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| Technical Report |
| 3rd Generation Partnership Project;Technical Specification Group Services and System Aspects;Study on architecture enhancements of UAS, UAV and UAM;Phase 3(Release 19) |
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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document is to investigate and identify potential architecture and system level enhancements to support additional scenarios and requirements for UAV (Uncrewed Aerial Vehicle) and UAM (Urban Air Mobility) including:

- Enhancement of NEF services to support service exposure and interactions between MNOs and UTM functions for i.e. pre-mission flight planning, in-mission flight monitoring, C2 communication reliability, interfacing with UTM (e.g. supporting the scenario of multiple USS serving the geographical areas corresponding to UAV flight path).

- Support of network-assisted/ground-based mechanism for DAA (Detect And Avoid).

- Support of no-transmit zones for UAVs.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 23.256: "Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2".

[3] [ECC Decision (22)07 (cept.org)](https://docdb.cept.org/download/4240) <https://docdb.cept.org/download/4240>: "Harmonised technical conditions for the usage of aerial UE for communications based on LTE and 5G NR in the bands 703-733 MHz, 832-862 MHz, 880-915 MHz, 1710- 1785 MHz, 1920-1980 MHz, 2500-2570 MHz and 2570- 2620 MHz harmonised for MFCN".

[4] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[5] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[6] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[7] 3GPP TS 23.273: "5G System (5GS) Location Services (LCS); Stage 2".

[8] 3GPP TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**No-transmit zones**: Geographical area where aerial UE are not allowed to operate in a certain frequency band. The purpose and requirements of NTZ is described in ECC Decision (22)07 [3].

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

DAA Detect and Avoid

LDS Localized DAA Server

NTZ No-Transmit Zone

NWDAA Network-Based/Assisted DAA

RTA Restricted Transmission Area

# 4 Architectural Assumptions and Requirements

## 4.1 Architectural Assumptions

The following architectural assumptions apply:

- For solutions to enable network-assisted/ground-based mechanism for DAA (Detect And Avoid),

- co-existence with and leveraging, to the extent possible, Direct DAA solutions specified in TS 23.256 [2] shall be considered.

- sensing related information is out of scope of this study.

- Regarding C2 communication reliability aspects in KI#1, only C2 over the Uu interface is considered in this study, and UAV using multiple-PLMN connectivity to support C2 communication reliability will not be considered in this release.

The following assumptions apply to the support of NTZ:

- NTZ may be defined according to regional/national requirements;

- an NTZ may map to one or more cells or a fraction of a cell, or overlap different cells in a mobile operator network.

NOTE: NTZ scope and mapping to cell(s) need to be coordinated with RAN WGs.

## 4.2 Architectural Requirements

Editor's note: This clause provides list of architectural requirements, if needed.

- The existing procedures specified in TS 23.256 [2] should be reused as much as possible for solutions.

- Service exposure mechanisms defined in TS 23.256 [2] should be reused as much as possible.

# 5 Key Issues

## 5.1 Key Issue #1: Enhancement of NEF services to support service exposure and interactions between MNOs and UTM functions

### 5.1.1 Description

In this key issue, the following aspects are required to be studied:

- whether and how to enhance NEF services to support service exposure and interactions between MNOs and UTM functions for supporting i.e.

- Pre-mission flight planning and in-mission flight monitoring for UAVs.

- C2 communication reliability.

- The scenario of multiple USS serving different geographical areas corresponding to the UAV flight path.

NOTE: In the scope of this key issue, UTM can represent any authorized aviation AF that may require interaction with the MNO for the functions listed above.

## 5.2 Key Issue #2: Network-assisted/ground-based mechanism for DAA (Detect And Avoid) with 5GS information

### 5.2.1 Description

Network-assisted/ground-based mechanism for DAA (NWDAA) for tactical deconfliction, collision avoidance, and UTM control of UAV flight path, can be considered a complement for existing DAA based on the PC5 reference point specified in Rel-18.

In this key issue, the following aspects are required to be studied:

- Study whether and how to enable network-assisted/ground-based mechanism for DAA (Detect And Avoid):

- Any architectural impacts for the support of NWDAA.

- Whether and what information is needed for NWDAA:

- Study which existing information collected and generated in the 5GS can be utilised to enable NWDAA.

- Study whether any and what type of new information may be collected and/or generated in the 5GS to support NWDAA.

- Whether and how to provide UTM and UAVs with the information collected or generated by the 5G system for the purpose of NWDAA.

## 5.3 Key Issue #3: Support of No Transmit Zones

### 5.3.1 Description

This key issue relates to the introduction by CEPT ECC Decision 22(07) [3] of No Transmit Zones for aerial UEs. The ECC Decision asserts that a mechanism is necessary to ensure that aerial UEs respect no-transmit zones in order to protect incumbent radio systems from potential interference from aerial UEs.

Since the ECC Decision does not identify any specific RAT, NTZs can be supported by both LTE and NR.

This key issue addresses the following aspects:

- How to ensure an aerial UE respects no-transmit zones, including:

- whether a mobile network cells overlapping completely or partially with the NTZ and using the restricted frequency bands of the NTZ;

- whether mechanisms are needed to differentiate aerial UEs that support functions defined for NTZs in Rel. 19 and aerial UEs that don't;

- what if any, specific aerial UE behaviour when the aerial UE approaches, enters, or exits the NTZ.

- Whether and how to enable configuration of NTZ information in the aerial UE.

- Whether to allow the enforcement of no-transmit zone(s) for both aerial UEs in connected mode and aerial UEs in idle mode and if yes then how.

Editor's note: Interaction with potential other regulatory services is TBD.

NOTE: Any potential solutions developed shall be coordinated with RAN WGs or progressed together with RAN WGs input.

# 6 Solutions

## 6.0 Mapping of Solutions to Key Issues

Table 6.0-1: Mapping of Solutions to Key Issues

|  |  |  |  |
| --- | --- | --- | --- |
| Solutions |  |  |  |
|  | <Key Issue #1> | <Key Issue #2> | <Key Issue #3> |
| #1 | x |  |  |
| #2 | x |  |  |
| #3 | x |  |  |
| #4 |  | x |  |
| #5 |  | x |  |
| #6 |  | x |  |
| #7 |  |  | x |
| #8 |  |  | x |
| #9 |  |  | x |
|  |  |  |  |

## 6.1 Solution #1: Support Pre-Mission Planning and In-Mission Monitoring Flight

### 6.1.1 Key Issue mapping

This solution addresses KI#1 aspects.

### 6.1.2 Description

Enhance NEF services to support service exposure and interactions between MNOs and UTM functions for supporting pre-mission flight planning and in-mission flight monitoring for UAVs, is one of the study aspects in KI#1. This solution proposes to enhance NEF services, enable USS/UTM to request NEF assistance for pre-mission flight planning and in-mission flight monitoring.

### 6.1.3 Procedures and Parameters

#### 6.1.3.1 Procedure for NEF Assist Pre-mission Flight Planning



Figure 6.1.3.1-1: Procedure for NEF Assist Pre-mission Flight Planning

1. The UAV (or UAV-C) establishes a PDU Session for communication with the USS/UTM as described in clause 5.2.3 of TS 23.256 [2].

2. The UAV (or via its paired UAV-C) requests Pre-mission flight planning service from USS/UTM. The request message includes identifier of the UAV (e.g. GPSI, CAA-Level UAV ID), information of the starting and ending points for the flight, requirements on the flight route (e.g. on time), and may include candidate flight route(s) if available.

3. The USS/UTM derives information for the Pre-mission flight planning request and decides to request assistance information from NEF.

NOTE 1: The content of Pre-mission flight planning service information derived at USS is out of scope.

NOTE 2: The solution uses request/response since considers such approach is more suitable for this scenario. Pre-mission flight planning, after receiving the planned route from USS, the UAV is expected to plan by following the route. There is no need to keeps receiving the notifications. When it is required to keep receiving notification during flight, the solution belongs to in-mission monitoring.

4. The USS/UTM sends Pre-mission flight planning assist request to NEF. The request message includes identifier of the UAV (e.g. GPSI), information of the starting and ending points for the flight, requirements on the flight route (e.g. on time), candidate flight route(s) (received from the UAV or local derived at the USS/UTM), and accuracy level of predictions relevant to the flight planning.

5. The NEF maps parameters included in the request from the USS/UTM to information used by the 3GPP system (e.g. map the geographical area into an area of interest that is represented by a list of Cell IDs, gNB IDs or TAIs). The NEF determines services needed for the request and relevant NFs, e.g. NEF service on UAV tracking and mode (UAV location reporting mode, UAV presence monitoring mode, List of Aerial UEs in a geographic area), NWDAF analytics service (Movement Behaviour analytics), GMLC service (e.g. Ranging/Sidelink Positioning location).

6. If the NEF cannot satisfy the requirements on flight planning (e.g. cannot get predictions relevant to the flight planning from NWDAF with the required accuracy level), the NEF responses to the USS/UTM to reject the Pre-mission flight planning assist request, and may include the detail reason.

7. If being rejected in step 6, the USS/UTM may response to the UAV (or its paired UAV-C) to reject the Pre-mission flight planning request, may include the detail reason if available.

8. The NEF performs steps 2-5 in clause 5.3.4 of TS 23.256 [2], and filter list of UAVs in the areas of interest.

9. The NEF subscribes/requests for notification on Movement Behaviour analytics provided by NWDAF as defined in clause 6.21.4 of TS 23.288 [6]. The subscribe/request message include identifier of the UAV (e.g. GPSI) obtained in step 4. The other parameters included in the request are described in clause 6.1.3.3. The list of UAVs in the areas of interest output from step 8 can be used as inputs for the NEF to request the NWDAF on Movement Behaviour analytics.

10. The NEF may request GMLC service(s), e.g. Ranging/Sidelink positioning location as defined in clause 6.20.3 of TS 23.273 [7]. The list of UAVs in the areas of interest output from step 8 can be used as inputs for the NEF to request the GLMC service on Ranging/Sidelink Positioning location.

11. The NEF generates assistance information for pre-mission flight planning based on the information and analytics from steps 8-10. The assistance information may be the best matched route among the ones provided from the USS/UTM in step 4, or potential flight route(s) if candidate flight route(s) is not provided in step 4.

12. The NEF responses to the USS/UTM with the assistance information.

13. The USS/UTM decides flight planning by using the assistance information and flight planning mechanism which is out of scope.

14. The USS/UTM sends response to the UAV (or its paired UAV-C) with the planned flight route.

NOTE 3: USS/UTM are used to represent the consumer of the enhanced NEF services in Figure 6.1.3.1-1, the consumer can also be other entities, e.g. TPAE.

