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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, certain modal verbs have the following meanings:

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

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

NOTE 1: The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

NOTE 2: 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

NOTE 3: 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

NOTE 4: The constructions "can" and "cannot" shall not to be used as 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

NOTE 5: The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

This study item shall address the following system enablers for 5GS and EPS to support additional scenarios and requirements for UAV (Uncrewed Aerial Vehicles) and UAM (Urban Air Mobility) by identifying how and whether existing mechanisms can be re-used, and identifying architectural and functional modifications required:

- a mechanism to transport Broadcast Remote Identification and C2 communications via the 3GPP system;

- a mechanism to support aviation applications such as Detect And Avoid (DAA).

# 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 23.501: "System architecture for the 5G System (5GS)".

[3] 3GPP TS 23.502: "Procedures for the 5G System (5GS)".

[4] 3GPP TS 22.125: "Uncrewed Aerial System (UAS) support in 3GPP".

[5] 3GPP TS 23.256: "Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking".

[6] DEPARTMENT OF TRANSPORTATION Federal Aviation Administration 14 CFR Parts 1, 11, 47, 48, 89, 91, and 107 [Docket No.: FAA-2019-1100; Amdt. Nos. 1-75, 11-63, 47-31, 48-3, 89-1, 91-361, and 107-7] RIN 2120-AL31 Remote Identification of Unmanned Aircraft.

[7] EASA NPA 2021-14: "Notice of Proposed Amendment 2021-14".

[8] 3GPP TS 23.304: "Proximity based Services (ProSe) in the 5G System (5GS)".

[9] 3GPP TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".

[10] 3GPP TR 23.754: "Study on supporting Unmanned Aerial Systems (UAS) connectivity, Identification and tracking".

[11] 3GPP TS 23.273: “5G System (5GS) Location Services (LCS)”.

[12] ASTM F3411.19 “Standard Specification for Remote ID and Tracking”

[13] ASD-STAN prEN 4709-002:2022-03, Aerospace series - Unmanned Aircraft Systems - Part 002: Direct Remote Identification

# 3 Definitions of terms and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1], TS 23.256 [5] 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] or TS 23.256 [5].

**U2X communication:** A communication to support UAV-to-Everything (U2X) services leveraging Uu and / or PC5 reference points. U2X services are realized by various types of U2X applications, i.e. UAV-to-UAV (U2U) and UAV-to-Network (U2N).

**U2X message:** A dedicated messaging type of U2X service, for example Broadcast Remote ID messages.

**U2X service type:** A type of U2X service, which is identified by e.g. ITS-AID (ITS Application Identifier), PSID (Provider Service Identifier) or AID (Application Identifier).

## 3.2 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].

BRID Broadcast Remote Identification

C2 Command and Control

DAA Detect And Avoid

RID Remote Identification

TPAE Third Party Authorized Entity

UAS Uncrewed Aerial System

UAV Uncrewed Aerial Vehicle

U2X UAV to everything

U2XP U2X Policy

# 4 Architectural Assumptions and Principles

## 4.1 Architectural Requirements

- When applicable, existing UAV authentication and authorization procedures specified in TS 23.256 [5] should be reused as much as possible for solutions.

- When applicable, solutions that involve UAV to UAV communications should apply to UAVs of different PLMNs.

- Solutions should consider both UAVs in coverage and UAVs out of coverage, though different solutions may apply to the two cases.

- When applicable, solutions should be backward compatible with mechanisms specified in TS 23.256 [5].

## 4.2 Architectural Assumptions

The following architectural assumptions apply:

- Solutions for transport of broadcast remote identification shall support existing regulations for remote identification, including FAA regulations ([6]) and U-Space regulations EASA NPA 2021-14 ([7]).

- For solutions using PC5, the use of relay communications is not considered in this study.

- A UAV shall obtain authorization from 3GPP system and USS to perform direct C2 communication as defined in TS 22.125 [4].

