in chapters 2,3,4,5,6,7 for the UAS Geoawareness function and the smooth interaction of an optional automatic limitation of UAS access to certain airspace and of the UAS flight control system are an intermediate proposal that is supposed to be superseded, for the Open category of UAS, by the PrEN4709 once published.

Until then, these chapters 2, 3, 4, 5, 6, 7 can be used to understand the intended purpose and usage by the UAS of the UAS geographical zone data described in chapter 8, 9 and appendix 2.

The document is structured as follows:

Chapter 1 of this document provides information to understand the context of use and the characteristics and tests defined in the remaining chapters. Definitions essential to proper understanding of this document are also provided in Chapter 1.

Chapter 2 contains preliminary general design requirements of the UAS Geofencing function.

Chapter 3 contains the preliminary minimum performance specification for the UAS Geofencing function, defining performance under standard operating conditions.

Chapter 4 prescribes the preliminary 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 preliminary recommended test requirements for demonstrating compliance with Chapters 3 and 4. It is on purpose simplified as the detailed test requirements and procedures shall be those of prEN4709 for the UAS Geofencing function.

Chapter 6 specifies the performance required of the installed UAS Geofencing function. Ground and flight tests for the installed Geofencing function are included when performance cannot be adequately determined through testing under standard test conditions.

Chapter 7 lists some considerations for Aircraft Operational Performance Characteristics.

Operational performance standards that refer to equipment capabilities that exceed the stated minimum requirements are identified as 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 UAS FUNCTION

Geofencing is a UAS function that, based on the data provided by authoritative sources on UAS geographical zones, detects a potential breach of airspace restrictions and assists the remote pilot in preventing that breach.

Geoawareness is the minimum sub-function of Geofencing that provides a warning alert to the remote pilot to avoid breaching an airspace restriction, the remote pilot being then responsible to act on the UAS controls to adapt the trajectory with regard to the airspace restrictions.

Automatic Geofencing is an additional optional sub-function (option left to manufacturer's decision) that automatically prevents the UA to penetrate a forbidden zone by connecting with the flight command and control system and engaging an adequate manoeuvre without any remote pilot action.

1.4 COMPOSITION OF EQUIPMENT

The UAS Geofencing function can be realized as a set of hardware and /or software components inside the UAS, either in the remote pilot station and/or on board the UA itself.

1.5 DEFINITIONS AND ABBREVIATIONS

BVLOS: Beyond Visual Line of Sight (the UA is not directly visible by the Remote Pilot)
Caution Alert: For conditions that require immediate flight crew awareness and subsequent flight crew response.

CEP: Circle of Error Probability

DAA: Detect and Avoid

HMI: Human-Machine Interface

OPERATOR: any legal or natural person operating one or more UAS

RPS: Remote Pilot Station

RP: Remote Pilot, the person conducting the flight

STD: Standard Deviation

UA: Unmanned Aircraft

UAS: Unmanned Aircraft System = UA + RPS, including the Command & Control (C2) data link between them

UAS Geozone = UAS Geographical zones: means a portion of airspace established by the competent authority that facilitates, restricts or excludes UAS operations in order to address risks pertaining to safety, privacy, protection of personal data, security or the environment, arising from UAS operations.

UTM: Unmanned Traffic Management

VLOS: Visual Line of Sight (the UA is directly visible by the Remote Pilot)

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

1.6 REFERENCES

Commission Implementing Regulation (EU) 2019/947 of 24 May 2019 on the rules and procedures for the operation of unmanned aircraft

Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems.

1.7 DOCUMENT HIERARCHY

None.

1.8 OPERATIONAL APPLICATIONS

Geoawareness sub-function is required for most operations in the Open Category, as per EU UAS Implementing Regulation, reference 2019/947 and Delegated Regulation, reference: 2019/945. These regulations also envisage the possibility of an automatic limitation of access to the geographical zones, in which case it is required to interact smoothly with the flight control system in order to not affect adversely the safety of the flight.

But nothing in this specification prevents using Geoawareness or Automatic Geofencing in other category of UAS operations.

1.9 INTENDED FUNCTION

See definition in sections 1.3 and 1.8.

1.10 OPERATIONAL GOALS

The Geofencing function, either Geoawareness or Automatic Geofencing is defined for any mode of UA command and control:

- manual control: direct control of aerodynamic surfaces & engines by the remote pilot (even in manual control, the Automatic Geofencing will block the UA at the external limit of the forbidden zone)
- semi-automatic control: speed vector control by the remote pilot; e.g.: heading + horizontal speed + vertical speed
- automatic flight: automatic following of a succession of legs between waypoints previously defined by the remote pilot (even in automatic flight, the Geoawareness alert will be raised to the remote pilot who is supposed to react and take over manually the control if no Automatic Geofencing is implemented).

