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| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on enhanced Application Architecture for UAS applications;  (Release 18) | |
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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:

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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.

# Introduction

As part of Rel-17, 3GPP TS 23.255 [3] specified the overall application layer architecture to enable application support for UAS applications over 3GPP networks, generic support for UAS applications were specified in the SEAL layer as outlined in 3GPP TS 22.434 [5], while general UAS-related aspects for the 3GPP-architecture were specified in 3GPP TS 23.256 [4].

In Rel-18, the UAS application layer architecture requires enhancements to further improve and enhance functionality in 3GPP for improved support assisting the aviation industry.

# 1 Scope

The present document analyze requirements and identify key issues and develop potential enhancements to the UAS application architecture. The study includes identification of potential enhancements to the UAS architecture, potential enhancements to the Service Enabler Architecture Layer (SEAL) and corresponding application requirements.

The study bases its work on the existing stage 1 work within 3GPP related to UAS as specified in 3GPP TS 22.125 [2].

The conclusions of the study will be aligned with 3GPP TR 23.700-58 [6]. The recommendations from the study include solutions for the UAS architecture and SEAL that will be considered for normative work.

# 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 22.125: “Uncrewed Aerial System (UAS) support in 3GPP”.

[3] 3GPP TS 23.255: “Application layer support for Uncrewed Aerial System (UAS); Functional architecture and information flows”.

[4] 3GPP TS 23.256: “Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2”.

[5] 3GPP TS 23.434: “Service Enabler Architecture Layer for Verticals (SEAL); Functional architecture and information flows”.

[6] 3GPP TR 23.700-58: “Study of further architecture enhancements for uncrewed aerial systems and urban air mobility”.

[7] 3GPP TS 23.304: “Proximity based Services (ProSe) in the 5G System (5GS)”.

[8] 3GPP TS 23.502: “Procedures for the 5G System (5GS)”.

[9] 3GPP TS 23.303: “Proximity-based services (ProSe); Stage 2”.

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP 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 3GPP TR 21.905 [1].

## 3.2 Symbols

No symbols are introduced in this Technical Report.

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP 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 3GPP TR 21.905 [1].

DAA Detect And Avoid

DN Data Network

EDN Edge Data Network

LUN Local USS Network

SEAL Service Enabler Architecture Layer

UAE UAS Application Enabler

UAS Uncrewed Aerial System

UAV Uncrewed Aerial Vehicle

UAV-C Uncrewed Aerial Vehicle-Controller

USS UAS Service Supplier

UTM UAS Traffic Management

# 4 Key issues

## 4.1 Key issue #1: Direct communication between UAVs

In the current version of 3GPP TS 23.255 [3], the UAVs (UAV – UAV and UAV – UAV-C) communicate over Unicast Uu. Communication over a direct link between the UAVs can improve performance and connectivity. Enhanced PC5 is the expected solution for direct communication between UAVs.

Solutions for direct communication between UAVs is based on and must be coordinated with the work outlined by 3GPP TR 23.700-58 [6].

It is required to study the following:

a) How the UAE layer can be enhanced to support usage of direct communication between UAVs.

b) Whether and how the UAE layer functionality related to C2 communication support can be enhanced if PC5 is used for direct communication.

## 4.2 Key issue #2: Support for multi-USS deployments

In the current version of 3GPP TS 23.255 [3], it is assumed that the UE communicate with a single USS/UTM during a flight. However, it is not unlikely that a single flight can span the service area of more than one USS/UTM.

In some scenarios, a UAS can be served by more than one USS, or by more USSs in a USS network. A USS network can be considered a set of connected USSs for exchanging information and sharing relevant details to ensure shared situational awareness for UTM participants. USSs could have several geographic areas and times for which they are providing services.

It must be secured that change of USS/UTM during an ongoing session (flight) is supported by the UAE layer. In multi-USS scenarios, each USS can also be located in different clouds and potentially deployed at the edge.

Solutions for UAE layer support for UAS operation in multi-USS deployments must be coordinated with the work outlined by 3GPP TR 23.700-58 [6].

The key issue will investigate:

a) Whether and how the UAE layer can be enhanced to support change of USS/UTM during flight.

b) Whether and how the UAE layer needs to be enhanced to assist the traffic steering of UAS application traffic to different DN/EDN to avoid application service disruption while in-flight.

NOTE: Liability/legal responsibility for UAV operation stays with UTM/UAS operator.