# 5 Key Issues

## 5.1 Key Issue #1 - Transport C2 communication over PC5 interface

This key issue focuses on the transport of C2 communications over PC5 in the 3GPP system. This includes studying how to enable the direct C2 communication (as defined in TS 22.125 [4]) between a UAV and a UAV controller. The following aspects are to be considered:

- whether PC5 can support C2 communications between a UAV and a UAV controller;

- Whether any architectural modifications are required, and what they are, with respect to the current solutions using PC5 (e.g. ProSe, C-V2X):

- this includes studying both scenarios where both the UAV and the UAV controller are registered to the 5GS, and scenarios where the UAV controller may not be registered to the 5GS or may not have Uu capabilities;

- this includes studying both scenarios where radio resources used for PC5 are configured and scheduled by the MNO (in coverage operation), and scenarios where the radio resources used for PC5 are "non-operator-managed", as defined in TS 23.304 [8] and TS 23.287 [9];

- Whether and how the existing PC5-based Unicast communication can be reused and/or extended to transport C2 communication;

- how is the C2 communication over PC5 between a UAV and UAV controller established;

- how is the UAV authorized for setting up direct C2 communication over PC5 with a UAV controller, both for in-coverage and out of coverage scenarios, and how is the authorization revoked;

- whether the UAV needs to discover the UAV controller, or vice versa and if so, how?

## 5.2 Key Issue #2 - Support of Broadcast Remote ID

This key issue focuses on the transport of Broadcast Remote Identification in the 3GPP system. The following aspects are to be considered:

- Whether and how PC5-based solutions can be reused and/or extended to transport Broadcast Remote Identification, and whether any architectural modifications are required, and what they are, with respect to the current solutions using PC5 (e.g. ProSe, C-V2X):

- This includes whether and how the existing PC5-based solutions, e.g. broadcast over PC5 can be reused and/or extended to transport Broadcast Remote ID;

- Whether solutions based on Uu interface can be used to transport Broadcast Remote Identification

For all solutions, study whether they support mandatory regional regulations (e.g. see annex in TR 23.754 [10] and EASA NPA 2021-14 [7]).

## 5.3 Key Issue #3 - Support of Detect and Avoid Mechanism in 3GPP system

This key issue focuses on the support of detect and avoid mechanisms in the 3GPP system, based on requirements for DAA defined in TS 22.125 [4]. The following aspects are to be considered:

- Whether any architectural modifications are required, and what they are, with respect to the current solutions using PC5 (e.g. ProSe, C-V2X), to support direct UAV to UAV communication for the purpose of DAA:

- For solutions based on direct UAV-to-UAV communication mechanisms, whether only broadcast communications are required, or whether also unicast and/or groupcast communications are required, and whether and how current solutions can be re-used or extended;

- Whether network-assisted (ground based) DAA solutions are applicable, what solutions may be applicable, and whether a combination of network-assisted and direct solutions should be defined;

- What assumptions need to be made about considering security solutions outside of 3GPP, e.g. similar to application layer security as in C-V2X. It is assumed security discussion is to be coordinated with SA WG3.

## 5.X Key Issue #X: <Key Issue Title>

### 5.X.1 Description

Editor's Note: This clause provides a description of the key issue.

# 6 Solutions

Editor's Note: This clause is intended to document the agreed architecture solutions. Each solution should clearly describe which of the key issues it covers and how.

## 6.0 Mapping Solutions to Key Issues

Table 6.0-1: Mapping of Solutions to Key Issues

|  |  |
| --- | --- |
|  | Key Issues |
| Solutions | 1 | 2 | 3 |  |  |  |  |
| 1 | X |  |  |  |  |  |  |
| 2 |  |  | X |  |  |  |  |
| 3 |  | X |  |  |  |  |  |
| 4 | X |  |  |  |  |  |  |
| 5 |  | X | X |  |  |  |  |

## 6.1 Solution #1: <Solution Title>

### 6.1.1 Key Issue mapping

This solution addresses KI#1.

### 6.1.2 Description

6.1.2.1 General assumptions

The solution is based on the below assumptions:

- In a UAS system, that comprises of a UAV and a UAV-C, both the UAV and the UAV-C use either "operator managed" or "non-operator managed" radio resources for Direct Discovery and Communication.

- In a geographical area whether "operator managed" or "non-operator managed" frequency band is used for Direct Discovery and Communication is defined by local regulations.

- In one alternative it is possible that the UAV and UAV-C may come pre-paired, i.e. the UAV is always controlled by a single permanent controller. In this case both the UAV and the UAV-C may be configured with the Layer 2 ID of paired device, to be used for Direct Communication.