1.11 ASSUMPTIONS

The UAS operator ensures that the Geofencing function has access to up-to-date UAS Geozone data.

Operational restrictions that are not included in a UAS Geographical zone will not be considered by the Geofencing function.

No difference has been identified in the Geofencing function depending on VLOS or BVLOS operation.

No difference is made in the present standard between UAS or operators excepted the possibility of conditional restrictions coded in the geozone database. The process of waiver or authorization is not addressed by this standard, excepted the possibility to indicate the need for authorization in the geozone database.

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 UAS Geofencing function.

2.2 AIRWORTHINESS AND CERTIFICATION

Not addressed by this MOPS.

2.3 INTENDED FUNCTION

REQ001: The equipment implementing the Geofencing function shall perform its intended sub-functions, as defined by the manufacturer, and its proper use shall not adversely affect the safety of the UAS operation.

REQ002: A user's manual shall state which are the sub-functions and performances implemented and their level of conformance to this standard (for example: Geoawareness only or with automatic Geofencing, real-time automatic update capability for the Geozone data, behavior in case of loss of C2 communication etc).

2.4 OPERATION OF CONTROLS

REQ003: The equipment shall be designed so that controls (means for the remote pilot to configure, command, control the UAS) intended for use during flight 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.

2.5 ACCESSIBILITY OF CONTROLS

REQ004: Controls that do not require adjustment during flight shall not be readily accessible to flight personnel.

2.6 FIRE PROTECTION

Not applicable.

2.7 FUNCTION INTERFACES

The protocol to get the UAS Geographical zone data as input to the Geofencing function, the associated data format, the expected characteristics and properties of these data are described in chapters 8 and 9 plus appendix 2.

2.8 RELIABILITY, AVAILABILITY AND INTEGRITY

No reliability or availability requirements are set on the Geofencing function by this present MOPS, but it is the responsibility of the manufacturer or operator to check if other requirements are applicable coming from other documents.

Maintaining the integrity and validity of UAS geozone data during the transfer to the UAS is ensured by the interface proposed in chapter 9 (use of WS-Light and TLS). However, the present standard does not address the integrity and validity of the geozone data themselves.

2.9 MAINTAINABILITY

No maintainability requirements are set on the Geofencing function by this present MOPS, but it is the responsibility of the manufacturer or operator to check if other requirements are applicable coming from other documents.

2.10 SOFTWARE AND HARDWARE MANAGEMENT DESIGN

No requirements are set on the software and /or hardware design assurance by this present MOPS, but it is the responsibility of the manufacturer or operator to check if other requirements are applicable coming from other documents.

CHAPTER III

MINIMUM PERFORMANCE SPECIFICATION UNDER STANDARD CONDITIONS

3.1 GEOAWARENESS FUNCTION

3.1.1 Alerting

REQ005: The Geoawareness function shall provide the remote pilot with a Geoawareness warning alert when a potential or actual breach of airspace restrictions (as defined by the UAS Geozone information) is detected, either in horizontal plane or in vertical axis or both.

REQ006: This warning alert should be maintained until the breach or risk of breach is ended.

REQ007: The Geoawareness function should provide to the remote pilot a depiction of the current horizontal and vertical UA position relatively to geographical zones, in order to better anticipate and understand the situation.

REQ008: The Geoawareness function shall operate correctly for any geographical zone defined in conformance with the data format chapter 8 and the appendix 2.

REQ009: If more than one restriction or condition to enter the zone is set at the same position and time, the Geoawareness function shall give priority to the most restrictive one.

REQ010: If the UAS is in a location or at a time for which the Geozone data have not been loaded, the Geoawareness function shall set a warning alert to the remote pilot (for example: Geoawareness warning alert + indication "out of available geozone data").

NOTE: *It is left to the remote pilot to decide of further steps, following the applicable regulation.*

REQ011: Multiple information messages associated with a geographical zone shall be displayed simultaneously, in a clear manner.

REQ012: As the geographical zone data (typically restrictions) are time-related, a caution alert shall be provided to the remote pilot when the current location is to become forbidden soon and will have to be exited.

- This caution alert should be provided soon enough to enable exit before active restriction, for example considering the distance to come back to the authorized limit (or distance to exit) divided by anticipated ground speed to do so. A minimum value should be two minutes.
- It is also recommended to have an advisory alert before this last one (either 10 minutes or five times the caution anticipation time).