#### 6.1.3.2 Procedure for NEF Assist In-mission Flight Monitoring



Figure 6.1.3.2-1: Procedure for NEF Assist In-mission Flight Monitoring

NOTE 1: The NFs in Figure 6.1.3.2-1 represents all the other NFs beside GMLC and NEF/UAS NF involved in the procedure.

1. The USS/UTM sends In-mission flight monitoring assist request to NEF. The request message includes identifier of the UAV (e.g. GPSI) and information of the flight route, monitoring mode (e.g. UAV location monitoring, fight route monitoring, flight environment monitoring, Ranging/Sidelink positioning location monitoring), report requirements (e.g. report format (event triggered or periodically), assistance information (e.g. the monitoring results, information generated from the monitoring results)), and may include planned fight route if fight route monitoring, list of UAVs in the areas of interest if flight environment monitoring, preset value for distance if Ranging/Sidelink positioning location monitoring.

2. NEF maps the parameters in the request from the USS/UTM to information used by the 3GPP system. The NEF determines services needed for the request and relevant NFs, e.g. NEF service on UAV tracking (UAV location reporting mode, UAV presence monitoring mode, List of Aerial UEs in a geographic area), GMLC service (Ranging/Sidelink Positioning location).

3. If the NEF cannot provide the requested assistance information for In-mission flight monitoring, the NEF responses to the USS/UTM to reject the In-mission flight monitoring assistance request, may include the detail reason if available.

4. For UAV location monitoring, the NEF executes steps 2-5 in clause 5.3.2 of TS 23.256 [2] to obtain the location of the target UAV.

5. For fight route monitoring, the NEF executes steps 2-4 in clause 5.3.3 of TS 23.256 [2]. Upon to the request in step 1 for reporting, the NEF may compare the monitored flight route with the planned fight route (if provided in step 1) and generate assistance information on whether the UAV is flight in right route.

6. For flight environment monitoring, the NEF executes steps 2-5 in clause 5.3.4 of TS 23.256 [2] to obtain the information of aerial UEs in the same geographic area of the target UAV.

7. For Ranging/Sidelink positioning location monitoring, the NEF requests GLMC service for Ranging/Sidelink Positioning location results as described in clause 6.20.4 of TS 23.273 [7], the procedure of SL-MT-LR for periodic, triggered Location Events (steps 1-20 for initiation the monitoring, steps 21-31 for monitoring periodic). The list of UAVs in the areas of interest output from step 6 can be used as inputs to step 7 for NEF to request GLMC service for Ranging/Sidelink Positioning location, if the UAVs is unknown in the areas of interest.

8. The NEF notifies the USS/UTM the monitoring results (e.g. the location of the target UAV, indication on whether the UAV is flight in right route, the target UAV presence in areas of interest, the information of aerial UEs in the same geographic area of the target UAV, the distance of other UAVs and the target UAV and whether the distance is smaller than a preset value).

Steps 4-8 may be repeated for report monitoring results periodically.

NOTE 2: USS/UTM are used to represent the consumer of the enhanced NEF services in Figure 6.1.3.2-1, the consumer can also be other entities, e.g. TPAE.

#### 6.1.3.3 Parameters in Request for Movement Behaviour Analytics

The USS acting as an Application Function communicates with the NEF which corresponds to the NF consumer in clause 6.21.4 of TS 23.288 [6].

Editor's Note: The final list of parameters is FFS.

The USS can either subscribe to notifications from the NEF (i.e., a Subscribe-Notify model) or request a single notification from the NEF (i.e. a Request-Response model). The USS request contains the following parameters:

- Analytics ID = "movement behaviour";

- Target of Analytics Reporting: any UE;

- Analytics Filter Information:

- Area of Interest (AOI): restricts the scope of the movement behaviour analytics to the provided area. The AOI may be described as shown in clause 5.5 of TS 23.273 [7];

- Optionally, the list of analytics subsets that are requested among those specified in clause 6.21.3 of TS 23.288 [6];

* An Analytics target period indicates the time period over which the statistics or predictions are requested;
* Optionally, preferred level of accuracy of the analytics;
* Optionally, preferred level of accuracy per analytics subset (see clause 6.21.3 of TS 23.288 [6]);
* Optionally, preferred granularity of location information: "longitude and latitude level";
* Optionally, preferred orientation of location information: ("horizontal", "vertical", "both"); and
* Optionally, maximum number of objects.

### 6.1.4 Impacts on services, entities and interfaces

UAS NF/NEF:

- Enhance for supporting pre-mission flight planning assistance service.

- Enhance for supporting in-mission flight monitoring assistance service.

NWDAF:

- Enhance the inputs and the outputs of Movement Behaviour Analytics.

USS/AF:

- Enhance for supporting UAV/UAV-C trigger pre-mission flight planning service.

- Enhance for supporting in-mission flight monitoring service.

Editor's Note: It is FFS other possible impacts related to services, entities and interfaces.

## 6.2 Solution #2: UAV flight path deviation exposure

### 6.2.1 Key Issue mapping

This solution aims to resolve

Key Issue #**1**, "Enhancement of NEF services to support service exposure and interactions between MNOs and UTM functions".

### 6.2.2 Description

The solution also makes use of UE flight path reporting feature (AAM). It is assumed, in this solution, the UE flight path reporting is also implemented/available in 5G NR. Alternatively, or complementary, this solution can use MDT reports that also bring an insight of the radio conditions and UE location. The solution further proposes enhancements where the reporting can be triggered by an NF/AF (e.g. NEF) via the AMF on the NG RAN and then the NG RAN configures the UE to report its flight path (see steps 2 and 4a in the call flow diagram).

### 6.2.3 Procedures

#### 6.2.3.1 Monitoring & reporting of UAV flight path deviation

The USS/UTM (acting as an external AF) can access 3GPP exposed services using public identifier of the UE (used in the UAV). Below pre-conditions apply:

- When UAV authentication/authorization procedure is used:

- UAV is authenticated during PDU session establishment (or optionally at 5GS registration) by USS/UTM.

- 3GPP system provides the public identifiers (e.g. 3GPP UAV ID, IP address) of the UE (used in the UAV) to the USS/UTM.

- USS/UTM uses the public identifier of the UE to access 3GPP exposed services.

- Or UAV authentication/authorization procedure is not used:

- UAS operator provides the serving MNO information and the public identifier (e.g. 3GPP UAV ID) of the UE (used in the UAV) to the USS/UTM.

- USS/UTM uses the public identifier of the UE to access 3GPP exposed services.

Editor's Note: It is FFS, how the UAS operator knows about GPSI/3GPP UAV ID without the authorization procedure?



Figure 6.2.3.1-1: Monitoring and reporting of UAV flight path deviation using NWDAF analytics.

1. The USS/UTM sends a request for flight path monitoring of a UE (used in a UAV) to NEF/UAS NF. The request contains at least the following information elements:

a. UE ID (i.e., 3GPP UAV ID) or group of UE Ids)

b. the authorized flight path in 3D way points along with estimated time,

c. the acceptable deviation from the authorized flight path expressed in 3D distance deviation and/or time deviation (absolute or relative units).

d. Conditions, e.g. that may alter or define differently the acceptable 3D deviation including the dimension of time.

2. NEF subscribes to new flight path monitoring analytics from NWDAF. The request contains, at least the following information elements:

a. (a new) Analytics ID=FlightPathDeviation,

b. the UE ID,

c. the authorized flight path in 3D way points along with estimated time,

d. the acceptable deviation or the means (e.g. function) to derive the acceptable deviation considering certain conditions (e.g. weather) from the authorized 3D flight path in the form of:

i Acceptable 3D deviation in distance (absolute or relative units).

ii. Acceptable deviation in time (absolute or relative units).

Editor's note: It is FFS how to set Analytics target period as this new Analytics ID is neither for statistics nor for predictions.

3. Implementation alternatives

a. Or NWDAF subscribes to periodic UE location reporting via GMLC or MDT reports.

b. NWDAF collects UE flight path report from NG RAN (via OAM) and the UE location reporting via GMLC.

4. NWDAF analyses/compares the UE location report received through GMLC or MDT reports and the UE flight path report collected from NG RAN with the authorized flight path information received in the request from USS/UTM (forwarded by NEF).

a. NWDAF first verifies if the UE reported flight path information matches with the corresponding location reports received from GMLC (requested in 4b). If the two reports do not match, then the NWDAF reports it to the USS/UTM (via NEF) in step 6.

b. If the UE reported flight path information matches with the GMLC reported location, the NWDAF then further compares the UE reported flight path with the authorized flight path information received in the request from USS/UTM. The NWDAF also takes into consideration "acceptable deviation" information received as input in the request from USS/UTM.

If a flight path deviation is found, the NWDAF reports it to USS/UTM via the NEF. The report also contains information on detected deviation points (e.g. 3D location) or detected deviation time or both, and confidence of the reported deviation.

NOTE 1: The NWDAF can collect location information from 5GC and/or RAN without using NEF and create analytics for acceptable deviation path.

NOTE 2: The NWDAF is intended to be used as a monitoring entity for path deviation without needing any historical data analysis. The NWDAF can use existing data collection from RAN/GMLC.

Editor's Note: No new MDT enhancement is assumed for this solution. It is FFS, whether existing MDT reports are applicable and/or accurate for UAV UEs.

### 6.2.4 Impacts on services, entities and interfaces

NWDAF

- Support for new analytics ID and analytics event.

NEF

- Potential impact to existing exposure API due to new analytics, if any.

## 6.3 Solution #3: UAV flight planning and monitoring

### 6.3.1 Key Issue mapping

This solution addresses Key Issues #1 which proposes to enhance the notification on QoS Sustainability Analytics mechanism to the AF (e.g. USS/UTM) for pre-mission flight planning and in-mission flight monitoring.

The enhancement of QoS Sustainability Analytics supported by NWDAF is to consider the height information, corresponding to the UAV flight path when deriving the likelihood of a QoS change for an Analytics target period in the future in a certain area.

### 6.3.2 Description

An AF (e.g. USS/UTM) may request notifications on QoS Sustainability Analytics from the NEF for an indicated geographic area or a path of interest and a target time interval in order to adjust the application behaviour in advance according to the potential QoS change. How the AF (e.g. UTM/USS) makes use of QoS Sustainability Analytics is outside of 3GPP scope.

AF can in principle reuse what is defined for V2X Application Server in clause 5.4.5.2 in TS 23.287 [8]. The main new aspect is to introduce the "height"information in the location information. The location or path information of UAVs differs from that of ground vehicles considering the UAV flight path information. As described in TS 38.300, the Aerial UE flight path information consists of a number of waypoints defined as 3D locations and may contain a time stamp per waypoint. Based on this information, the solution adds "height" information as an attribute to the location information.