- In another alternative the UAV and UAV-C pairing may be dynamically done. In this case the Direct Discovery method may be used to learn the Layer 2 ID for Direct Communication.

- Either the UAV or the UAV-C is configured to perform discovery and Direct Communication Request.

- Only IPv4/IPv6 or unstructured data unit types are supported for C2 communication using PC5.

- For authorization of direct C2 communication over PC5, the existing mechanism for authorization of Direct Discovery and Direct Communication apply as explained in clause 6.1.3.1. The Authorization of C2 communication over a PDU session as specified in TS 23.256 is not applicable for direct C2 communication over PC5.

- Current limitations w.r.t. range for direct communication over PC5 interface apply for C2 communication using PC5 interface.

Editor's Note: It is FFS whether the UAV/UAV-C needs to support ProSe or only the associated procedures for PC5

### 6.1.2.1 Mapping of ProSe Architectural reference model to UAS architecture

Editor's Note: It is FFS how the ProSe reference architecture is mapped to the UAS architecture.

### 6.1.3 Procedures

#### 6.1.3.1 Authorization for Direct Discovery and Direct Communication

##### 6.1.3.1.1 Authorization of Direct Discovery

The UAV and the UAV-C are provisioned with following sets of information for Direct Discovery over PC5 reference point:

- Authorization policy for Restricted 5G ProSe Direct Discovery as described in clause 5.1.2.1 of TS 23.304

- The mapping of ProSe services (i.e. ProSe identifiers for C2) to Destination Layer-2 ID for sending/receiving initial signalling of discovery messages.

- Application identifier for C2 communication to be used for Direct Discovery over PC5 interface.

- Security parameters used for direct discovery over PC5

- Radio parameters when the UAV/UAV-C is "not served by NG-RAN" as explained in 5.1.2.1 of TS 23.304

- Restricted ProSe Discovery UE ID for Restricted Direct Discovery

- Group Member Discovery parameters as explained in 5.1.2.1 of TS 23.304 that is required for UAV/UAV-C to identify the which UAV can be controlled by a Controller and vice versa.

- Validity timer indicating the expiration time of the Policy/Parameter for Direct Discovery.

The UAV and UAV-C may be pre-configured with the required provisioning parameters for Direct Discovery, without the need for them to connect to the 5GC to get this initial configuration.

The UAV/UAV-C uses the principles defined in clause 5.1.2.2 of TS 23.304 for applying parameters for Direct Discovery.

##### 6.1.3.1.1 Authorization of Direct Communication

For Direct Communication the UAV and UAV-C shall comply with the principle described in clause 5.1.3 of TS 23.304 with following considerations specific for UAS:

- Only the mapping of ProSe services (i.e. ProSe identifiers for C2) to default Destination Layer-2 ID(s) for initial signalling to establish unicast connection is provisioned in the UAV-C. Mapping to Destination Layer-2 ID(s) for broadcast and groupcast is not needed/provisioned.

#### 6.1.3.2 C2 communication using PC5 Unicast link in 5G

The PC5 based Unicast link for C2 communication between the UAV and the UAV controller is only supported over NR based PC5 reference point. Figure 6.1.3.2-1 illustrates an example of PC5 unicast link for C2 communication.



Figure 6.1.3.1-1: C2 communication between UAV and UAV-C using PC5 Unicast Link

For C2 communication over the PC5 unicast link, the principles of Unicast mode 5G ProSe Direct Communication as specified in clause 5.3.4 of TS 23.304 apply with following considerations specific to UAV and UAV-C:

- A PC5 unicast link between the UAV and the UAV-C allows communication between the Application (i.e. the C2 communication service) running in the UAV and UAV-C. The Application used for C2 communication in Figure 6.1.3.1-1 is named as "C2 communication service".

- The Application Layer Identity identifies the UAV and the UAV-C uniquely in the context of the C2 communication. The format of this identifier is outside the scope of 3GPP.

- The PC5 unicast link supports C2 communication using a single network layer protocol e.g. IP or non-IP.

- There may be multiple QoS flow in a single PC5 Unicast Link for C2 communication. This is based on the per-flow QoS model as specified in clause 5.6.1 of TS 23.304.