## 4.3 Key issue #3: Coordination between Uu and PC5 for direct UAV-to-UAV or UAV-to-UAV-C communication

In the current version of 3GPP TS 23.255 [3], the UAVs (UAV – UAV and UAV – UAV-C) can communicate over Unicast Uu interface. Besides this, ProSe/PC5 Communication over a direct link mentioned in 3GPP TS 23.304 [7] can also be a solution for communications between UAVs. Communication over Uu and PC5 can be used in parallel between UAVs for redundancy or for different kinds of service scenarios. In some cases, the UAV needs to distinguish which traffic use which kind of interface. In addition, the mechanisms for communications between UAVs using multicast/broadcast Uu and ProSe/PC5 scenarios need further study.

Solutions for coordination between Uu and PC5 is based on and must be coordinated with the work outlined by 3GPP TR 23.700-58 [6].

Therefore, it is required to study the following:

a) How the UAE layer can be enhanced to make coordination between network based communication (Uu) and direct communication (PC5) for communications between UAVs or between UAV and UAV-C.

## 4.4 Key issue #4: Support for detect and avoid services and applications

Development of the Support for Detect and Avoid Mechanism in 3GPP system is being studied in 3GPP TR 23.700-58 [6]. The 5GC enhancement work for DAA includes services for network assisted DAA and direct DAA via PC5.

Considering the stage 1 requirements and also 5GC enhancements for DAA, it is required to study the aspects that UAE layer and SEAL can be supported for DAA.

Further study is also required for UAE layer to support DAA scenarios where UAVs belong to multiple PLMNs.

It is required to study the following:

a) Whether and how the UAE layer and/or SEAL services can be enhanced to support DAA services and applications for collision avoidance considering the Stage 1 requirements.

b) How the UAE layer can support DAA scenarios where UAVs belong to multiple PLMNs.

NOTE: Solutions for DAA will be coordinated with the conclusions of the work outlined by 3GPP TR 23.700-58 [6] and based on requirements for DAA specified in 3GPP TS 22.125 [2].

# 5 Architecture requirements

## 5.1 General

This clause specifies all requirements related to enhanced application architecture for UAS applications.

## 5.2 Support for multi-USS deployments

### 5.2.1 Description

This clause specifies the requirements related to support for multi-USS deployments.

### 5.2.2 Requirements

[AR-5.2.2-a] The UAE Server shall provide a mechanism for configuring of multi-USS capabilities from the USS.

[AR-5.2.2-b] The UAE Server shall provide a mechanism for configuring the multi-USS capabilities at the UAE Client (UAV).

[AR-5.2.2-c] The UAV Server shall provide a mechanism to support change of USS during UAS operations.

[AR-5.2.2-d] The UAE Client (UAV) shall provide a mechanism to support change of USS based on the multi-USS capabilities when an immediate change of USS is needed.

NOTE: The details of multi-USS capabilities will be specified during the normative work.

## 5.3 Support for C2 direct mode feasibility reporting

### 5.3.1 Description

This clause specifies the requirements related to support for C2 direct mode feasibility reporting.

### 5.3.2 Requirements

[AR-5.3.2-a] The UAE Server shall provide a mechanism for monitoring the feasibility of ProSe/PC5 link for C2 communications.

[AR-5.3.2-b] The UAE Client shall be capable of reporting the feasibility of ProSe/PC5 link for C2 communications.

## 5.4 Support for detect and avoid services and applications

### 5.4.1 Description

This clause specifies the requirements related to support for detect and avoid services and applications.

### 5.4.2 Requirements

[AR-5.4.2-a] The UAE Server shall provide a mechanism for configuring of DAA capabilities from the USS.

[AR-5.4.2-b] The UAE Server shall provide a mechanism for configuring the DAA capabilities at the UAE Client (UAV).

[AR-5.4.2-c] The UAS application enabler layer shall provide a mechanism for a UAS application specific server to obtain events for a UAV that can be relevant for DAA.

[AR-5.4.2-d] The UAS application enabler layer shall provide a mechanism for a UAS application specific client to obtain events for a UAV that can be relevant for DAA.

# 6 Architecture

## 6.1 General

Figure 6.1-1 illustrates the detailed UAS application layer functional model as outlined in 3GPP TS 23.255 [2].



Figure 6.1-1: UAS application layer functional model

## 6.2 Architecture enhancement

No enhancement to the Release 17 architecture is identified.