The added "height" information is an important input for the NWDAF in order to generate a realistic QoS Sustainability analytics for UAV pre-mission flight planning and in-mission flight monitoring. While the antennas of the base station have a specific azimuth, the antennas are often directed to the ground, and the high-altitude coverage is thus rather limited (called "ground cells" in the following description). It can however be expected that there are also dedicated base stations deployed to provide a certain coverage for the high altitude (called "sky cells" in the following description).

Editor's note: The assumption that such dedicated "sky cells" exist need to be confirmed during this study.

If the UAV flight path is on a low altitude or close to the ground, the performance measurement information of the ground cells should be used for the generation of the analytics. If the UAV flight path is at higher altitudes, the coverage area of the ground cell is rather small (or there may be even no coverage anymore). Hence, the QoS Sustainability analytics for the UAV at a certain height should be only based on the performance measurement information of the sky cells. If the altitude is in a range where both types of cells (i.e. ground and sky cells) could provide connectivity, the NWDAF could combine the performance measurement information of both types of cells (e.g. applying certain altitude dependent weights).

Editor's note: It is FFS whether the NWDAF can be enabled to calculate the coverage area of "ground cells" for different heights.

The NWDAF should therefore take the UAV height information into consideration in order to generate the QoS Sustainability analytics based on the performance measurement information of the most appropriate cells from OAM. In consequence, the AF has more accurate information available for UAV pre-mission flight planning and in-mission flight monitoring.

Editor's note: It is FFS whether the NWDAF can be configured with information about the available "sky cells" and their coverage area.

### 6.3.3 Procedures

Editor's note: This clause describes high-level procedures and information flows for the solution.

### 6.3.4 Impacts on services, entities and interfaces

AF (USS/UTM):

- Provide location information (waypoints defined as 3D locations) to NEF when request QoS Sustainability Analytics.

NWDAF:

- Consider 3D location for deriving QoS Sustainability Analytics in order to identify the performance measurement information of the most appropriate ground and/or sky cell and to estimate the coverage area of the ground cell at the respective height (Input and Output data of the Analytics is not impacted).

## 6.4 Solution #4: Network-supported Tactical Deconfliction

### 6.4.1 Key Issue mapping

This solution applies to Key Issue #2.

### 6.4.2 Description

#### 6.4.2.1 Introduction

Sense and Avoid (SAA), Detect and Avoid (DAA), or tactical deconfliction systems are technologies that allow uncrewed aerial vehicles (UAVs) and drones to integrate safely into civilian airspace, avoiding collisions with other aircraft, buildings, power lines, birds and other obstacles. These systems observe the environment surrounding the drone, decide whether a collision is imminent, and generate a new flight path to avoid collision.

Traditional UAV sense and avoid systems may combine data from communication interfaces (e.g. A2X), a number of sensors, using sensor fusion algorithms, image recognition and artificial intelligence to provide the best outcome. Data is fed back to the drone on-board computer and/or drone flight controller, which can then decide on the best evasive maneuver or flight path correction to avoid collision. A reliable onboard DAA system is crucial for obtaining a waiver for flight operations in many jurisdictions that typically otherwise require human observers or ground-based observation systems along the entire flight path. DAA systems are thus key to unlocking commercially viable BVLOS (beyond visual line of sight) drone operations that provide services such as inspection and cargo delivery over extremely long distances.

Regulations regarding tactical deconflictions are being developed, and they traditionally refer to solution components that employ a ground component in order to:

- Not having to rely fully on RPS (remote Pilot Station)/UAVC (UAV controller)/GCS (Ground Control Station)/human pilot;

- Leverage the high level of automation that is already widely available in aerial vehicles, while at the same time not relying solely on aerial vehicle awareness of surrounding traffic;

- Leverage ground networks ability to have higher spatial awareness of traffic.

In the scope of this solution, we use the term Network-based DAA (NWDAA) to refer to tactical deconfliction solutions that utilize a network-based or ground-based component to collect, elaborate, and distribute tactical deconfliction information.

#### 6.4.2.2 Solution Overview

The solution proposed assumes the deployment of an AIML-based localized USS/UTM function tailored specifically to provide NWDAA services to UAVs and UTM. We identify this function as Localized DAA Server (LDS) for tactical deconfliction. We assume that LDS is a functionality separate from USS/UTM due to the different service it provides, and the fact that LDS may be provided by the MNO.

The solution is based on the following assumptions:

- The LDS provides a subscription-based service, available to all aerial UEs or a subset of the aerial UE (identified by the aerial subscription introduced in Rel. 15).

- LDS nodes elaborate spatial awareness based on information collected on UAVs and potentially other aerial vehicles.

- LDS collects spatial awareness information from a set of sources: UAVs, sensors (e.g. radar station, ADS-B receivers, A2X receivers, etc.). The location of such sensors and interfacing with the LDS is dependent on deployment.

- LDS may belong to the MNO domain or may be provided by a 3rd party.

Editor's Note: How trust of LDS is assured (including LDS authorization) and how a 3rd party LDS can access NWDAF and NEF services is FFS.

- A UAV may be visible to multiple LDSs. Only one LDS interacts and serves a UAV UE, but multiple LDSs may consider a specific UAV UE presence and information.

- LDS could interact with NDWAF and leverage information obtained by NDWAF.

NOTE 1: No new services for NWDAF are proposed in this solution, but if new services related to UAV become available, the LDS is assumed to be able to access those.

- Each LDS serves a specific area

- an LDS implements conflict detection and traffic separation algorithms and collision notification features across one or more mobile network cells.

- the LDS service area is configured in the LDS and may be configured in the PLMN. It is assumed that an LDS may communicate the serving area to UTM.

- The LDS obtains situational awareness information about UAVs (e.g. UAV identity, location, flight vectors) and potentially additional situational awareness about the airspace (e.g. obstacle identification, crewed aircraft that transmit ADS-B).

- The LDS may leverage NEF/UAS NF services for interaction with UTM/USSs

- LDS may obtain specific UAVs flight plans.

- LDS may report potential or actual conflicts to UTM, and receive instructions and configuration information from the UTM.

- LDS may provide via NEF exposure Aerial congestion information API and UAV information to USS to support USS in flight authorization.

- LDS is assumed to communicate with USS via UAS NF/NEF, and as such LDS is not required to know the serving USS, and the serving USS is not required to know the serving LDS function, i.e. no information about the serving USS is provided to the LDS, and the LDS is not required to discover the serving USS. The UAV communicates with LDS providing the current CAA-Level UAV ID, and the LDS uses the CAA-Level UAV ID to discover the serving UAS NF and provide the information together with the CAA-level UAV ID. The UAS NF can then forward such information to the USS(s) serving the UAV associated to the CAA-Level UAV ID received from the LDS.

- for any asynchronous request from USS to the LDS, it is assumed that the LDS serving a UAV ID registers itself with the serving UAS NF for the UAV ID using the CAA-Level UAV ID to indicate which UAV UE it is serving.

- The serving LDS for a UAV may change during the flight path of the UAV, and the UAV context is moved between UAVs using application layer mechanisms.

- Connectivity between the UAV and the LDS is over user plane, and it is assumed that a dedicated PDU session is established to enable such communication (e.g. to leverage edge connectivity).

Editor's Note: Re-use of existing PDU sessions (e.g. for UAV-UTM communications) is FFS.

NOTE 2: Edge relocation mechanisms may be used to relocate the serving LDS for a UAV.

#### 6.4.2.3 Solution Architecture

The solution assumes that the LDS is deployed by the MNO at the edge of the network, and communications over the UAV and the LDS are carried out over user plane.

The LDS can interface with NEF/UAS NF using existing or new/extended service exposure functionality.

### 6.4.3 Procedures

#### 6.4.3.1 Overall Information Flow

The following logical flow is assumed:



Figure 6.4.3.1-1: Overall Information Flow for NWDAA Solution.

NOTE: Steps 4 to 7 are exchanged at application layer and are outside the scope of 3GPP. They are described here to provide an overview of how the solution would work as a whole.

1. The UAV registers to the 5G System using existing procedures, with the enhancements described in this solution.

2. The UAV establishes connectivity with the LDS server. This may include authorization and authentication of the UAV to be enabled to access LDS services. This may also include the UAV receiving policy information on LDS availability, and on LDS communication (what information is to be exchanged, and at what frequency, etc.). The LDS server registers itself with the UAS NF of the UAV and provides the CAA-Level UAV ID of the UAV.

3. At any time the LDS may retrieve UAV-related information from USS via NEF, e.g. the UAV flight plan or any other information that supports LDS functionality.

Editor's Note: Whether an existing NEF service is used or a new one needs to be defined will be determined during normative phase.

4. The UAV sends information to the LDS according to the policies received in step 2. This includes information about the UAV (e.g. CAA-Level UAV ID, location, flight vector, etc.), and information received by the UAV via A2X and regarding other UAVs visible to the UAV. The LDS may also receive information from other sources, e.g. ADS-B receivers, radar stations, etc.

5. Upon detecting a potential conflict, the UAV may indicate the conflict to the LDS and request deconfliction assistance.

6. Based on information received at step 4 or based on conflict detection performed autonomously by the LDS, the LDS may send deconfliction information or warn the UAV of potential conflict. The UAV may exchange such information with the UAVC for deconfliction actions.

7. Based on information received at step 4 or based on an urgent and serious conflict detection performed autonomously by the LDS, the LDS may send emergency directives to one or more UAVs. It is expected that emergency directives are processed locally and autonomously by the UAV, and the UAV may inform the UAVC.

8. At any time the LDS may interact with the USS via NEF to provides aerial congestion/conflict information to support flight planning in USS.

9. At any time the USS may subscribe to LDS service notifications regarding a specific UAV.

It is assumed that a UAV UE that is capable of LDS indicates it supports NWDAA in NAS signaling capabilities as described in the following sections.

LDS service may not be available ubiquitously in the whole serving network; therefore, an indication of LDS Service Area needs to be provided to the UAV. The network may provide to the UAV UE that has indicated LDS support and is subscribed to LDS whether LDS is available or not and may provide an LDS Service Area (e.g. whole PLMN, current RA, list of TAs, etc.). This may be generated by the AMF based on OAM configuration and provided to the UE directly in MM signaling or passed to the SMF and returned to the UAV UE upon successful establishment of PDU session for UAS services.

#### 6.4.3.2 UAV-LDS Connectivity Establishment for LDS@Edge

UAV UE that is capable of LDS provides the LDS indication during a PDU Session Establishment for UAS services as described in TS 23.256 [2] and may be for a PDU session established for C2, for C2 and UTM services, or dedicated for LDS services depending on UAV UE configuration as to which DNN shall be used for LDS services. UUAA-SM may be extended to contain an indication that the UAV is requesting LDS service, to enable UTM to authorize the use of LDS service and to authorize the specific LDS server. The UUAA-SM may return to the SMF information about the LDS server(s).