##### 6.1.3.2.1 PC5 Unicast link establishment for C2 communication

This procedure is performed when the UAV is always controlled by a single UAV-C. The Application Layer ID and the Layer-2 IDs of the peers are pre-configured in the UAV and the UAV-C.

To perform unicast mode of Direct communication over PC5 reference point for C2 communication, the UE is configured with the related information as described in clause 6.1.3.1.1.

Figure 6.1.3.2.1-1 shows the PC5 Unicast Link establishment for C2 communication which is based the procedure for Layer-2 link establishment over PC5 reference point as described in clause 6.4.3.1 of TS 23.304.

For PC5 Unicast link established, only "UE oriented Layer-2 link establishment" procedure as described in clause 6.4.3.1 if TS 23.304 (option A) is supported for UAV.

Editor's Note: It is FFS whether a single UAV-C can control multiple UAVs at the same time. If so, the UAV-C may broadcast Direct Communication Request and "ProSe Service oriented Layer-2 link establishment" procedure as described in clause 6.4.3.1 if TS 23.304 (option B) may be supported.

The procedure for Layer-2 link establishment over PC5 reference point as described in clause 6.4.3.1 of TS 23.304 is followed with below modification:



Figure 6.1.3.2.1-1: PC5 Unicast Link establishment for C2 communication

1. The UAV determines the destination Layer-2 ID for reception of signalling related to PC5 unicast link establishment for C2 communication.

2. The application layer (i.e. the C2 communication service) of the UAV-C provides application information for PC5 unicast communication. The application information shall include the Service Info, UAV-C's Application Layer ID and the target UAV's Application Layer ID.

3. The UAV-C unicasts a Direct Communication Request message to the UAV using the configured source Layer-2 ID and the destination Layer-2 ID.

4. Same as step 4a in clause 6.4.3.1 of TS 23.304

5. Same as step 5a in clause 6.4.3.1 of TS 23.304

6. Same as step 6 in clause 6.4.3.1 of TS 23.304. C2 communication data can be now transmitted over the established unicast link. The UAV-C sends the C2 data using its own Layer-2 ID as the source Layer-2 ID and UAV's Layer-2 ID as the destination Layer-2 ID for this unicast link. Similarly, the UAV uses its own Layer-2 ID as the source Layer-2 ID and the UAV-C's Layer-2 ID as the destination Layer-2 ID when sending C2 communication data to the UAV-C.

##### 6.1.3.2.2 PC5 Unicast link establishment for C2 communication with dynamic discovery

This procedure is performed when the UAV is controlled different UAV-C at different time i.e. there is no fixed controller dedicated to a UAV. The UAV-C learns the Layer-2 ID of the UAV using the Direct Discovery procedure and then the UAV-C uses the Layer-2 ID for establishing the PC5 Unicast link.

Figure 6.x.3.2.2-1 shows the PC5 Unicast Link establishment for C2 communication with dynamic discovery of the UAV.



Figure 6.1.3.2.2-1: PC5 Unicast Link establishment for C2 communication with dynamic discovery

1. The UAV-C uses the Direct Discovery (wither Model A or Model B) as described in clause 6.3 of TS 23.304 to discover the UAV and the associated Layer-2 ID. Restricted discovery mechanism is used for UAV discovery. When model A is used the UAV-C acts as the announcing UE and the UAV acts as the monitoring UE. In model B, the UAV-C acts as the discoverer and the UAV acts as the discoveree.

2. After the Layer-2 ID of the UAV is learnt by the UAV-C at step 1, it follows the procedure described in clause 6.x.3.2.1 to establish the PC5 Unicast Link.

3. C2 communication data can be now transmitted over the established unicast link. The UAV-C sends the C2 data using its own Layer-2 ID as the source Layer-2 ID and UAV's Layer-2 ID as the destination Layer-2 ID for this unicast link. Similarly, the UAV uses its own Layer-2 ID as the source Layer-2 ID and the UAV-C's Layer-2 ID as the destination Layer-2 ID when sending C2 communication data to the UAV-C.

#### 6.1.3.3 C2 communication over P5 in E-UTRA

Editor's Note: To be updated.

### 6.1.4 Impacts on Services, Entities, and Interfaces

Editor's Note: This clause captures impacts on existing 3GPP services, entities, and interfaces.

6.2 Solution #2: Network-assisted DAA

6.2.1 Key Issue mapping

This solution tries to solve the key issue that what network-assisted (ground based) DAA solution may be applicable.