REQ013: Before entering into a geographical zone subject to Notification (to a given authority as defined in the geographical zone data), such information shall be provided to the remote pilot.

NOTE: *It is left to the remote pilot to send the notification if not already done and to decide of further steps, as per applicable regulation, in case of impossibility to send the notification.*

REQ014: Before entering into a geographical zone subject to Authorization (by a given authority as defined in the geographical zone data), such information shall be provided to the remote pilot.

NOTE: *It is left to the remote pilot to know if the authorization is already obtained, to request and get the authorization if not already done, and to decide of further steps, as per applicable regulation, in case of impossibility to get the authorization.*

REQ015: The HMI for all warning, caution, advisory alerts, indications, messages, and subsequent actions shall be defined and assessed to ensure prompt detection and unambiguous interpretation.

3.1.2 Time/Threshold for Geoawareness Warning Alert

REQ016: The time or threshold to alert shall be defined by the manufacturer, taking into account the subsequent reaction time and trajectory correction manoeuvre span, in order to avoid the UAS penetrating the forbidden zone.

REQ017: Margin on limits (meaning additional distance to the border) shall be defined and implemented by the manufacturer, taking into account the accuracy of the UAS position/altitude measurement which is compared to the geographical zone limit.

See Appendix 1 for guidelines.

3.1.3 LOADING

REQ018: The Geoawareness function shall load the data defining the UAS geographical zones provided by authoritative sources using methods and/or services which meet the applicable regulations, using the data model and interface described in chapters 8, 9, and Appendix 2.

REQ019: Data with degraded validity or integrity shall not be used.

NOTE: *The interface proposed in chapter 9 enables to ensure that the geozone data have not been degraded in integrity and validity at loading or updating (use of WS-Light and TLS).*

3.1.4 UPDATE

REQ020: The Geoawareness function shall provide the remote pilot with a clear indication of the time since the last successful update of the UAS geographical zones data.

NOTE: *It is the responsibility of the remote pilot to ensure the update is made appropriately before and during flight, as defined by the applicable regulation.*

REQ021: If automatic real-time update capability is claimed and provided the availability of the communication, the Geoawareness function shall be capable of effectively using the most recent data communicated by the geozone data server with a minimum delay (typically some dozen seconds).

NOTE: *it is deemed sufficient to handle exceptional situations when a zone changes immediately of status (e.g. to evacuate an emergency area, for which anyway there will a delay probably longer for gathering and publishing the information).*

REQ022: If automatic real-time update capability is claimed, the Geoawareness function shall inform the remote pilot when the quality of communication or other reason no longer enables to get timely updates and notification of changes (e.g.: when two periods of publicationLinkVerificationFrequency period have elapsed without receiving the related message, see chapter 9).

REQ023: The Geoawareness function shall log the uploads, updates, subscriptions and change publications received, with their date/time and their scope (area or regions of interest and time window of interest).

REQ024: The minimum period for storage of logs shall be 3 months.

REQ025: It shall be reasonably impossible to erase or modify these minimum logs by the remote pilot or operator.

NOTE: *It is a design precaution to enable further investigations.
Three months for storage limits the volume of data to be stored while it is deemed sufficient for differed investigation.
The recording of transactions may be performed also by the server based on the protocol of transmission.*

3.1.5 OPERATING STATUS

REQ026: The Geoawareness function shall provide the remote pilot with information on the Geoawareness health status as well as a warning alert when the positioning or navigation of the UA or the loss of C2 data link or another participating element cannot ensure normal operation of the function. Only the elements participating in the Geoawareness function operation are to be included in this Geoawareness operating status.

NOTE: *In case of loss of C2 data link, the Geoawareness function is no longer available. But normally the flight is supposed to be automatically shortened to the minimum reasonable time, thanks to an automatic lost C2 link procedure. The trajectory of this lost C2 link procedure pre-loaded in the UA, should be designed compatible with the zone restrictions as known before the C2 link loss.*

3.1.6

ACTIVATION STATUS

REQ027: Real-time digital information on the activation status of the Geoawareness function should be made available for the use by other functions that might require it.

Recommended list for activation status data:

- UA Position currently close to reaching an Horizontal or Vertical Limit (min or max) or both,
- Geoawareness warning alert currently raised for Horizontal or Vertical Limit (min or max) or both,
- Limit currently trespassed in Horizontal or Vertical (min/max or both),
- Geoawareness function currently out of order (not operative).