# 7 Solutions

## 7.1 General

The proposed solutions in this clause attempt to resolve all, or part of one or more Key Issues provided in clause 4. As part of the proposed solution, the proposed solution is also evaluated against the key issue(s) it attempts to resolve.

## 7.2 Mapping of solutions to key issues

Table 7.2-1 Mapping of solutions to key issues

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | KI #1 | KI #2 | KI #3 | KI #4 |
| Sol #1 |  | X |  |  |
| Sol #2 |  | X |  |  |
| Sol #3 | X |  | X |  |
| Sol #4 |  |  |  | X |
| Sol #5 |  |  |  | X |

## 7.3 Solution #1: Change of USS during flight

### 7.3.1 Architecture enhancements

None.

### 7.3.2 Solution description

#### 7.3.2.1 General

This solution aims to address the gaps identified in Key Issue #2 “Support for multi-USS deployments”.

The solution covers registration of the UAE clients and the UAE servers multi-USS capabilities to the USS, provision of the capabilities and policies of the USS to the UAE client and the UAE server, and assistance by the UAE layer at change of USS.

The functions of the USS are out of scope of the solution.

#### 7.3.2.2 Registration of multi-USS capabilities

Pre-conditions:

- The UAE client has discovered the UAE server and is aware of the address of the UAE server (e.g., FQDN).

NOTE: How the UAE client is provisioned with the UAE server information is outside the scope of the current document.

- The UAV has already been assigned with the UAV ID.



Figure 7.3.2.2-1: Registration of multi-USS capabilities of UAE client and UAE server

1. The UAE client sends a registration request to the UAE server. The UAE client includes its Multi-USS capabilities.

2. The UAE server performs authentication and authorization check (e.g., based on pre-provisioned security information or by interacting with UAS application specific server (e.g., USS/UTM)).

3. The UAE server sends a registration response to the UAE client indicating success or failure of the registration.

#### 7.3.2.3 Provision of multi-USS capabilities

##### 7.3.2.3.1 Multi-USS management

Figure 7.3.2.3.1-1 illustrates the procedure where the UAE server receives an application request for managing the multi-USS capabilities from the UAS application specific server.

Pre-condition:

- The UAV has received its UAS ID from the UAS application specific server.

- The UAV has performed the UAS UE registration procedure.



Figure 7.3.2.3.1-1: Multi-USS management procedure

1. The UAS application specific server sends to the UAE server a Multi-USS management request with the USS policies. The UAE server receives a Multi-USS management request from a serving USS for managing the support for multi-USS. The request includes the UAV (UAE client) identification information and Multi-USS configuration parameters. The configuration includes: list of allowed USSes information (e.g. FQDN), current serving USS information, USS-change-initiation information (whether the UAE layer can initiate change of USS), a Multi-USS support policy (when/how to initiate a change of USS). The UAE server stores the Multi-USS support configuration parameters in the UAE client context. In the case of removal of Multi-USS configuration parameters for a USS from the UAE server, then the request shall include the UAV identifier and a USS identifier (e.g. FQDN) for the USS that will be removed.

2. The UAE server sends to the UAS application specific server a Multi-USS management response with a positive or negative acknowledgement of the request.

3. UAE server executes the multi-USS configuration according to clause 7.3.2.3.2.

4. After successful execution of USS management configuration, the UAE server notifies the UAS application specific server with a Multi-USS management complete based on the configured capabilities of the UAE client and the UAE server.

##### 7.3.2.3.2 Multi-USS configuration

This procedure enables the configuration of the UAE client, based on a request from UAS application specific server (which can be the USS/UTM) to configure multi-USS capabilities to the UAE client.

Figure 7.3.2.3.2-1 illustrates the USS management configuration procedure.

Pre-conditions:

1. The UAS UEs are connected to 5GS and authenticated and authorized by UAS application specific server as specified in clause 5.2 of 3GPP TS 23.256 [4].

2. UAE server has established a UAE session with the respective UAE clients as the UAE clients are successfully registered to the UAE server.

3. UAE server has performed the initiation of USS management capabilities as in clause 7.3.2.2.2.



Figure 7.3.2.3.2-1: Multi-USS configuration procedure

1. The UAE server sends a Multi-USS configuration request to the UAE client. The UAE client receives a Multi-USS configuration request from the UAE server that includes the Multi-USS configuration parameters. In the case of removal of Multi-USS configuration parameters for a USS from the UAE client, then the request shall only include a USS identifier (e.g. FQDN) for the USS that will be removed.