6.2.2 Description

USS knows the flight path of each UAV UE during the UAV Flight Authorization procedure or Application layer report. In some case, the flight path of different UAV UEs is overlapped or within the same area. USS can request to the 5GS system to perform the DAA between any two UAV UEs whose flight path may be overlapped or within the same area, i.e., network-assisted DAA solution is used.

The network-assisted DAA is useful, for scenarios where regulations might not consider a device to device solution sufficient or for scenarios where the availability of PC5 connectivity in all UAVs cannot be assumed.

This solution applies to the UAV UEs belonging to the same PLMN. For the UAV UEs belonging to the different PLMNs, USS can get the UAV location from the network and check by itself.

Editor’s NOTE: it is FFS how the solution works if multiple USS operated by different parties serve a specific country.

6.2.3 Procedures



Figure 6.2.3-1: High-level procedure for network-assisted DAA

1. USS as AF/LCS client sends the relative positioning request to GMLC, including UAV UE1 ID (UE1 GPSI) and UAV UE2 ID (UE2 GPSI), and optional including a distance threshold. GMLC determines a scheduled location time to get the location information of UE1 and UE2 at the same time.

2. GMLC obtains UAV UE1 location using GMLC based procedure as described in clause 6.1.2 of TS 23.273 [11], where the scheduled location time determined in step 1 is used.

3. GMLC obtains UAV UE2 location using GMLC based procedure as described in clause 6.1.2 of TS 23.273 [11], where the scheduled location time determined in step 1 is used.

4. GMLC calculates the relative positioning result based on the UAV UE1 location and UAV UE2 location from step 2 and step 3.

5. GMLC reports the relative position result to USS. And optionally before that, GMLC checks the relative position result is lower than the distance threshold.

After the USS gets the relative position result, USS may send the DAA notification to UAV or the corresponding UAV controller via application layer, so that the UAV can change the flight path timely to avoid the collisions. The specific action of USS is out of scope of this specification.

This solution can be extended to cover the DAA between any two UAV UEs in a UAV UE list, where USS provides a UAV UE list in the relative positioning request of step 1.

6.1.4 Impacts on Services, Entities, and Interfaces

GMLC**:**

- Support of calculate the relative positioning between any two UAV UEs.

## 6.3 Solution #3: MBS-based UAV remote ID broadcast

### 6.3.1 Key Issue mapping

This solution address key issue#2: Support of Broadcast Remote ID

### 6.3.2 Description

When UAV UE registers to the network, based on TS 23.256, the AMF is aware of the UAV subscription, and interacts with the USS for authentication an authorization.

NOTE: this solution applies only to UAVs that have a 3GPP subscription, have Uu capability, are in coverage, and are registered to the 3GPP system.

Editor’s Note: whether the solution is applicable where regulations require the support of Broadcast Remote ID even for UAVs without 3GPP subscription, without Uu capability, and to receivers without 3GPP subscription and without Uu capability is FFS.

Overview of the solution:

- USS/UTM knows the UAV location based on UAV location reporting, defined in clause 5.3.2, TS 23.256. In detail, USS/UTM triggers the deferred location request indicating a location event, to subscribing for notification when the UAV moves in/out of a geographic area.

- USS/UTM to broadcast remote identification via MBS system in specific area. USS/UTM may establish a single broadcast session to deliver all the broadcast remote ID(s).

Editor’s Note: whether to establish multiple broadcast session, e.g. one session per a geographic area, and how the server informs it to the UE is FFS.

- USS/UTM triggers location request to the 5G network for the UE location reporting. This is used by the USS/UTM to n

- The broadcast session establishment may take place by the USS/UTM(server) at any time, or triggered by a UAV registration (after UUAA procedure)

Editor’s Note: it is FFS how the location of the UAV-C is known to the USS/UTM in order to be broadcasted together with the location of the UAV to satisfy standards and regulations that mandate this.

### 6.3.3 Procedures



Figure 6.3.3-1 MBS-based UAV remote ID broadcast

Editor’s Note: missing step details like how server (USS/UTM) interacts with MB-SMF, how server (USS/UTM) retrieves UAV location, how server (USS/UTM) determines to establish one or multiple broadcast session, whether and how USD and other service data configuration of the UAV are FFS.