NOTE: *This is a design provision to enable for example the Detect and Avoid function, when also installed, to manage compatibility of alerts and guidance cues, or this could enable to send Geofencing status information on a surveillance link to UTM, but this coexistence of functions may necessitate further investigations and standardization.*

3.1.7

HEIGHT/ALTITUDE LIMITS

REQ028: The Geozone data format enables to set per zone lower /upper altitude limits (Above mean sea level) or height limits (Above ground level). The reference and unit of measurement are sent along with the data.

The UAS Geoawareness function shall adapt to the reference and unit of measurement received.

NOTE: *When altitude limits are used, if the terrain altitude is varying and if the editor of the database wants to follow it to express in fact a height limitation, several smaller zones could be described with their own altitude limits. The operational height limits (relative to terrain below or to Take –Off point) can also be recalled using the 'Message' field of data per zone. Above mean sea level or Above ground level references are not intended to impose a given type of sensor.*

The different possibilities (when geozones are defined in altitude) are illustrated in the figure below:

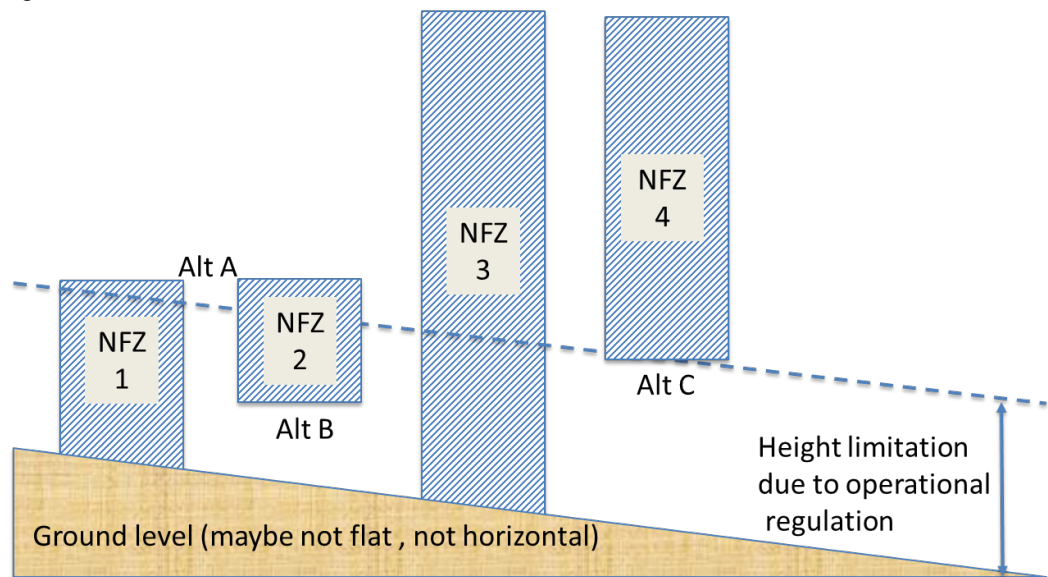


FIGURE 1: DIFFERENT TYPES OF ALTITUDE LIMITATIONS

The NFZ1 is a zone with a restriction starting from the ground and up to a given altitude A (flights above altitude A will not generate alerts, flying above A might be anyway forbidden by the operational regulation on Height).

The NFZ2 is a zone with a restriction starting from an Altitude B and up to an altitude A (flights below Altitude B or above altitude A will not generate alerts, flying above A might be anyway forbidden by the operational regulation on Height).

The NFZ3 is a zone with a restriction starting from the ground and up to any altitude (all flights in this horizontal zone are restricted whatever the altitude and will generate alerts).

The NFZ4 is a zone with a restriction starting from a given altitude C and up to any altitude (flights below altitude C will not generate alerts).

NOTE: In this example above, Alt A, B, C, D are not necessarily aligned with height limitations imposed by operational regulation.

3.2

AUTOMATIC GEOFENCING

3.2.1

Optional Addition to Geoawareness

The Automatic Geofencing is an option in addition to the Geoawareness function.

All the Geoawareness requirements shall be met.

This section sets the additional requirements to meet for an automatic limitation.

The Automatic Geofencing works with the same data defining airspace restrictions as Geoawareness and with the same loading and update rules.

3.2.2

Automatic Geofencing Limitation

REQ029: The Automatic Geofencing shall command a trajectory correction or limitation manoeuvre in order to avoid any breach of airspace restriction, in horizontal plane.

REQ030: If more than one restriction or condition is set at the same position, the Automatic Geofencing function shall give priority to the most restrictive one.