NOTE: Further details on the elements and other procedures of multi-USS configuration will be specified during the normative work in stage 2 and stage 3.

2. The UAE client stores or removes the Multi-USS configuration parameters as per the information received in step 1.

3. The UAE client sends a Multi-USS configuration response to the UAE server.

#### 7.3.2.4 UAE layer assisted change of USS

Figure 7.3.2.4-1 illustrates the procedure where the UAE server initiates change of USS.

Change of DN/EDN to avoid disruption while in flight due to change of USS is not covered by this solution.

Pre-conditions:

1. UAE client and UAE server have indicated Multi-USS support.

2. UAS application specific server has provided Multi-USS capabilities and policies to the UAE client and the UAE server.



Figure 7.3.2.4-1: UAE layer assisted change of USS

1. The UAE server receives a USS change request from a UAS application specific server. The request includes the UAV (UAE client) identification information, a new serving USS information and USS change authorization information (e.g. authorization token), USS change constraints parameters (e.g. delay or geo location/area threshold for change). The UAE server verifies that the request is authorized (e.g., Multi-USS capability is enabled, new USS part of the allowed USS list).

Alternatively, the UAE server initiates the change of USS (i.e. on behalf of the USS) based on USS provided Multi-USS configuration parameters (e.g. USS-change-initiation parameter, Multi-USS support policy). If the UAE server is allowed to initiate a change of USS according to the Multi-USS configuration, the UAE server may select a new USS from the allowed USS list for the UAE client to connect to without reception of an USS change request from the UAS application specific server.

2. The UAE server sends a USS change request to the UAE client including the new serving USS information. The UAE client initiates the communication with the new serving USS based on the USS change request and Multi-USS configuration parameters.

3. Perform change of USS.

If an emergency change of USS is deemed necessary by the UAE Client (e.g. sudden loss of contact with the serving USS), the UAE client initiates the change of USS (i.e. on behalf of the USS) based on USS provided Multi-USS configuration parameters. In this case, the steps 1-2 are not performed.

4. The UAE client sends a USS change response/notification message indicating that a change of USS has been performed.

5. The UAE server sends a USS change response/notification to the UAS application specific server indicating that a change of USS has been performed.

### 7.3.3 Solution evaluation

Key Issue #2 outlines the following to be investigated further with respect to the impact on the application layer functional model for UAS:

a) Whether and how the UAE layer can be enhanced to support change of USS/UTM during flight.

b) Whether and how the UAE layer needs to be enhanced to assist the traffic steering of UAS application traffic to different DN/EDN to avoid application service disruption while in-flight.

This solution fully addresses the bullet a) in Key Issue #2:

A summary of the UAE layer capabilities are:

1) UAE server and UAE client provide support for application specific layer message exchanges related to change of USS/UTM during flight.

2) UAE client change USS/UTM during flight as per Multi-USS configuration parameters.

NOTE: Change of DN/EDN to avoid disruption while in flight due to change of USS is not covered by this solution.

The solution enables the USS/UTM to take or give back control of the change of USS/UTM from/to the UAE server and/or the UAE client at any time.

## 7.4 Solution #2: Support for USS re-mapping for a UAS

### 7.4.1 Architecture enhancements

None.

### 7.4.2 Solution description

#### 7.4.2.1 General

This solution aims to address one of the gaps identified in Key Issue #2 “Support for multi-USS deployments”.

The solution covers the assistance by the UAE layer at change of USS based on partially overlapping multi-USS deployments, based on UAV location tracking. UAE layer assists on the mapping and traffic steering of UAS traffic to different DNAI based on the deployment of the USSs in different edge/cloud networks.

In multi-USS scenarios, each USS can be physically located in different clouds, and it is also possible that a USS is deployed at the edge. In such multi-USS/LUN scenarios, the interaction with the communication network for supporting a UAS session which requires the interaction to more than one USS e.g. due to UAV mobility to different geographical area covered by different edge cloud, needs to be specified.

One example is shown below, where USSs are deployed in different edges/clouds and are clustered in different LUNs. In these cases, the interaction with 5GS can be via different DNAIs, and the UAV/UAV-C can be travelling to any location which is allowed to be based on the UAV route and the UAS operator wishes/restrictions.