Step 0 broadcast session is established using mechanism defined in TS 23.247. The USS/UTM (server) firstly requests to the NEF/UAS NF for the broadcast session establishment.

Step 1 UAV UE registers to the network and establishes user plane connection with USS/UTM (server).

Step 2 UAV UE reports its remote ID to the server, via user plane.

Step 3 if the broadcast session is not yet established, triggered by step 2, USS/UTM requests the 5G network to establish a broadcast session using mechanism defined in TS 23.247. USS/UTM (server) firstly requests to the NEF/UAS NF for the broadcast session establishment.

After the broadcast session is established, USS/UTM (server) starts to broadcast the remote ID of UAV.

Editor’s Note: whether additional parameter needs to broadcast is FFS.

### 6.3.4 Impacts on Services, Entities, and Interfaces

Editor's note: This clause captures impacts on existing 3GPP services, entities, and interfaces.

## 6.4 Solution #X: Direct C2 communication over PC5

### 6.4.1 Key Issue mapping

This solution aims to address Key Issue #1.

### 6.4.2 Description

In this solution, a UAV and a UAV-C follows V2X (see TS 23.287 [9]) direct communication procedure to establish a secure C2 communication link over PC5. Both UAV and UAV-C supports PC5, but may or may not support Uu connection.

If the UAV is capable of Uu connection, it is authenticated and authorized by the USS for C2 over PC5 prior to establishing C2 communication over PC5, following existing R17 procedures. The UAV may be provisioned with necessary information for C2 over PC5 (identifiers, security info, etc.) through these procedures. The UAV may also use this information for C2 if preconfigured in the UAV.

Identifiers used for establishing PC5 direct communication for C2:

- **UAS** **Service Identifier:** The UAV derives a Service ID for C2 over PC5 that's equivalent of V2X Service Type (see [9]) from its CAA-Level UAV ID. Or the UAV may be preconfigured or provisioned with the Service ID for C2 over PC5. The UAS Service Identifier can be used to derive Destination Layer-2 ID as described in 5.6.1.4 of TS 23.287 [9].

Editor’s Note: the exact motivation and value of deriving the Service ID from the CAA-Level UAV ID is FSS.

- **Source Layer-2 ID and Destination Layer-2 ID**: The L2 IDs can be configured or derived using the existing mechanisms described in 5.6.1.4 of TS 23.287 [9].

### 6.4.3 Procedures

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



Figure 6.4.1-1: Establishing C2 communication over PC5

1. If the UAV is capable of Uu communication, the UAV performs UUAA procedure as described in 5.2.2 or 5.2.3 of TS 23.256 [5]. The UAV may obtain a new CAA-Level UAV ID through this procedure. The UAV uses the new CAA-Level UAV ID or a pre-configured CAA-Level UAV ID in the following steps.

2. If the UAV is capable of Uu communication, the UAV performs C2 Authorization procedure as described in 5.2.5 of TS 23.256 [5]. The UAV may obtain the UAV-C identification/addressing information and optionally security information for C2 communication through this procedure. In the following steps, the UAV uses the UAV-C information obtained during C2 authorization or pre-configured.

3. To set up C2 communication over PC5, the UAV sends Direct Communication Request to initiate the unicast layer-2 link establishment. The DCR includes:

 - Source User Info: the UAV's CAA-Level UAV ID.

Editor’s Note: whether the UAV CAA-Level UAV ID or other identifiers are used as the Source User Info is FFS.

- Target User Info: if the UAV-C identifier is available in the UAV, the UAV uses it as the target user info. If the UAV-C identifier is not available, Target User Info is not included in the DCR and service-oriented link established as described in 6.3.3.1 of TS 23.287 [9] applies.

- UAS Service Identifier: the service identifier may be preconfigured or derived from the UAV's CAA-Level UAV ID.

- Security Info

4. The UAV-C responds and establishes the security with the UAV, as described in TS 33.536 [x].

5. The UAV-C sends Direct Communication Accept over the established link.

6. The UAV and UAV-C can start C2 communication over PC5.

### 6.4.4 Impacts on Services, Entities, and Interfaces

Editor's Note: This clause captures impacts on existing 3GPP services, entities, and interfaces.