REQ031: The Automatic Geofencing shall interact smoothly with the flight control system and shall not adversely affect the flight safety.

REQ032: In order to favour safety and enable compatibility management by DAA when necessary, the automatic correction manoeuvre for horizontal limitation should be exclusively of the following type:

- put the UA in stationary hover mode if capable, or if not command a circular holding pattern mode, left or right, of the smallest reasonable radius, within the authorized area; while staying at the altitude reached.

REQ033: This automatic trajectory correction or limitation manoeuvre shall supersede any orders from the remote pilot that would breach the restrictions.

REQ034: The exit of the automatic correction manoeuvre should be made possible only by new remote pilot commands compatible with the restrictions.

REQ035: If, as an alternative, an automatic end of manoeuvre and resumption of flight are implemented, this shall be shown safe with the various constraints and conditions of the operation.

REQ036: If the UA is on ground and in a zone forbidden down to the ground, the take-off shall be prevented.

REQ037: Any location or time for which the restriction data have not been loaded shall be considered by the Automatic Geofencing function as forbidden.

REQ038: A dedicated warning alert shall be provided to the remote pilot at and during activation of the automatic limitation in order to make him/her aware of the UA behaviour.

REQ039: In case of too complex conditions for determination by the automatic function if the zone is forbidden or not, the most restrictive conclusion shall apply by default: consider the zone as forbidden and engage the correction manoeuvre to avoid entry.

NOTE: *This avoids to disengage the Automatic Geofencing and ask the remote pilot a rapid reaction while automatic flight was in progress for example.*

REQ040: In case of presence in flight in a forbidden zone (for example because the UA contingency manoeuvre has not been successful or because of a sudden new restriction for an emergency situation in the zone), the strategy of exit to apply automatically is deemed difficult to specify and validate in advance. In such corner cases, the automatic manoeuvre should be engaged but the remote pilot should be informed and enabled to manage these exceptional situations (not blocked by the above mentioned priority of the limitation). If an automatic strategy of exit is implemented instead of leaving the control to the pilot, this strategy shall be shown safe with the various constraints and conditions of the operation.

REQ041: As the geographical zone data (typically restrictions) are time-related, the automatic limitation should ensure that the near-future restrictions already defined in the Geographical zone database loaded will not be violated (for example, consider the time anticipation corresponding to the distance to the zone limit divided by speed).

REQ042: Before entering into a geographical zone subject to Notification (to a given authority as defined in the geographical zone data), such information shall be provided to the pilot (It is then left to the remote pilot to send the notification if not already done) or the notification may be automatically sent. In case of impossibility to send the notification, the entry shall be considered prohibited, excepted if the remote pilot clears this absence of notification by a dedicated command.

REQ043: Before entering into a geographical zone subject to Authorization (by a given authority as defined in the geographical zone data), such information shall be provided to the pilot. It is left to the remote pilot to know if the authorization is already obtained and then clear the UA to go on by a dedicated command. Until the authorization is confirmed granted (cleared) by the remote pilot, the entry shall be considered forbidden. Alternate implementations with automatic authorizations and grant receptions may be possible without remote pilot intervention but not analysed through the present standard.

REQ044: The HMI for all warning, caution, advisory alerts, indications, messages, and subsequent actions linked with Automatic Geofencing shall be defined and assessed to ensure prompt detection and unambiguous interpretation.

3.2.3

Time/Threshold for Automatic Limitation

First, as defined previously, the Geoawareness warning alert will be provided for the remote pilot to take action to avoid trespassing the limit of the UAS geographical zone.

Then, if no effective action has been taken by the remote pilot before a given time limit or distance threshold, the Automatic Geofencing will engage and perform the necessary trajectory correction manoeuvre.

REQ045: The time or threshold to trigger the automatic limitation shall be defined by the manufacturer, taking into account the subsequent reaction time and correction manoeuvre span, in order to avoid the UAS penetrating the forbidden zone.

REQ046: Margin on limits (meaning additional distance to the border) shall be defined by the manufacturer, taking into account the accuracy of the UAS position/altitude measurement which is compared to the restriction zone limit.

See Appendix 1 for guidelines.

3.2.4

Operating Status

REQ047: The Automatic Geofencing function shall provide the remote pilot with indication on its health status.