Figure 7.4.2.1-1: Example multi-USS deployment

#### 7.4.2.2 Procedure

Figure 7.4.2.2-1 illustrates the procedure where the UAE server supports the change of USS.

Pre-conditions:

- The UAV has performed the UAS UE registration procedure.

- UAE client and UAE server have indicated Multi-USS support.



Figure 7.4.2.2-1: UAE layer assisted change of USS

1. The UAE server has performed the USS management procedure of clause 7.3.2.3.1; however at the Multi-USS management request, UAE server also receives from UAS application specific server the USS service areas (geographical) for all allowed USSs, and optionally the USS to DNAI mapping and a USS list per given Local USS network (LUN).

NOTE: If USS to DNAI mapping is not provided in step 1, it is assumed that such mapping is available / pre-configured at UAE server (e.g. mapping of geographical area to DNAI).

2. The UAE server maps each USS with different topological areas based on the USS to DNAI mapping (based on step 1), for all USSs which are allowed for a target area where the UAV is allowed to fly (this for example can be within the LUN). Then it also maps and stores all pairs of <USS x, DNAI y> per LUN or for the areas of interest for the UAV (e.g. based on the allowable routes).

3. The UAE server tracks the location of the UAV, by requesting on-demand location monitoring from SEAL LMS (acting as VAL server in procedure of clause 9.3.4 or clause 9.3.5 of 3GPP TS 23.434 [5]) or via subscribing for monitoring the UAV location deviation (discussed in clause 9.3.11 of 3GPP TS 23.434 [5]).

4. The UAE server if detects an expected UAV location change to an area covered by a different USS (based on SEAL LMS monitoring subscription/request as in step 3), it generates a trigger event indicating that the UE moves to an area where the USS is overlapping with other USS or another overlapping USS within LUN area is not available.

If it is an overlap, the UAE server checks whether the performance of serving USS is expected to get impacted (e.g. by requesting DN performance analytics for the target area) or if the serving USS is not supported at target area, checks what is the best available USS and whether this can provide the same services. The criteria for the best available USS are mainly the location of the UAV, but it can be also the priorities of the USS (based on the policies received) at the target area and the capabilities (services) provided by the target USS to be equivalent.

5. The UAE server sends to the UAS application specific server a trigger message indicating the recommendation for a USS change for the UAS and provides the target USS ID or just a need for changing USS. Alternatively, the trigger message indicates a UAV mobility event, based on steps 3/4.

6/7. The UAS application specific server, based on the trigger and after coordinating with source and target USSs (coordination is out of scope) sends to the UAS application specific server a USS change command message indicating the new USS information for the UAS.

8. The UAE server translates this to a UP path change and interacts with NEF as AF for influence UP path (switching to target DNAI). In particular UAE server (acting as AF) checks whether it can serve the target DNAI corresponding to the target USS based on the mapping of USS to DNAI which was performed in step 3. Interaction with 5GC is performed according to functionality for application function influence on traffic routing, see 3GPP TS 23.502 [8] clause 4.3.6.3.

9. The UAE server sends a USS change command to the UAV, indicating the UAV (UAE client) ID, a new serving USS information and optionally USS change authorization information.

10. The UAE server receives a positive or negative acknowledgement for the USS change.

11. The UAE server sends a USS change notification to the UAS application specific server upon successful USS change.

### 7.4.3 Solution evaluation

Key Issue #2 outlines the following to be investigated further with respect to the impact on the application layer functional model for UAS:

a) Whether and how the UAE layer can be enhanced to support change of USS/UTM during flight.

b) Whether and how the UAE layer needs to be enhanced to assist the traffic steering of UAS application traffic to different DN/EDN to avoid application service disruption while in-flight.

This solution addresses bullet a) and bullet b) in Key Issue #2. Management aspects based on solution #1 are provided by the USS and used by the UAE server to provide additional information for multi-USS configuration, like service areas of the USSes, etc.

A summary of the UAE layer capabilities are:

1) UAE server handles USS service area mapping to DNAI configuration to support application function influence on traffic routing as defined in 3GPP TS 23.502 [8] clause 4.3.6.

2) UAE server provides assistance at change of USS for partially overlapping multi-USS deployments based on UAV location tracking support related to change of USS/UTM during flight.

3) UAE server forwards the commands for change of USS from the USS/UTM.