## 6.5 Solution #X: U2X for support of Broadcast Remote ID and direct DAA via PC5

### 6.5.1 Introduction

This solution applies to KI#2 and KI#3.

### 6.5.2 Functional Description

The high-level points of the proposed UAV-to-everything (U2X) solution are:

- U2X leverages V2X mechanisms as defined in TS 23.287 [9] to support BRID and direct DAA, with the differences described in this solution

- both LTE PC5 and NR PC5 are supported, and the RAT selection is based on the U2XP.

- Communications modes:

- Broadcast communication mode is used for BRID

- Broadcast communication mode is used for DAA to advertise UAV information, and unicast over PC5 may be used between two UAVs for DAA deconfliction

Editor’s Note: unicast over Uu via the U2X AS is FFS due to lack of requirements.

- When NR PC5 is selected, connection-less groupcast communications may be used for DAA. Application layer managed groupcast are not considered in this release due to lack of clear requirements

- U2X is supported by an U2X Application Server which interfaces with the operator network via NEF, as in the case of the V2X Application Server

Editor’s Note: whether the same set of services is required or not is FFS.

NOTE 1: multiple deployment scenarios need to be allowed where the U2X AS and the USS serving a UAV are the same or different entities.

- a U2X Policy (U2XP) is defined to provide configuration parameters to the UE for U2X communication over the PC5 reference point or over the Uu reference point

- the configuration parameters may be pre-configured in the ME, or configured in the UICC, or preconfigured in the ME and configured in the UICC, or provided/updated by the U2X Application Server via PCF and/or V1 reference point, or provided/updated by the PCF to the UE.

- the UE shall consider them in the following priority order: provided/updated by the PCF, provided/updated by the U2X Application Server via V1 reference point, configured in the UICC, pre-configured in the ME.

NOTE 2: a scenario where the U2X Application Server provides the U2XP to the UAVC via means of communication outside the scope of 3GPP (e.g. Internet connection) over U2X1, and the UAVC provides the U2XP to the UAV is also considered. In such case, the UE considers the parameters as being pre-configured in the ME.

- Similar to V2X, Tx Profiles or NR Tx Profiles are determined based on U2XP mapping ofU2X service types.

- both UAVs with UICC and UAVs without UICC (i.e. with no subscription to an MNO) are supported.

- UAVs with no UICC can only perform U2X communications when authorized for “not served by E-UTRA” and “not served by NR”

- U2X communications parameters from U2X Application Server or PCF may be delivered via UAV-C UE

- The transmission method between the UAV and UAV-C UE is out of the scope of the specification

- in addition to existing parameters for V2X, the radio parameters per PC5 RAT (i.e. LTE PC5, NR PC5) can be configured with Geographical Area, Altitude Limitation, and Validity timer

- this additional information may be needed to enable policing the use of PC5 depending on the specific location of the UAV

- the definition of DAA/UAV service type is out of scope of 3GPP

- the use of PC5-based communications for BRID and DAA for UAV with UICC is subjected to successful UUAA authentication/authorization of the UAV as defined in TS 23.256 [5] and authorization via U2XP. However, no specific authorization of the use of PC5 for either BRID or DAA is required by the USS. For UAVs without UICC, the use of PC5-based communications for BRID and DAA is authorized only by U2XP.

Editor’s Note: whetherU2X services will be identified by more than one, and which ones, of e.g. ITS-AID (ITS Application Identifier), PSID (Provider Service Identifier) or AID (Application Identifier) is FFS.

The functional architecture is as follows:



Figure 6.5.2-1: Non-roaming 5G System architecture for U2X communication over PC5 and Uu reference points.

The reference points of TS 23.287 [9] apply, with the following differences:

**U2X1**: The reference point between the U2X applications in the UE and in the U2X Application Server. This reference point is out of scope of this specification.

**U2X5**: The reference point between the U2X applications in the UEs. This reference point is not specified in this release of the specification.

**N1**: In addition to the relevant functions defined in TS 23.501 [2] for N1, in the case of U2X Service it is also used to convey the U2X policy and parameters (including service authorization) from AMF to UE and to convey the UE's U2X Capability and PC5 Capability for U2X information from UE to AMF.

**N2**: In addition to the relevant functions defined in TS 23.501 [2] for N2, in the case of U2X Service it is also used to convey the U2X policy and parameters (including service authorization) from AMF to NG-RAN.