Upon successful PDU session establishment for LDS services, the UAV is provided by the SMF with information on how to reach the LDS, and the UAV establishes connectivity with the LDS directly using application layer signaling outside the scope of this solution.

NOTE: It is expected that security mechanisms may be required to ensure the UAV is authorized to access the LDS. This may require the LDS to perform an additional UUAA procedure, or an additional security mechanism may be required.



Figure 6.4.3.2-1: UAV-LDS Connectivity Establishment for LDS@Edge.

1. The UAV UE registers to the network.

2. UAVE UE provide the LDS indication to the SMF in the PDU Session Establishment request. This may be during the establishment of a PDU session for UAS services as described in TS 23.256 [2], for a PDU session established for C2, for C2 and UTM services, or a dedicated PDU session for LDS services depending on UAV UE configuration as to which S-NSSAI/DNN shall be used for LDS services.

3. The SMF verifies the LDS subscription and may perform UUAA-SM, depending on the type of PDU session being used.

4. Upon successful PDU session establishment, the SMF provides indication that LDS is available and authorized, and provides information on how to reach the LDS.

5. The UAV UE establishes connectivity with the LDS directly using application layer signaling outside the scope of this solution.

### 6.4.4 Impacts on services, entities and interfaces

The following entities are impacted:

- UE:

- NWDAA capability indication in 5GSM;

- ability to receive policies for LDS information transmission;

- ability to receive LDS@Edge addressing information transmission.

- SMF:

- verify LDS service subscription;

- configuration of LDS service availability;

- provide UAV UE with LDS information;

- receive LDS information and policies from PCF (optional).

- NEF/UAS NF:

- extend existing services or define new services for interaction between LDS and UTM.

- UDM: optional indication of NWDAA service subscription.

The following impacts on services are identified:

- UUAA-SM extended to carry LDS information (information may be in existing payload or new payload and does not impact NEF/UAF NF);

- Existing NEF services may be extended, or new ones defined, to enable the UTM to subscribe to LDS services (e.g. even reporting for potential or identified traffic conflicts);

- Existing NEF services may be extended, or new ones defined, to enable the UTM to provide UAV flight plan and additional UAV information to LDS.

NOTE: The specific impacts on NEF services will be identified during normative phase.

## 6.5 Solution #5: Support Network-assisted DAA with Existing 5GC Services

### 6.5.1 Key Issue mapping

This solution addresses KI#2 aspects.

### 6.5.2 Description

Study which existing information collected and generated in the 5GS can be utilised to enable NWDAA is one of the study aspects in KI#2. This solution proposes to utilize the GMLC service on Ranging/Sidelink Positioning location and Relative Proximity predictions on collision generated at NWDAF to support Network-assisted DAA.

### 6.5.3 Procedures and Parameters

#### 6.5.3.1 Procedure for UAV/UAV-C Triggered Network-assisted DAA



Figure 6.5.3.1-1: Procedure for UAV/UAV-C Triggered Network-assisted DAA

1. The UAV (or UAV-C) establishes a PDU Session for communication with the USS as described in clause 5.2.3 of TS 23.256 [2].

2. The DAA service may be triggered by UAV(s) or UAV-C. The UAV(s) (via its paired UAV-C) or the UAV-C requests DAA service from USS. The request message includes identifier of the UAV(s) (e.g. GPSI(s), CAA-Level UAV ID(s)). USS derives information on DAA service and decides to subscribe/request to 5GC for GMLC service on Ranging/Sidelink Positioning location and/or Relative Proximity predictions on collision from NWDAF.

NOTE: The other content of DAA service information derived at USS is out of scope.

3. The USS may request GLMC service via NEF for Ranging/Sidelink Positioning location results as described in clause 6.20.3 of TS 23.273 [7] for one notification, or clause 6.20.4 of TS 23.273 [7] for notifications (steps 1-20 for initiation monitoring, steps 21-31 for monitoring periodic).

4. The USS may subscribe or request notification on Relative Proximity predictions provided by NWDAF via NEF by invoking Nnef\_AnalyticsExposure\_Subscribe service operation as defined in clause 6.1.1.2 of TS 23.288 [6] or Nnef\_AnalyticsExposure\_Fetch service operation as defined in clause 6.1.2.2 of TS 23.288 [6]. The subscribe/request message include identifier of the UAV(s) (e.g. GPSI(s)). The other parameters included in the request are described in clause 6.5.3.3.

5. After NEF receive the request from the USS, the NEF interacts with the NWDAF as described in the procedure in clause 6.19.4 of TS 23.288 [6]. The NEF maps the parameters in the request from the USS to information used by the 3GPP system.

6. If the NEF receives the response from the NWDAF, the NEF notifies the USS with the Relative Proximity predictions by invoking Nnef\_AnalyticsExposure\_Notify service operation for a Subscribe-Notify model as defined in clause 6.1.1.2 of TS 23.288 [6] or Nnef\_AnalyticsExposure\_Fetch service operation for a Request-Response model as defined in clause 6.1.2.2 of TS 23.288 [6].

7. The USS estimates the potential collision based on the information received in step 3 and/or the predictions from step 6. The USS informs the UAV-C(s) the potential collision. The message may include collision alert, predicted time of collision, CAA-level UAV IDs of the paired UAVs which may collision (e.g. UAV 1 and UAV 2), deconflicting specific parameters (e.g. trajectory correction information to avoid collision).

8. The UAV-C(s) informs its paired UAV(s) the potential collision, and information received from the USS, include collision alert, predicted time of collision, CAA-level UAV IDs of the paired UAVs which may collision, and deconflicting specific parameters (e.g. trajectory correction information to avoid collision).

9. UAVs performs operations to avoid collision.

9a. If both the two UAVs which may collision (e.g. UAV 1 and UAV 2) been informed by their paired UAV-C(s), the UAVs can be steered to avoid collision in accordance with the received information (e.g. trajectory correction information to avoid collision) and using mechanisms that are out of scope for 3GPP.

9b. If only one of the two UAVs which may collision (e.g. UAV 1) been informed by its paired UAV-C, the UAV 1 triggers conflict resolution procedure with UAV 2 as described in clause 5.6.1 steps 4-7 in TS 23.256 [2].

#### 6.5.3.2 Procedure for AAM Triggered Network-assisted DAA



Figure 6.5.3.2-1: Procedure for AAM Triggered Network-assisted DAA

1. As described in clause 5.7.2 steps 1-6 of TS 23.256 [2], the UAV(s) listens for signals on the correspondingly destination Layer-2 ID configured for the used service type. The AAM scans the airspace over the area/arena for UAV(s), retrieves for each detected UAV the corresponding Remote-ID, and establishes a PC5 direct communication link with the discovered UAV. Using the PC5 unicast direct communication link the AAM and the UAV establishes a bidirectional communication channel for exchange of messages.

2. The AAM establishes a PDU Session for communication with the USS as described in clause 5.2.3 of TS 23.256 [2].

3. The AAM may request network assist DAA service from USS. The request message includes identifier of the UAV(s) (e.g. GPSI(s), CAA-Level UAV ID(s)). USS derives information on DAA service and decides, e.g. to request GMLC service for Ranging/Sidelink Positioning location, to subscribe/request to NWDAF for Relative Proximity predictions on collision.

NOTE: The other content of DAA service information derived at USS is out of scope.

4. The USS requests GMLC service for Ranging/Sidelink Positioning location, and/or subscribes/requests notification on Relative Proximity predictions provided by NWDAF via NEF, as described in clause 6.5.3.1 steps 3-6.

5. The USS estimates the potential collision based on the received information/analytics in step 4. The USS informs the AAM the potential collision. The message may include collision alert, predicted time of collision, CAA-level UAV IDs of the paired UAVs which may collision (e.g. UAV 1 and UAV 2), deconflicting specific parameters (e.g. trajectory correction information to avoid collision).

6. The AAM provides the determined steering policy to the specific UAVs (e.g. UAV 1 and UAV 2) according to the information received in step 5, and the UAVs are steered to avoid collisions in accordance with received policy and using mechanisms that are out of scope for 3GPP, as described in clause 5.7.2 steps 7-8 of TS 23.256 [2].

#### 6.5.3.3 Parameters in Request for Relative Proximity Analytics

The USS acting as an Application Function communicates with the NEF which corresponds to the NF consumer in clause 6.19.4 of TS 23.288 [6].

The USS can either subscribe to notifications from the NEF (i.e., a Subscribe-Notify model) or request a single notification from the NEF (i.e. a Request-Response model). The USS request contains the following parameters:

- Analytics ID = "Relative Proximity";

- Target of Analytics Reporting: a UE, a group of UEs;

- Analytics Filter Information:

- Area of Interest;

- An individual or set of direction(s) of interest;

- Number of UAVs to be accounted for relative proximity (i.e. the number of UAVs for which one UAV may report proximity information);

- One or several attributes to be accounted for relative proximity (i.e. additional information that can be provided in addition to distance between two UAVs): velocity, average speed, orientation, mobility trajectory;

- Preferred level of accuracy of the analytics;

- Maximum number of objects;

- An Analytics target period indicating the time period over which the predictions are requested.

### 6.5.4 Impacts on services, entities and interfaces

UAS NF/NEF:

- Enhance Nnef\_AnalyticsExposure service, e.g. additional parameters.

NWDAF:

- Enhance the inputs and the outputs of Relative Proximity Analytics.

Editor's Note: It is FFS if existing data is enough or enhancement is needed.

USS/AF:

- Enhance for supporting UAV/UAV-C trigger DAA service.

- Enhance for supporting AAM trigger network assist DAA service.

Editor's Note: It is FFS other possible impacts related to services, entities and interfaces.

## 6.6 Solution #6: UTM requests information used for DAA

### 6.6.1 Key Issue mapping

This solution address key issue #2: Network-assisted/ground-based mechanism for DAA (Detect And Avoid) with 5GS information.

### 6.6.2 Description

In this solution, it is the UTM request the following existing information from 5GC used for DAA:

- Sidelink positioning location results when certain trigger events occur. The trigger events are described in clause 6.20.4 in TS 23.273 [7], e.g. one trigger event occurs if the distances between at least one UE of the n UEs and each of the other UEs are such that any distance for the one UE is less than the threshold.

- List of Aerial UEs in a geographical area as specified in clause 5.3.4 in TS 23.256 [2],

- NWDAF analytics specified in TS 23.288 [6], e.g. UE mobility analytics, relative proximity analytics.