The solution enables the USS/UTM to be in control of the USS changes and utilizes the UAE layer’s assistance to track the UAV and trigger change of USS.

## 7.5 Solution #3: Support for C2 direct mode feasibility reporting

### 7.5.1 Architecture enhancements

None.

### 7.5.2 Solution description

#### 7.5.2.1 General

This solution aims to address Key Issue #1 “Direct communication between UAVs” and in particular enhancements related to C2 communication monitoring over PC5. This solution addresses also Key Issue #3 since the outcome of such solution can trigger some coordination between PC5 and Uu for C2 mode switching.

The network-assisted mode (in-direct) is used to facilitate the C2 communication in BLOS; however when the PC5 is feasible/available UAVs needs to switch to direct fast and without any loss of data. The feasibility/availability of PC5 can be e.g. when the UAV returns towards the UAV-C or when the expected QoS over PC5 is better than Uu (due to possible congestions/QoS degradation/resource starvation in one or both Uu links).

The PC5 availability/feasibility indication for a C2 communication, will provide the awareness to the UAE server to switch to direct C2 communication if it is possible. The PC5 availability/feasibility can be captured at the UAV/UAV-C, e.g. the UAV-C can periodically broadcast signals in different frequencies, and upon reception of an ACK from the UAV to understand (based on the received signal) whether direct C2 is possible. The UAE server based on this indication can perform the procedure specified in 3GPP TS 23.255 [3] for C2 mode switching if possible.

NOTE: This solution will not be considered for normative work unless SA2 provides the required functionality that aligns with this solution.

#### 7.5.2.2 Procedure

Figure 7.5.2.2-1 illustrates the procedure where the UAE server supports C2 direct mode feasibility checking.

Pre-conditions:

- The UAV has performed the UAS UE registration procedure.

- The UAV and UAV-C are both connected to 3GPP network and operate in network-based C2 mode.

- UAE Server has performed the C2 mode switching/selection capability initiation as in clause 7.4.2.1 of 3GPP TS 23.255 [3].



Figure 7.5.2.2-1: Support for C2 direct mode feasibility reporting

1. The UAE server sends a C2 direct mode feasibility request including the ProSe codes for direct C2 operation, the UAV and UAV-C IDs and addresses, and the time and area for which the monitoring of feasibility will apply. Also, the request can include configuration of the expected reporting and periodicity/frequency of reporting required.

2. The UAE client of the UAV sends a feasibility response for the C2 communication.

3. The UAE client performs PC5 discovery between UAV and UAV-C UEs, as specified in ProSe Direct Discovery Models A, B defined in clause 5.3 of 3GPP TS 23.303 [9]. The PC5 discovery information can be exchanged between UAE clients, based on the configured ProSe announcements (e.g., based on codes received in step 1).

4. When the UAE clients are aware of the PC5 discovery, one or more clients sends a PC5 feasibility report to the UAE server, to notify on the PC5 possibility. This PC5 feasibility report message can include the UE identifiers, the UAS identification, a PC5 availability/feasibility notification indication, PC5 capabilities/configuration. The PC5 feasibility report can also include a preference/priority of the C2 operation mode, e.g., based on application requirements at the UAV-C and/or UAV.

5. The UAE server triggers a dynamic C2 mode switching operation as in clause 7.4.2.4 of 3GPP TS 23.255 [3].

### 7.5.3 Solution evaluation

This solution addresses Key Issue #1 and Key Issue #3 and provides an enhancement of C2 related functionality specified in Release 17, by allowing the PC5 feasibility monitoring. This solution is dependent on SA2 Release 18 support for ProSe/PC5 for C2 communication (3GPP TR 23.700-58 [6]).

NOTE 1: This solution will be considered feasible only if the SA2 provided concluded solution (as in 3GPP TR 23.700-58 [6]) works in the same manner as required by this solution.

NOTE 2: The enhancements to procedures in clause 7.4.2 of 3GPP TS 23.255 [3] to fulfill the objectives of this solution will be considered during normative work (if concluded).

## 7.6 Solution #4: UAE layer support for DAA

### 7.6.1 Architecture enhancements

None.

### 7.6.2 Solution description

#### 7.6.2.1 General

This solution aims to address the gaps identified in Key Issue #4 “Support for detect and avoid services and applications”.

The solution covers registration of the UAE clients’ DAA capability to the UAE server, provisioning of the DAA policies from the UAS application specific server to the UAE server and the UAE client and support for DAA from the UAE layer to the UAS application layer.