Use or U2X for BRID:

- the content of the messages for BRID are defined according to the regional regulations for BRID (e.g. message set of ASTM F3411.19 [12] or ASD-STAN prEN 4709-002 P1 [13]) and optionally according to regional mean of compliance documents.

Editor’s Note: references to means of compliance will be listed as example when available.

Use of U2X for DAA:

- the content of the messages for DAA are defined according to the regional regulations for DAA and is out of scope of this specification

### 6.5.3 Procedures

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

### 6.5.4 Impacts on services, entities and interfaces

The following impacts have been identified:

* UE: In addition to the functions defined in TS 23.501 [2], the UE may support the following functions

- Report the U2X Capability and PC5 Capability for U2X to 5GC over N1 reference point.

- Indicate U2X Policy Provisioning Request in UE Policy Container for UE triggered U2X Policy provisioning.

- Receive the U2X parameters from 5GC over N1 reference point.

- Procedures for U2X communication over PC5 reference point.

- Configuration of parameters for U2X communication. These parameters can be pre-configured in the UE, or, if in coverage, provisioned or updated by signalling over the N1 reference point from the PCF in the HPLMN or over U2X1 reference point from the U2X Application Server.

* AMF: In addition to the functions defined in TS 23.501 [2], the AMF performs the following functions:

- Obtain from UDM the subscription information related to U2X and store them as part of the UE context data.

- Select a PCF supporting U2X Policy/Parameter provisioning and report the PC5 Capability for U2X to the selected PCF.

- Obtain from PCF the PC5 QoS information related to U2X and store it as part of the UE context data.

- Provision the NG-RAN with indication about the UE authorization status about U2X communication over PC5 reference point.

- Provision the NG-RAN with PC5 QoS parameters related to U2X communication.

- PCF: In addition to the functions defined in TS 23.501 [2], the PCF includes the functions described in 23.287 [9] to provision the UE and AMF with necessary parameters in order to use U2X communication

- UDM: Subscription management for U2X communication over PC5 reference point. The UE subscription data types are extended according to the following table:

|  |  |  |
| --- | --- | --- |
| U2X Subscription data  | NR U2X Services Authorization | Indicates whether the UE is authorized to use the NR sidelink for U2X services as UAV UE, UAV-C UE, or Authority UE. |
|  | LTE U2X Services Authorization | Indicates whether the UE is authorized to use the LTE sidelink for U2X services as UAV UE, UAV-C UE, or Authority UE. |
|  | NR UE-PC5-AMBR | AMBR of UE's NR sidelink (i.e. PC5) communication for U2X services. |
|  | LTE UE-PC5-AMBR | AMBR of UE's LTE sidelink (i.e. PC5) communication for U2X services. |

* U2X Application Server: implements a subset of the V2X AS functionality specified in TS 23.287 [9]:

- includes AF functionality, and may support at least the following capabilities:

Editor’s Notes: whether any uplink data from the UE or downlink data to the UE is required for U2X service handling is FFS.

- For U2X service parameters provisioning, the U2X AS provides the 5GC and the UAV UE (possibly via the UAVC) with parameters for U2X communications over PC5 and Uu reference points.

- UDR: In addition to the functions defined in TS 23.501 [2], the UDR stores U2X service parameters.

- NRF: In addition to the functions defined in TS 23.501 [2], the NRF performs PCF discovery by considering U2X capability.

- NEF: for U2X AS, the NEF supports U2X service parameters.

## 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 3GPP services, entities, and interfaces.

# 7 Overall Evaluation

Editor's Note: This clause will provide evaluation of different solutions.

# 8 Conclusions

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

Annex A:
Change history

|  |
| --- |
| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-02 | SA2#149 | S2-2201196 | - | - | - | TR Skeleton | 0.0.0 |
| 2022-02 | SA2#149 |  | - | - | - | Inclusion of documents approved in SA2#149-e:S2-2201198, S2-2201342, S2-2201343, S2-2201344, S2-2201345, S2-2201346, S2-2201347. | 0.1.0 |
| 2022-04 | SA2#150E |  | - | - | - | Inclusion of documents approved at SA2#150E: S2-2203273, S2-2203274, S2-2203275, S2-2203276, S2-2203277 | 0.2.0 |