### 6.6.3 Procedures



Figure 6.6.3-1: UTM requests information from 5GC

1-3. USS/UTM obtains the aerial UE list in a geographical area by invoking the existing procedure of obtaining list of Aerial UEs in a geographic area in clause 5.3.4 in TS 23.256 [2].

4-5. USS/UTM requests the relative proximity analytics of the UEs obtained in steps 1-3. The steps 4-5 represent the existing procedure for NWDAF providing relative proximity analytics in clause 6.19.4 in TS 23.288 [6].

6-8. USS/UTM triggers the existing procedure for SL-MT-LR for periodic, triggered location events in clause 6.20.4 in TS 23.273 [7]. The threshold type could be set to threshold type a, in this case, the trigger event occurs if the distances between at least one UE of the n UEs obtained in steps 1-3 and each of the other UEs are such that any distance for the one UE is less than the threshold.

 Based on the NWDAF analytics, event report and flight path of the aerial UEs, if a collision is detected, the USS/UTM initiates a collision avoidance/conflict resolution procedure which is out of 3GPP scope.

### 6.6.4 Impacts on services, entities and interfaces

UTM/USS:

- Obtain aerial UE list in a geographical area.

- Obtain the NWDAF analytics on relative proximity analytics of the aerial UEs.

- Obtain the sidelink positioning location results when certain trigger events occur. The trigger events are described in clause 6.20.4 in TS 23.273 [7], e.g. one trigger event occurs if the distances between at least one UE of the n UEs and each of the other UEs are such that any distance for the one UE is less than the threshold.

## 6.7 Solution #7: Mobility Enhancements for enforcements of NTZ

### 6.7.1 Key Issue mapping

This solution applies to Key Issue #3.

### 6.7.2 Description

#### 6.7.2.1 Introduction

The solution addresses the following aspects:

- How to ensure an aerial UE respects no-transmit zones. This includes the following scenarios:

- mobile network cells overlapping completely or partially with the NTZ and using the restricted frequency bands of the NTZ.

- support NTZ of any size, depending on regional requirements.

*-* the provisioning of NTZ-related information to the UAV UE.

- how to allow the enforcement for both aerial UEs in connected mode and aerial UEs in idle mode.

#### 6.7.2.2 Solution Overview

The solution assumes the following:

- NTZ information is provided to the PLMN functions (depending on the solution options described below) via OAM by external parties, with the idea that at national level there will be entities in charge of defining NTZs and providing related information to PLMNs.

Editor's Note: Whether NEF services are extended to enable providing dynamic NTZ information to the 5GC is FFS.

- NTZ information refer to a geospatial description of an NTZ (in two dimensions or three dimensions to consider height restrictions) and the restricted frequencies corresponding to such area.

Editor's Note: The solution is based on a set of assumptions related to the expected behavior of a UAV UE when in the NTZ (i.e. the NTZ area and the restricted frequency bands). Depending on verification of such assumptions, the solution may need to be revised.

The solution provides multiple options which cater for different size of NTZs with respect to the size of the cells impacted by NTZs:

- Extension of Service Restrictions to cater for NTZs: this solution is suitable for large NTZs that impact a variety of cells in a specific area.

- use of NTZ policy configuration in the UE.

- Per-cell indication of the presence of NTZs: this solution assumes that mechanisms are adopted in RAN to provide information to UAV UEs wrt the overlap of an NTZ with the cell (i.e. the whole cell is not suitable for transmission for a UAV UE) in order to ensure that the UAV UE does not transmit at all in the NTZ area of a cell that overlaps partially or fully with an NTZ. The solution is mostly suitable for scenarios where the NTZ covers the majority or entirety of a cell.

A PLMN may use one or more of these solutions depending on local policies and the size of the NTZs impacting the PLMN.

In the solutions below, the following behavior is assumed:

- The UAV UE never transmits any signalling or data in the area of a cell corresponding to an NTZ (i.e. the geospatial area corresponding to the NTZ and the frequency band(s) corresponding to the NTZ).

- the UAV UE is provided by the network with NTZ-related information as described in the solutions below.

- the UAV UE deactivates the AS layer or ceases to transmit any data when entering an area corresponding to the NTZ.

NOTE: It is assumed that if the UE can receive DL data, the UE cannot perform any actions that require any transmission while in the area corresponding to an NTZ.

Editor's Note: Whether the UE is allowed to receive DL data in an area corresponding to and NTZ is FFS.

- the UAV UE may perform a registration update before entering the NTZ with an indication that the UAV UE is about to enter an NTZ, so that the network considers the UAV UE unreachable but registered, similarly to the mechanisms adopted in previous releases for high latency communication behavior. The UAV UE does so based on the NTZ information it receives as described below. The UAV UE would then perform re-registration when exiting the NTZ. This enables the network to know the exact status of the UAV UE.

- for connected mode UAV UEs, it is expected that the network is configured to know which cells correspond to an NTZ and the RAN will attempt to avoid handing over a UAV UE to a cell corresponding to an NTZ. However, in some scenarios the only suitable cell for a handover may be a cell impacted by an NTZ (location and frequency bands), and the UE behavior described below must apply. Optimizations in the case of connected mode handover to minimize loss of connectivity and ensure the respect of NTZs need to be discussed further with RAN WGs.

- for IDLE mode mobility, the UAV UE behavior is described below.

Editor's Note: Additional/what parameters need to be considered to properly describe NTZ and actual restrictions/enforcement aspects and roles of NTZ in the core and radio network are FFS.

Editor's Note: Coordination with RAN WGs are required to progress the solution to ensure that RAN (eNB/gNB) has inputs required to enforce UE compliance with NTZ.

Editor's Note: How the solution can address change of NTZ information is FFS.

#### 6.7.2.3 Extension of Service Restrictions for NTZs

In this solution component, a UAV UE supporting NTZ restrictions provides an indication in 5GMM of support of NTZ Restrictions.

The CN receives the NTZ information (e.g. via OAM from external party) and maps the NTZ information to a Restricted Transmission Area (RTA). If the AMF determines that the supporting UE is an UAV UE, i.e. the UE provided indication of NTZ support, the UE has an aerial subscription, and after successful UUAA procedure when it is performed, then the AMF configures the UE with this Restricted Transmission Area. If a UAV UE does not provide the indication, the AMF may deregister the UE and may provide a cause code (and a backoff timer) to indicate not to re-register for a time for this PLMN.

The Restricted Transmission Areas is similar to a Non-Allowed Area, but it is explicitly identified as being different from a Non-Allowed Area to induce a different behavior in the UAV UE. The concept is that the UE is not allowed transmit at all the RTA in the frequencies corresponding to the NTZ.

Based on the RTA information, the UAV UE behavior differs from a traditional UE which, when entering a non-allowed area, may still act as a regular UE in limited state and transmit for emergency services, and is banned from performing any PLMN reselection. An UAV UE entering an RTA shall not initiate any service request or any signaling, including emergency services. When entering an RTA, the UAV UE shall behave as a UE with no suitable serving cell banned from performing any emergency services. An UAV UE in an RTA shall not respond to any paging from the network. When entering an RTA, the UAV UE is allowed to use this event to trigger PLMN reselection.

In order to provide NTZ information as part of the RTA:

- the AMF may be configured with NTZ information and provide RTA to the UAV UE based on the NTZ information after the AMF determines it is a supporting UAV UE (i.e. the UE provided indication of NTZ support), that the UE is an aerial UE based on aerial subscription, and after successful UUAA procedure when it is performed.

- Alternatively, the AMF may be configured to know that there is at least one NTZ in the area served by the AMF but may not create any RTA information. During the registration, the PCF which is configured with NTZ information, may create an RTA for the UAV UE and return it to the AMF which in turn provides it to the UAV UE.

The UDM and the PCF may update the Service Area Restrictions of a UE at any time. For UE in CM-IDLE state in an RTA marked as NTZ, the AMF shall store the updated service area restriction and update the UE upon next signalling interaction with the UE. For a UE located in an RTA marked as NTZ, the AMF shall not initiate paging for a UE to update Service Area Restrictions with Generic UE Configuration Update procedure.

#### 6.7.2.4 NTZ Restriction Policies

This component of the solution re-uses concepts similar to the PC5 policy configuration that was adopted in previous releases to define geofence where certain frequencies are not allowed. However, in the case of NTZs, a blocklist of frequencies associated to the specific area are provided, whereas in the case of PC5 a allowlist was provided. In the solution, the UE is configured with NTZ Restriction Policies that identify the area corresponding to the NTZ and the banned frequency or frequencies. The UE shall not transmit data or signaling when in the area of the NTZ and is being served by the frequencies identified in the NTZ Restriction Policies. The description of the NTZ may be in the form of a 2D or 3D (to include specific altitudes) geo-area/polygon.

In this solution, a UAV UE supporting NTZ restrictions provides an indication in 5GMM of support of NTZ Restrictions.

The UE may be provided with NTZ Restriction Policies in one of the following alternatives:

- Option 1: From AMF. During the registration procedure, if the AMF determines that the supporting UE is an UAV UE, i.e. the UE provided indication of NTZ support, the UE has an aerial subscription, and after successful UUAA procedure when it is performed, then the AMF provides the NTZ Restriction Policies applicable to the UAV UE and the current registration area. This option requires all AMF serving areas impacted by NTZ to be configured with NTZ information.

- Option 2: From PCF. When the UAV UE is in a TA where there is at least NTZ, or when the registration Area that the AMF assigns to the UAV UE contains at least one NTZ, and if the AMF determines that the supporting UE is an UAV UE, i.e. the UE provided indication of NTZ support, the UE has an aerial subscription, and after successful UUAA procedure when it is performed, then the AMF provides a new indication that an NTZ is present in the registration area. The UAV UE triggers the retrieval of NTZ Restriction Policies from the PCF using existing procedures. Alternatively, the AMF may indicate to the PCF during the registration procedure that NTZ are present in the registration area and the PCF triggers NTZ Restriction Policies delivery to the UAV UE. This solution reduces the impact on AMFs by requiring only AMFs that serve area impacted by NTZs to be configured to know there is an NTZ, without the need to impact other AMFs and without requiring AMFs to be aware of the complete NTZ information.

- Option 3: from NTZ AF. This option assumes that a third-party service is present outside MNOs to provide NTZ-specific information to UAV UEs. This may be a service provided by regulators or other third parties. As in option B, When the UAV UE is in a TA where there is at least NTZ, or when the registration Area that the AMF assigns to the UAV UE contains at least one NTZ, and if the AMF determines that the supporting UE is an UAV UE, i.e. the UE provided indication of NTZ support, the UE has an aerial subscription, and after successful UUAA procedure when it is performed, then the AMF provides a new indication that an NTZ is present in the registration area, and may provide assistance information (e.g. URL) to instruct the UAV UE how to reach the AF. Upon receiving the indication and the assistance information, the UAV UE ​uses existing a suitable user plane connection or establishes an appropriate user plane connection (e.g. the UAV UE may be configured with a specific DNN/S-NSSAI for such connectivity) to the AF and uses application layer signalling to retrieve the information (out of scope of the solution).