NOTE: *In case of loss of C2 Link, the Automatic Geofencing function may stay operational or not in lost C2 link state. Even if the Automatic Geofencing function stays operational, the geozone data updates are no longer possible when lost C2 link. Normally, the flight is supposed to be automatically shortened to the minimum reasonable time, thanks to an automatic lost C2 link procedure. The trajectory of this lost C2 link procedure, pre-loaded in the UA, should be designed compatible with the zone restrictions as known before the C2 link loss.*

3.2.5

Activation Status

REQ048: Real-time digital information on the activation status and type of manoeuvre engaged by the Automatic Geofencing function should be made available for the use by other functions that might require it.

Recommended list for activation status data:

- UA position currently close to reaching an Horizontal or Vertical Limit (min or max) or both (identical to Geoawareness function),
- Geoawareness Warning Alert currently raised for Horizontal or Vertical Limit (min or max) or both (identical to Geoawareness) function,
- Automatic Correction/Limitation manoeuvre type X currently engaged
- Limit currently trespassed in Horizontal or Vertical min/max or both (identical to Geoawareness),
- Automatic Geofencing currently out of order (not operative).

NOTE: *This is a design provision to enable for example the Detect and Avoid function, when also installed, to manage compatibility of alerts and manoeuvres, or this could enable to send Geofencing status information on a surveillance link to UTM, but this coexistence of functions may necessitate further investigations and standardization.*

3.2.6

HEIGHT/ALTITUDE LIMITS

REQ049: Since probably the Geozone database does not deal with obstacle definition, the Automatic Geofencing function should not limit automatically the flight in the vertical axis (only the Geoawareness warning alert in vertical).

NOTE: *The Automatic Geofencing function must not prevent the remote pilot to overfly obstacles when the applicable regulation authorizes this. The remote pilot stays responsible for applying the local regulations with respect to height/altitude considering the possibility of extra allowance for obstacle clearance. The capability to land immediately if needed is also a reason to not limit firmly with respect to min altitude.*

CHAPTER IV

MINIMUM PERFORMANCE SPECIFICATION UNDER ENVIRONMENTAL TEST CONDITIONS

The Geofencing function shall operate normally in all the environmental conditions in which the UAS the function is installed on is supposed to operate.

CHAPTER V

TEST PROCEDURES

Note that this section is only a skeleton as it is assumed that the detailed verification procedures will be specified in PrEN4709.

5.1 UAS INSPECTION

Check completeness and correctness of User's manual as per section 2.3 (functional capabilities, behaviour, options and limitations) and Appendix 1 (Computation of margins/thresholds).

Check of the safety of the controls as per section 2.4, 2.5.

5.2 UAS ANALYSES & DEMONSTRATIONS

Provide a justification dossier for Time/Threshold settings; as per section 3.1.2, 3.2.3 if implemented, and Appendix 1 (position sensing error, reaction time, limitation or corrective manoeuvre span, wind effect).

Provide –if implemented- analysis and demonstration of the safety of the automatic resumption after an automatic limitation; as per section 3.2.2.

Provide –if implemented- analysis and demonstration of the safety of an automatic exit of a suddenly forbidden zone (having entered it before it was forbidden); as per section 3.2.2.

5.3 UAS TESTS

Note that the tests below might be performed on bench, or when installed on UAS, as convenient.

Test of non-implemented sub-functions/options can be skipped if compliant with the product documentation (user's manual).

Check the provision of Operating Status information as per section 3.1.5: test in each value of status output, before and during flight, check HMI (noticeable and non-ambiguous health status warning alert and indication).

Check horizontal and vertical Geoawareness warning alert in different conditions:

- UA well out of the restriction, going in, already inside, going out:
 - with different horizontal shapes of geographical zones, including concave with the sharpest angles as per ch.8;
 - with different sizes of geographical zones from the minimum one; as per ch.8; including polygons and circles, with/without holes, with zones of different shapes superimposed in height,
 - with different angles and closure speeds relative to the limits; as per ch.8
 - with the different time applicability conditions; as per ch.8;
 - for each of the different types of upper and lower limits (ground, unlimited, given value), references and units of measurement; as per 3.1.7 and per ch.8
 - with different height /altitude limits between adjacent zones;
 - with all combinations of restrictions and different conditional restrictions, as per ch. 8;
 - with multiple overlapping restrictions; as per section 3.1.1: test with partially and totally superimposed geographical zones in space and time.

Check that the Geoawareness warning alert effectively enables the remote pilot to avoid entering the zone, check the timely caution and advisory alert when near-future restriction, check Notification request, Authorization request.

Check the visibility of messages per zone, with single and multiple messages associated with the zones.

Check the related HMI of geographical situation depiction (understandable for appropriate anticipation and reaction), of Geoawareness warning alert, of caution and advisory alert for future restriction, notification/authorization requests: noticeable and non-ambiguous.