If in a PLMN multiple options are supported, this solution assumes that what the UAV UE receives in option 3 takes priority over the information received with other options.

#### 6.7.2.5 Per-cell indication of the presence of NTZs:

For potential solutions where a per-cell indication is provided to UAV UEs on the presence of NTZs (independently of the mechanism adopted to do so by e.g. RAN solutions), three categories of UEs need to be considered:

1. new UEs (i.e. Rel. 19) that support NTZ restriction functionality: in a cell where the NTZ indication applies, the UAV UE shall consider the cell barred.

2. pre Rel. 19 non-UAV UEs (i.e. terrestrial UEs): these UE should be allowed to use the cell either by ignoring the indication or not receiving it.

3. pre-Rel.19 UAV UEs that do not support NTZ restriction: solutions must enable such UAV UEs to consider the cell barred or not suitable.

We assume that the network would need to be aware of which of the three categories a UE belongs to, and we assume that new Rel.19 UAV UEs indicates to the network the ability to support NTZ restrictions. CN and RAN are already aware if this is an aerial UE based on the UE subscription being an aerial subscription, which since Rel. 15 is indicated to the RAN when the UE context is provided to the RAN.

Solutions that provide a per-cell indication of the presence of an NTZ shall be able to support all three categories of UAVs with the expected UE behavior described above. Specifically, if RAN WGs develop such solution, the solution must allow non-UAV UEs to use the cell without restriction and must block all UAV UEs from using this cell. This includes also UAV UEs of release 18, not just UAV UEs of Release 19. Moreover, such solutions would need to consider that RAN needs to be configured with NTZ information in order to provide any per-cell indication.

NOTE: Coordination with RAN WG is required to consider such solutions.

#### 6.7.2.6 Solution Architecture

No architectural modifications are assumed by the proposed solution.

### 6.7.3 Procedures

#### 6.7.3.0 General

NOTE: It is assumed that the following procedures take place when the UAV UE is outside an area corresponding to an NTZ.

#### 6.7.3.1 Extension of Service Restrictions for NTZs



Figure 6.7.3.1-1: Delivery of NTZ information via Service Area Restrictions.

1. The UE registers indicating support for NTZ.

2. If the AMF determines that the supporting UE is an UAV UE, i.e. the UE provided indication of NTZ support, the UE has an aerial subscription, and after successful UUAA procedure when it is performed, then the AMF decides to configure the UE with this Restricted Transmission Area. If a UAV UE does not provide the indication, the AMF may deregister the UE and may provide a cause code (and a backoff timer) to indicate not to re-register for a time for this PLMN. The AMF may be configured with NTZ information and provide RTA to the UAV UE based on the NTZ information.

3. Alternatively, the AMF may be configured to know that there is at least one NTZ in the area served by the AMF but may not create any RTA information. During the registration, the PCF which is configured with NTZ information, may create an RTA for the UAV UE and return it to the AMF which in turn provides it to the UAV UE.

4. The AMF confirms the registration and returns the RTA information to the UAV UE. Based on the RTA information, a UAV UE entering an RTA shall not initiate any service request or any signaling, including emergency services. When entering an RTA, the UAV UE shall behave as a UE with no suitable serving cell banned from performing any emergency services. An UAV UE in an RTA shall not respond to any paging from the network. When entering an RTA, the UAV UE is allowed to use this event to trigger PLMN reselection.

#### 6.7.3.2 NTZ Restriction Policies



Figure 6.7.3.2-1: Delivery of NTZ restriction policies to UAV UEs.

1. The UE registers indicating support for NTZ.

2. If the AMF determines that the supporting UE is an UAV UE, i.e. the UE provided indication of NTZ support, the UE has an aerial subscription, and after successful UUAA procedure when it is performed, then the AMF determines that NTZ Restriction Policies applicable to the UAV UE and the current registration area need to be provided to the UAV UE.

3a. In option 1, the AMF may retrieve the NTZ Restriction Policies from the PCF.

3b. in option 1, the AMF returns the NTZ Restriction Policies to the UAV UE.

4a. In option 2, the AMF provides a new indication that an NTZ is present in the registration area.

4b. In option 2, based on the indication in 4a the UAV UE triggers the retrieval of NTZ Restriction Policies from the PCF using existing procedures. Alternatively, the AMF may indicate to the PCF during the registration procedure that NTZ are present in the registration area and the PCF triggers NTZ Restriction Policies delivery to the UAV UE.

5a. In option 3, the AMF provides a new indication that an NTZ is present in the registration area, and may provide assistance information (e.g. URL) to instruct the UAV UE how to reach the AF.

5b. In option 3, upon receiving the indication and the assistance information in step 5a, the UAV UE uses existing a suitable user plane connection or establishes an appropriate user plane connection (e.g. the UAV UE may be configured with a specific DNN/S-NSSAI for such connectivity) to the AF.

5c. In option 3, the UAV UE uses application layer signaling to retrieve the information from the AF.

### 6.7.4 Impacts on services, entities and interfaces

The following entities are impacted:

- UE:

- indication of NTZ support for UAV UEs;

- receive and process NTZ information, and modify idle mode mobility and connected mode mobility based on received NTZ information as described in options above ;

- abstain from transmission in areas corresponding to NTZ;

- for per-cell solutions, the UE can receive per-cell indication of NTZ.

- AMF:

- configuration by OAM to be aware of presence of NTZ in serving area;

- potential configuration of NTZ information or assistance information to support NTZ information retrieval;

- restrain from paging a UAV UE that is in an NTZ.

- PCF:

- may be configured with NTZ information (area and frequencies) depending on solution options.

## 6.8 Solution #8: Network support for NTZ management

### 6.8.1 Key Issue mapping

This solution addresses part of KI#3 regarding non-NTZ-support UE.

### 6.8.2 Description

This solution addresses Key Issue #3 "Support of No Transmit Zones".

Considering the scenario that the UE doesn't support functions defined for NTZs wants to perform flight mission via 5G network in NTZ. There is a need to align NTZ setting with 5G network, so 5G network can manage aerial UEs based on the right aerial information (NTZ). In order to avoid the impact on non-aerial UEs, AMF needs to determine whether the UE is an aerial UE, and if yes, AMF can compare the NTZ information with the UE's local information to determine whether the user can initiate registration via 5G network.

Editor's Note: Applicability of whether an UAV can access the network while moving into or in a NTZ needs to be confirmed and any solution associated with such assumption will be further evaluated once clarification of this issue has been performed.

### 6.8.3 Procedures



Figure 6.8.3-1: Procedure for network support for NTZ

0. The AMF can store the NTZ information which is configured locally or obtained from the UTM/USS via UAS-NF/NEF.

1. The UE, which doesn't support functions defined for NTZs, sends a Registration request message and, and it shall provide a CAA-level UAV ID of the UAV if configured with one.

2. AMF could determine whether the UE is an aerial UE according to the CAA-level UAV ID or aerial subscription, and if yes, AMF can compare the NTZ information with the TA where the UE is to determine whether the UE can continue registration.

3. AMF sends Registration Accept/Registration Reject message to UE.

Editor's Note: The indication sent by the AMF to prevent subsequent registration or mobility registration attempt is for FFS.

4. The AMF can update and store the new NTZ information configured locally or obtained from the UTM/USS via UAS-NF/NEF.

5. The UE sends a mobility registration message due to the UE mobility.

6. AMF could determine whether the UE is an aerial UE according to the CAA-level UAV ID or aerial subscription, and if yes, AMF can compare the NTZ information with the TA where the UE will move to, to determine whether the UE can continue mobility registration.

7. AMF sends mobility registration Success/mobility registration Failure message to UE.

### 6.8.4 Impacts on Existing Nodes and Functionality

AMF:

- Obtain data from UTM/USS referring to NTZ and store it as NTZ information.

## 6.9 Solution #9: Enabling NTZ support for aerial UEs

### 6.9.1 Key Issue mapping

This solution addresses KI#3 aspects.

### 6.9.2 Description

The solution assumes that an aerial UE indicates its capability to respect no-transmit zones (NTZ), and UE’s subscription data has a record about that, as Operators have to enforce the NTZ respect, and the subscription-based approach is one possibility, as described below.

Several options/alternatives are considered when comes to obtaining NTZ information – preconfiguration at the relevant network nodes (e.g., gNodeB (gNB)/eNodeB(eNB), AMF/MME) as well as a network-based configuration of NTZ parameters (e.g. geographical area in form of coordinates (i.e., latitude and longitude), restricted frequency band(s), altitude/elevation etc.).

Editor's Note: Additional/what parameters need to be considered to properly describe NTZ and actual restrictions/enforcement aspects and roles of NTZ in the core and radio network are FFS.

In order to perform network-based configuration of NTZ parameters, it is assumed that there needs to be operator’s AF with trust relation for this purpose. This AF can be part of UTM (Uncrewed Aerial System Traffic Management) , which is outside operator’s trust domain, and therefore, the AF will invoke a service operation towards an UAS NF / NEF so that the NTZ information can be transferred towards RAN nodes (i.e., gNBs in case of 5GC and eNB in case of EPC), core network (CN) entities and to the affected aerial UEs.

Editor's Note: Whether UEs in NTZs are allowed to use UL for emergency support is FFS and depends on LS reply.

Current solution assumes that the aerial UEs supporting NTZ will not require emergency services support.

Until otherwise indicated, it is assumed that the NTZ does not allow UEs to send uplink data but allows reception of downlink data from the network. Also, Aerial UEs within NTZ(s) are able to communicate with the network for mobility/registration procedures for the purposes of keeping connectivity to the network.

The main principles/steps for the considered solution options/alternatives.

1. Provisioning RAN (gNB/eNB) with a set of NTZ information (e.g., geographical area in form of coordinates (i.e., latitude and longitude), restricted frequency band(s), altitude/elevation etc.), see Figure 6.9.3-1:

1(a). RAN is provided with NTZ information via a node-level signalling from operator’s AF via UAS NF/NEF, PCF and AMF using the AM Policy Association Establishment/Modification procedures (as described in clauses 4.16.1 and 4.16.2 of TS 23.502 [4]).

1(b). RAN node(s) are configured by OAM with the existing NTZ information that can be requested by the AF/UTM from network’s nodes in the area they serve (e.g., based on RAN node location, Tracking Area(s) identified by a list of tracking area identities (TAI) or a list of cell identities)

1(c): AMF/MME is pre-configured (e.g., local configuration) with NTZ information; and AMF/MME provides the NTZ information to relevant gNB/eNB nodes via non-UE associated signalling (e.g. during NG interface Setup/Reconfiguration procedure), UE-associated signalling (e.g., during Initial Context Setup/Modification procedure or PDU session resource management procedures).

To provide RAN nodes with new/updated NTZ information from the AF/UTM (i.e. triggered by UTM), a node-level signalling from operator’s AF/UTM can be used for Option 1(a), 1(b) and 1(c), whereas reprovisioning via OAM can be done only for Option 1(b).

2. UE’s subscription data include an additional record at UDM, indicating that the UE/UAV is compliant to NTZs requirements. This allows the operator and the network to enforce NTZ respect and to deliver the NTZ information only to UEs with the corresponding subscription. This indication is made available/delivered to RAN nodes (gNB/eNB) so they can enforce the NTZ respect. Additionally, UE’s subscription data at UDM can indicate which set(s) of NTZ are allowed to be disobeyed by high-priority UEs (e.g., first responders).

3. Providing the NTZ information to a UE with the corresponding subscription:

3(a). RAN (gNB/eNB) sends the NTZ information to a UE using the RAN defined procedure.

3(b). The NTZ information is sent to a UE from a core network node (e.g., UAS NF/NEF via an AMF) or from the serving AMF using Non-Access Stratum (NAS) signalling during UE’s registration in a Registration Accept message.

The UE/UAV stores the received NTZ information until the new NTZ information is provided or deleted, e.g., by explicit signalling from the core network (for instance, via AMF NAS signalling) due to request from the AF/UTM.

Editor's Note: It is FFS if SMF/UPF/PGW-U need to be impacted due to enforcement of no UL data transmission and Aerial UE movement in and out of NTZ(s).

Editor's Note: Coordination with RAN WGs are required to progress the solution to ensure that RAN (eNB/gNB) has inputs required to enforce UE compliance with NTZ.

### 6.9.3 Procedures

The main procedural steps to provision RAN nodes (gNB/eNB) with the NTZ information is shown in Figure 6.9.3-1.

Editor's Note: The current procedures assume 5GC signalling. The adaptation for EPC is FFS.

Aerial UE

NG-RAN

AMF

PCF

NRF

NEF (UAS NF)

UDM

AF (UTM) NF)

1. Naf\_Authentication\_Notification incl. NTZ information

2. NTZ info translation into 3GPP identifiers (a list of TAs or Cell IDs)

3A/B. Nnrf\_NFDiscovery (discovery of a PCF/AMF )

3C. Discovery of the serving AMF (with UE Context) via UDM

4A. Npcf\_AMPolicyAuthorization\_Create/Update with the NTZ information (incl. translated and the original)

5A. PCF takes a policy decision, considering UE’s capability to respect NTZ, and may initiate the AM Policy Association Modification

4B/C. Nnef\_Authentication\_Notification request with NTZ information (incl. the translated and the original)

4C. Naf\_Authentication\_Notification response

6A/B. AMF performs UE’s subscription compliance check

7. Determination of relevant NG-RAN nodes and delivery of the NTZ information together with the indication to enforce NTZ respect in a N2 message

**NTZ delivery to RAN: Option 1 – via node-level signalling**

1. RAN nodes are configured via OAM to sets of NTZ information

**NTZ delivery to RAN: Option 2 – RAN configured via OAM**

0. AMF is preconfigured with sets of NTZ information

Steps 1, 3B/C, 4B/C, 6A, and 7 as in Option 1

2A. Delivery of the NTZ information together with the indication to enforce NTZ during NG interface Setup/Reconfiguration procedure

2B. Delivery of the NTZ information together with the indication to enforce NTZ during Initial Context Setup/Modification procedure or PDU session resource management procedures

**NTZ delivery to RAN: Option 3 – AMF preconfiguration**

Figure 6.9.3-1: Procedure to provision RAN nodes (gNB/eNB) with the NTZ information.

**Option 1: node-level signalling.**

1. An AF (UTM) sends to the UAS NF/NEF an Naf\_Authentication\_Notification request to provide new/updated information about NTZ for the UE/UAV. The AF/UTM includes GPSI, CAA-Level UAV ID, PDU Session IP address if available and the NTZ information in the re-authentication/authentication data update request.

Editor’s Note: Whether to use the existing service operation (e.g., Naf\_Authentication\_Notification) or to design a new for this specific purpose is FFS.

NOTE 1: The similar request can be used by the AF/UTM to send an update about the NTZ information when e.g. the AMF/MME is preconfigured with the set of NTZ information or when the previously delivered information is not valid anymore.

2. The UAS NF/NEF translates the AF-provided NTZ information (e.g., geographical area in form of coordinates (i.e., latitude and longitude), restricted frequency band(s), altitude/elevation etc) into 3GPP identifiers, e.g. a list of Tracking Area Identifiers (TAIs) or a list of cell IDs, RFSP Index.

3A or 3B. The UAS NF/NEF discovers a PCF handling AM Policy for the UE (Option 3A) or a serving AMF (Option 3B); for that the NEF invokes the NRF discovery service and uses UE’s identity.

3C. The UAS NF/NEF uses UDM service (Nudm\_UECM\_Get operation as specified in clause 5.2.3.2.4 of TS 23.502 [4]) to get an NF ID of the AMF serving the UE, i.e. with UE Context. In congestion with that, the UAS NF may invoke another service operation to UDM to retrieve UE’s subscription data and check whether the UE is compliant to NTZs requirements allowing the operator and the network to enforce NTZs.

If the UE’s subscription does not have the NTZ indication, the UAS NF notifies the AF/UTM by sending the response message and include the information about the results inside this message.

NOTE 2: It is up to UTM to decide for which purpose this information can be used; it is outside 3GPP scope.

4A. The UAS NF/NEF sends to the discovered PCF an Npcf\_AMPolicyAuthorization\_Create/Update request containing the translated NTZ information, e.g. a list of TAs/Cell IDs, and the original AF-provided NTZ information (prior the translation by the NEF).

5A. After receiving the NTZ information, the PCF takes policy decision and then may initiate the AM Policy Association Modification procedure for the UE/UAV as described in clause 4.16.2.2 of TS 23.502 [2] to provide the AMF with the NTZ information.

The PCF does not initiate the AM Policy Associations Modification and rejects (i.e., responds with the failure cause) the Npcf\_AMPolicyAuthorization\_Create/Update request in cases when the PCF does not receive information about the UE’s capability to respect NTZ during the AM Policy Association Establishment (see Step 16 in clause 4.2.2.2.2 of TS 23.502 [4]). The PCF responds to the Npcf\_AMPolicyAuthorization\_Create/Update request (not shown in Figure 6.9.3-1), and the UAS NF/NEF responds to the AF (using Naf\_Authentication\_Notification response, not shown in Figure 6.X.3-1) to inform the UTM that the UE/UAV does not have capability required.

4B and 4C. If the UE’s subscription data contains the indication that the UE is compliant with NTZ requirements, the UAS NF/NEF sends an Nnef\_Authentication\_Notification request to the AMF/MME, containing the translated NTZ information, e.g. a list of TAs/Cell IDs, the original AF-provided NTZ information to the target AMF. If the UE subscription does not indicate the NTZ compliance, the UAS NF/NEF responds to the AF/UTM to notify that the UE/UAV does not have capability required.

6A and 6B. If the UE subscription check (i.e., compliance to NTZ requirements) has not been performed earlier in the procedure, the AMF/MME checks, based on the subscription data retrieved during the registration, whether the UE is compliant with NTZ requirements.

7. Based on the NTZ information, the AMF determine the relevant RAN node IDs and then sends N2 messages containing the NTZ information and include an indication to enforce (whenever required NTZ respect) to all applicable RAN nodes.

Editor's Note: What actions and how RAN uses the delivered NTZ information is up to RAN WGs to study, and it is FFS.

NOTE 3: RAN can use the NTZ information to adjust information broadcasting, e.g., prevent UEs from moving from RRC\_IDLE/INACTIVE states to RRC\_CONNECTED state.

**Option 2: OAM configuration.**

1. RAN node(s) are configured by OAM with the existing NTZ information that can be requested by the AF/UTM from network’s nodes in the area they serve (e.g., based on RAN node location, Tracking Area(s) identified by a list of tracking area identities (TAI) or a list of cell identities).

2. AMF sends an N2 message with indication that the RAN needs to enforce NTZ after the Registration Completion.

**Option 3: AMF preconfiguration with NTZ information.**

0. AMF is preconfigured with sets of NTZ information that can be requested by the AF/UTM.

1. To request a specific NTZ requirements, the AF/UTM may use e.g. an index (a number) to a specific set; Steps (some or all), 3B/C, 4B/C, 6A, and 7 as in Option 1 are executed.

2. Delivery of the NTZ information together with the indication to enforce NTZ during NG interface Setup/Reconfiguration procedure, during Initial Context Setup/Modification procedure or PDU session resource management procedures.

The main procedural steps to provide UEs with the NTZ information is shown in Figure 6.9.3-2.

AMF

UDM

PCF

RAN

Aerial UE

1. UE registration as specified in clause 4.2.2.2.2 of TS 23.502

2. N2 message with indication that RAN shall enforce NTZ

3. NTZ information delivery to the UEs with the corresponding subscription using RAN provided

**NTZ delivery to UE: Option 1 – RAN delivered**

1. Registration Request incl. NTZ capability

2. N2 message to a selected AMF

3. Verification of UE’s location

4. Registration Accept message with the NTZ information or Registration Reject message

5. (If Registration Reject due to NTZ): Emergency Registration

**NTZ delivery to UE: Option 2 – Registration Accept**

Figure 6.9.3-2: Procedure to providing UEs with the NTZ information.

**Option 1: RAN Mechanism**

1. UE preforms registration procedure as described in clause 4.2.2.2.2 of TS 23.502 [4].

2. AMF retrieves the subscription data from the UDM and checks whether the UE is compliant with NTZ requirements. If so, the AMF/MME sends N2 message with the indication to RAN that it shall enforce the NTZ whenever required.

3. RAN sends the received NTZ information, how this is done is FFS and need coordination with RAN WGs.

**Option 2: Registration Accept**

1. UE to RAN: UEs sends a Registration Request message and include parameters as specified in clause 4.2.2.2.2 of TS 23.502 [4]. Additionally, if the UE has capabilities to respect no-transmit zones, the UE includes the indication about this capability to the network.

2. RAN to AMF: Once RAN selects an AMF, the RAN sends an N2 message containing N2 parameters (specified in Step 3 of clause 4.2.2.2.2 of TS 23.502 [4]) and the received Registration Request message from the RAN (as described in Step 1). The AMF stores information UE’s support for NTZ consideration in the UE Context.