Check loading capability as per section 3.1.3.

Check behaviour with location and time out of loaded data.

Check appropriate time indication (noticeable, non-ambiguous) for the last update as per section 3.1.4.

Check real time automatic update capability as per section 3.1.4.

Check effective and accurate log of uploads/updates and absence of direct modification/erasure capability.

Check the provision of Activation status as per section 3.1.6, for each value of output ((by inspection or analysis at least).

Check the Automatic Geofencing option as per 3.2.2: same tests conditions as for Geoawareness alerting to be repeated, in horizontal and vertical.

- Check that the UA is performing smoothly (with regard to flight safety) the intended manoeuvre, that the UA does not penetrate the forbidden zone or does not take off if already in,
- Check that the exit of the manoeuvre is possible as intended,
- Check that the behavior is as intended when the zone the UA is in becomes suddenly forbidden,
- Check automatic behavior in case of: near-future restriction, Notification request, Authorization request,
- Check the related HMI: noticeable and non-ambiguous indication of manoeuvre engaged,
- Show (by inspection or analysis at least) the behavior in case of too complex/not manageable conditions.

Interface testing as per ch 8 & 9:

- Ensure the compliance of the implementation of all standardized communication protocols as prescribed by the related standards
- Test all the operations: initial load and update, subscription, publication of updates
- Test the pause from both sides, the heartbeat (periodic message from the provider) well received, the behavior in case of loss of heartbeat, the behavior in case of total loss of communication
- Test that integrity defaults in the transmitted set of data are detected (erroneous content, not valid date, not valid origin)
- Test and check the correct interpretation for each transmitted parameter in the data model: the possible range of numerical values (for example min, max, typical), the possible range in number of characters for text (for example min, max, typical), each possible value if enumerate,
- Test and check the correct interpretation for presence / absence of each optional parameter/fields and several random combinations of presence /absence of these fields.

NOTE: *At the time of edition of this standard, there is no known reference implementation of the data model or interface that could be used for testing.*

CHAPTER VI

INSTALLED EQUIPMENT PERFORMANCE

Not applicable. Already considered in other chapters.

CHAPTER VII

AIRCRAFT OPERATIONAL PERFORMANCE CHARACTERISTICS

Not applicable. Already considered in other chapters.