3. If the AMF sees in the registration request information about UEs capability to respect NTZ, the AMF check whether UE subscription data includes indication about UEs compliance with NTZ requirements. If the UE is compliant with NTZs, the AMF may verify the UE’s location before replying with a Registration Accept/Reject message.

4. If the UE is allowed to operate at its present location, the AMF sends to the UE a Registration Accept message and includes inside the message the previously received NTZ information.

If the UE is not allowed to operate at its present location, the AMF may either: (1) send a Registration Reject message with a cause value indicating that the UE is not allowed to operate at the present UE location, or alternatively, (2) send a Registration Accept message in which the AMF includes a UE Radio Capability ID and/or RFSP Index the UE is allowed to operate.

5. If the UE receives a Registration Reject message with cause value indicating the UE/UAV is not allowed to operate in the present location due to NTZ requirements, the UE may attempt to perform an Emergency Registration.

The overall NTZ procedure is as shown in Figure 6.9.3-3, and it includes:

AF (UTM) NF)

NEF (UAS NF)

UDM

NRF

PCF

AMF

NG-RAN

Aerial UE

1. NTZ information delivery to the relevant RAN nodes, as described in Figure 6.9.3-1

2. NTZ information delivery to UEs with the corresponding subscription, as described in Figure 6.9.3-2

3. UE location or UE’s in the area of interest (i.e., in NTZ) determination

4. Notifying the AF/UTM about UE’s disobeying NTZ requirements (relies on response signaling of Option 1 in Figure 6.9.3-1)

5. Updating UEs and RAN nodes with the newest NTZ information

6. For UEs in CM\_IDLE, the AMF may initiate, based on local policy, the Network Triggered Service Request procedure (clause 4.2.3.3 of TS 23.502 [4])

Figure 6.9.3-3: Procedure to support UE compliance with the provided NTZ information.

1. NTZ information and the indication to enforce NTZ delivery to the relevant RAN nodes as described in Figure 6.9.3-1.

2. NTZ information delivery to UEs with the corresponding subscription, as described in Figure 6.9.3-2.

3. UE location determination. As an option, and depending on UTM requirements, the AMF may use the UE mobility event notifications to get information about UE’s presence in Area(s) of Interest, as specified in clause 5.3.4.4 of TS 23.501 [5].

4. In case of UE’s presence in the AoI: once the AMF detects the UE’s presence in the NTZ, the AMF sends an N2 message with a new value of 'Index to RAT/Frequency Selection Priority' (RFSP Index) to RAN nodes. Based on the received RFSP Index, the NG-RAN nodes decide about redirecting UEs to different frequency layers or RATs (as specified in clause 5.3.4.3.1 of TS 23.501 [5]).

Editor's Note: How to detect UE transmit in NTZ and how to handle corresponding UL traffic is FFS.

5. If there is any change in the provisioned NTZ information, the RAN nodes and UEs need to be re-provisioned with the newest NTZ information.

6. For UEs/UAV in CM\_CONNECT with RRC\_INACTIVE state or in CM\_IDLE, the AMF may initiate, based on the local policy, the Network Triggered Service Request procedure as described in clause 4.2.3.3 of TS 23.502 [4] before executing Step 3-5. If the UE is not updated while it was in IDLE, the AMF updates the UE next time it becomes available gain (e.g., RRC\_CONNECTED).

### 6.9.4 Impacts on services, entities and interfaces

Impact depends on which options/alternatives selected for delivering NTZ information to UEs and RAN nodes and for updating them about any change from the AF/UTM. Overall, the impacts could be the following:

**AF:**

- Invoking a Naf\_Authentication\_Notification or a new service to request NTZ compliance from the network,

- Receiving notifications when UEs enter or disobey NTZ requirements.

**UAS NF/NEF:**

- Discovering a PCF handling AM policy,

- Discovering AMF serving the UE,

- Retrieving information about UE’s subscription and checking whether the UE can comply with NTZ,

- Translating the NTZ information to 3GPP identifiers such as TA, NG-RAN node identifiers, cell IDs.

**PCF:**

- Invoking AM Policy Association Modification due to NTZ.

**AMF:**

- Determining UE’s location/presence in the area of interest,

- Checking UE’s subscription for NTZ compliance,

- Informing PCF about UE’s capability to respect NTZ,

- Informing RAN nodes about enforcing NTZ requirements,

Editor's Note: It is FFS whether and how (e.g., based on which information) the indication to enforce NTZ is provided by AMF to RAN.

- Informing PCF about UE’s capability to respect NTZ,

- Sending notifications when UE enters the NTZ.

**RAN:**

- delivering NTZ information to the relevant UEs,

- Enforcing NTZ compliance.

**UE/UAV:**

- respecting NTZ requirements,

- announces its capability to comply with NTZ requirements.

**UPF:**

- Handling (e.g., discard, etc.) UL data traffic for UEs in NTZ (FFS if/when needed).

**UDM:**

- Inclusion of NTZ enforcement indication and provide to AMF.

Editor's Note: It is FFS if any additional parameter(s) is needed or existing subscription is sufficient.

## 6.X Solution #X: <Solution Title>

### 6.X.1 Key Issue mapping

Editor's note: This clause lists the key issue(s) addressed by this solution.

### 6.X.2 Description

Editor's note: This clause will describe the solution principles and architecture assumptions for corresponding key issue(s). Sub-clause(s) may be added to capture details.

### 6.X.3 Procedures

Editor's note: This clause describes high-level procedures and information flows for the solution.

### 6.X.4 Impacts on services, entities and interfaces

Editor's note: This clause captures impacts on existing and/or new 3GPP nodes and functional elements.

# 7 Overall Evaluation

Editor's note: This clause provides evaluations of different solutions, if exists.

# 8 Conclusions

Editor's note: This clause will list conclusions that have been agreed during the course of the study item activities.

Annex A:
Background Information about No Transmit Zones

## A.1 CEPT Decision 22(07)

This is an extract of the CEPT Decision 22(07) for No Transmit Zones.

In November 2022, CEPT made Decision 22(07) on Harmonised technical conditions for the usage of aerial UE for communications based on LTE and 5G NR in several bands harmonized for MFCN. The decision assumes multiple technical conditions and requirements to support aerial UEs in mobile systems (both LTE and NR). Two notable ones are no-transmit zone (NTZ) and out-of-band emission (OOBE) requirements, as shown in the following excerpt from the Decision (further details are in the Appendix):

|  |
| --- |
| In addition to the already harmonised technical conditions for MFCN bands and for spectrum compatibility purposes, there is the need to define some spectrum operational restrictions. This can be done using "no-transmit zones", which should be defined at national level as a geographical area where aerial UE are not allowed to operate in a certain frequency band. Another measure to achieve coexistence is to define additional OOB emission limits specific to aerial UE (to avoid interference to other services in some other bands (e.g. to protect MetSat at 1675-1710 MHz). The requirement may apply to aerial UE according to their operational frequency band, e.g. aerial UE operating in a specific band or specific channel (see no-fly zone definition set out in ECC Report 309, in this Decision referred to as "no-transmit zone"). In some cases, operation of aerial UE also requires respective cross-border coordination agreements.. . .**ECC DECISION OF 18 NOVEMBER 2022 ON HARMONISED TECHNICAL CONDITIONS FOR THE USAGE OF AERIAL UE FOR COMMUNICATIONS BASED ON LTE AND 5G NR IN T****HE 703-733 MHZ, 832-862 MHZ, 880-915 MHZ ,1710-1785 MHZ, 1920-1980 MHZ, 2500-2570 MHZ AND 2570-2620 MHZ MFCN HARMONISED BANDS (ECC DECISION (22)07)**"The European Conference of Postal and Telecommunications Administrations,*Considering*. . .*l) that a no-transmit zone in this Decision is defined as a geographical area where aerial UE are not allowed to transmit for spectrum compatibility purposes in a given harmonised MFCN band or part of it;**m) that national studies are needed, as appropriate, to define no-transmit zones for spectrum compatibility purposes, for aerial UE operating in the relevant frequency bands;**n) that a mechanism is necessary to ensure that aerial UE respect no-transmit zones;*. . .*DECIDES*. . .*that no-transmit zones as described in this Decision should be defined and implemented at national level and where necessary coordinated with neighbouring countries;* |

Some further details on no-transmit zones from the ECC Decision 22(07)

|  |
| --- |
| **A1.2 OPERATIONAL CONDITIONS**The operational conditions to be defined and implemented at national level provide additional measures to the technical conditions in order to protect other services.**703-733 MHz: Protection of DTT receivers and RAS sites** Aerial UE operating in 703-733 MHz should not transmit when less than 30 m above ground level to avoid interference to DTT receivers; Nationally determined no-transmit zones are required around RAS sites operating in 1400-1427 MHz for aerial UE operating in the 703-718 MHz frequency band, as appropriate.**832-837 MHz: Protection of RAS sites** Nationally determined no-transmit zones are required around RAS sites operating in 1660-1670 MHz for aerial UE operating in the 832-837 MHz frequency band, as appropriate.**2500-2570 MHz/2570-2620 MHz: Protection of RAS sites and radars** Nationally determined no-transmit zones are required around RAS sites operating in 2690-2700 MHz for aerial UE operating in the 2500-2570 MHz or 2570-2620 MHz frequency band, as appropriate; Nationally determined no-transmit zones might be required around radars operating in 2700-2900 MHz for aerial UE operating in the 2500-2570 MHz or 2570-2620 MHz frequency band. |

Annex B:
Change history

|  |
| --- |
| Change history |
| Date | Meeting | TDoc | CR | Rev | Cat | Subject/Comment | New version |
| 2024-01 | SA2#160e-adhoc | S2-2400226 | - | - | - | First version of the TR skeleton produced | 0.0.0 |
| 2024-01 | SA2#160-Ad Hoc-e | S2-2400169, S2-2401814, S2-2401815, S2-2401816, S2-2401817, S2-2401818, S2-2401819 | - | - | - | Approved pCRs implemented | 0.1.0 |
| 2024-03 | SA2#161 | S2-2403270,S2-2403694, S2-2403846, S2-2403273, S2-2403274, S2-2403695, S2-2403697, S2-2403840, S2-2403699 | - | - | - | Approved pCRs implementedSome editorial changes by rapporteurs-Added RTA in the acronym list-To use inclusive terminologies (i.e. to avoid non-inclusive terminologies) according to TR 21.801- In Sol#4: modify unmanned to uncrewed, manned to crewed- In Sol#7: modify blacklist to blocklist, whitelist to allowlist-Added reference to 23.287-Corrected many formatting errors and clause numbering | 0.2.0 |