CHAPTER VIII

UAS GEOGRAPHICAL ZONE DATA MODEL

8.1 UAS ZONE DIAGRAM

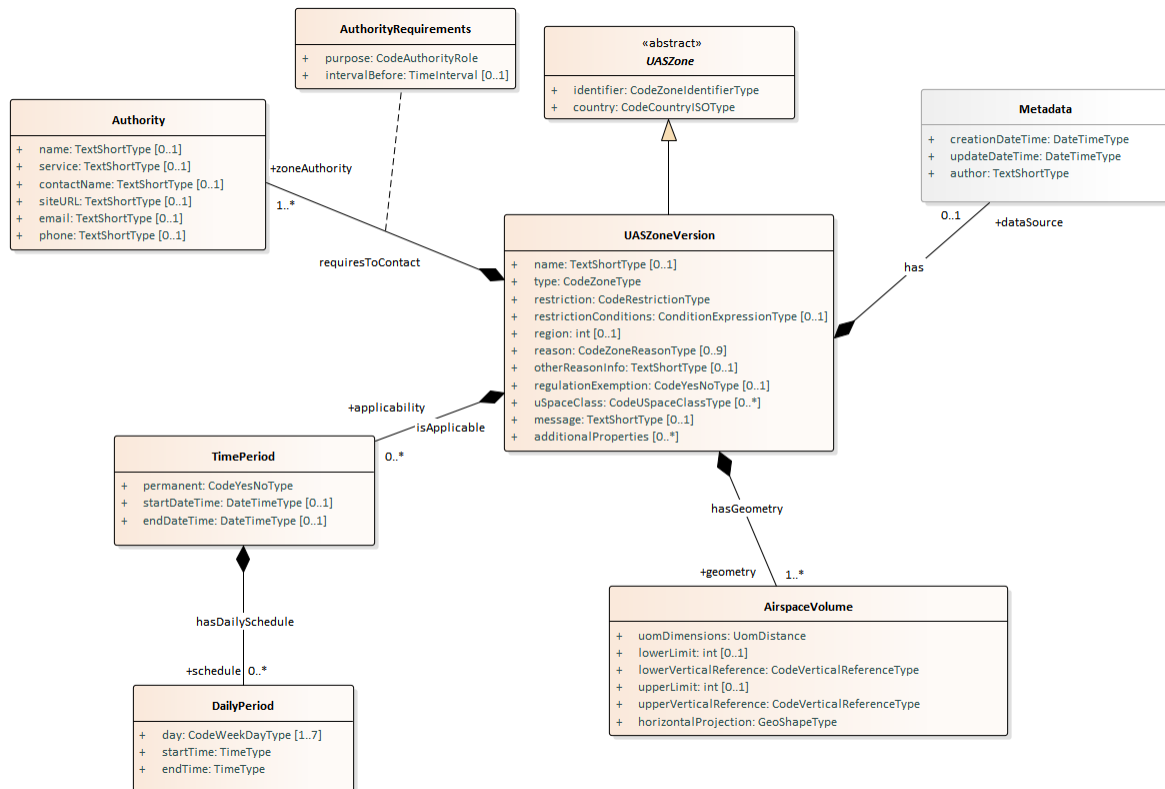


FIGURE 2: UAS ZONE - CLASSES

NOTE: Attributes that have a specified minimum multiplicity of '0' (such as [0..1], [0..9], etc.) are optional. All other attributes are mandatory.

8.1.1 UASZone

Abstract «abstract» in package 'Classes'

An airspace of defined dimensions, above the land areas or territorial waters of a State, within which a particular restriction or condition for UAS flights applies.

INCOMING STRUCTURAL RELATIONSHIPS

⇒ Generalization from UASZoneVersion to «abstract» UASZone

[Direction is 'Source -> Destination'.]

ATTRIBUTES

◆ identifier : CodeZoneIdentifierType Public

A string of characters that uniquely identifies the UAS Zone within the State/Territory identified by the country attribute.

Note - The UAS Zone is uniquely identified worldwide by the combination of the country and the identifier attributes

ATTRIBUTES

country : CodeCountryISOType Public

The State that has the authority to declare the zone.

Note - There will be no Zone belonging to two States. Not necessary to code the information that two zones are "in neighboring States" or "related".

8.1.2

UASZoneVersion

Class in package 'Classes'

Extends UASZone

OUTGOING STRUCTURAL RELATIONSHIPS

Generalization from UASZoneVersion to «abstract» UASZone
[Direction is 'Source -> Destination'.]

INCOMING STRUCTURAL RELATIONSHIPS

Aggregation from TimePeriod to UASZoneVersion
[Name is isApplicable. Direction is 'Source -> Destination'.]

Aggregation from AirspaceVolume to UASZoneVersion
[Name is hasGeometry. Direction is 'Source -> Destination'.]

Aggregation from Metadata to UASZoneVersion
[Name is has. Direction is 'Source -> Destination'.]

ATTRIBUTES

name : TextShortType Public
Multiplicity: ([0..1])

A free text name by which the zone may be known by the public or by the UAS community.

type : CodeZoneType Public

An indication whether the Zone is provided with its common definition or with a customised definition, for a particular user.

restriction : CodeRestrictionType Public

An indication if flying in the zone is conditional, forbidden or unrestricted.

ATTRIBUTES

◆ restrictionConditions : ConditionExpressionType Public
Multiplicity: ([0..1])

An indication of the conditions under which the zone can be used

◆ region : int Public
Multiplicity: ([0..1])

Where applicable, identifies a region inside a State where the UAS Zone is located.

Note 1) identified with a digit between 0-65535 (16 bit), corresponding to a list of regions pre-defined for each State.

Note 2) this attribute is intended to facilitate extracting sub-sets of data, for specific regions

◆ reason : CodeZoneReasonType Public
Alias: origin
Multiplicity: ([0..9])

A coded indication for the reason that led to the establishment of the zone.

◆ otherReasonInfo : TextShortType Public
Alias: origin
Multiplicity: ([0..1])

A free text description of the reason that led to the establishment of the zone, when not covered by a pre-defined coded value.

◆ regulationExemption : CodeYesNoType Public
Multiplicity: ([0..1])

This is an extension point. It allows adding additional attributes of national interest through this element.

◆ uSpaceClass : CodeUSpaceClassType Public
Multiplicity: ([0..*])

A code that identifies the category or class of the zone applying a "USpace concept".

Note: Two (draft) classifications exist, one from Eurocontrol and one from CORUS. Therefore, two instances of this attribute are expected, one from each sub-list. This might be later replaced with separate attributes and separate lists of values.

◆ message : TextShortType Public
Multiplicity: ([0..1])