The DAA capability of the UAE client is provided to the network to inform the network that the UAE client support reception of DAA-policies from the network and has functionality in the UAE layer to assist and coordinate support for DAA in the UE

A DAA policy has two components:

a) The DAA application policy. This policy is used by the application and transparently provided from the UAS application specific server to the UAS client. The DAA application policy is timestamped and may be stored at the UAE server, to let the operator know when and optionally what information was provided to the UAS application.

b) The DAA support policy. This policy is used by the UAE layer, and contains information pertaining to the UAE layer. This is parameters/rules for the UAE layer to provide support for DAA applications.

NOTE: The complete list of parameters for the DAA support policy will be specified during the normative work.

The Detect and Avoid operations performed by the UAS application layer is out of scope of the solution.

#### 7.6.2.2 Registration of DAA capability

Pre-conditions:

- The UAE client has discovered the UAE server and is aware of the address of the UAE server (e.g., FQDN).

NOTE: How the UAE client is provisioned with the UAE server information is outside the scope of the current document.

- The UAV has already been assigned with the UAV ID.



Figure 7.6.2.2-1: Registration of DAA capability of the UAE client

1. The UAE client sends a registration request to the UAE server. The UAE client includes an indication of its DAA capability.

2. The UAE server performs authentication and authorization check (e.g., based on pre-provisioned security information or by interacting with UAS application specific server).

3. The UAE server sends a registration response to the UAE client indicating success or failure of the registration for DAA support.

#### 7.6.2.3 Provision of DAA policies

##### 7.6.2.3.1 DAA support management procedure

Figure 7.6.2.3.1-1 illustrates the DAA support management procedure where the UAE server receives an application request for managing the DAA configuration parameters from the UAS application specific server.

Pre-condition:

- The UAV has received its UAS ID from the UAS application specific server.

- The UAV has performed the UAS UE registration procedure.



Figure 7.6.2.3.1-1: DAA support management procedure

1. The UAS application specific server sends to the UAE server a DAA support management request. The request includes the UAV (UAE client) identifier and the DAA policies.

2. The UAE server sends to the UAS application specific server a DAA support management response with a positive or negative acknowledgement of the request.

3. The UAE server executes the DAA configuration according to clause 7.6.2.3.2.

4. After successful execution of DAA configuration, the UAE server notifies the UAS application specific server with DAA support management complete.

##### 7.6.2.3.2 DAA support configuration procedure

Figure 7.6.2.3.2-1 illustrates the DAA support configuration procedure. This procedure enables the configuration of the UAE client, based on a request from UAS application specific server to configure DAA policies to the UAE client.

Pre-conditions:

1. The UAS UEs are connected to 5GS and authenticated and authorized by UAS application specific server as specified in clause 5.2 of 3GPP TS 23.256 [4].

2. UAE server has established a UAE session with the respective UAE clients as the UAE clients are successfully registered to the UAE server.

3. UAE server has performed the DAA support management procedure according to clause 7.6.2.2.2.



Figure 7.6.2.3.2-1: DAA support configuration procedure

1. The UAE server sends a DAA support configuration request to the UAE client. The UAE client receives a DAA support configuration request from the UAE server that includes the DAA configuration parameters.

NOTE: Details in case of e.g. removal of DAA policies will be specified during the normative work.

2. The UAE client stores or removes the DAA configuration parameters as per the information received in step 1.

3. The UAE client sends a DAA support configuration response to the UAE server.

#### 7.6.2.4 UAE layer support for DAA applications

##### 7.6.2.4.1 Client initiated DAA support

Figure 7.6.2.4.1-1 illustrates the procedure with client initiated DAA support.

Pre-conditions:

1. UAE server has provided DAA policies to the UAE client.



Figure 7.6.2.4.1-1: Client initiated DAA support

1. The UAE layer has, e.g. based on the DAA support policy and/or information provided by the U2X layer (see 3GPP TR 23.700-58 [6]) detected UAVs in proximity.

2. The UAE client sends a DAA support information (i.e. U2X layer detected information) to the UAE server indicating a detected flight path conflict with one or more UAVs in proximity.

If the UAE client considers an emergency situation (e.g., due to lack of response from the UAE server and/or UAS application specific server), the UAE client shall inform the application layer (i.e. UAS Client) based on the DAA support policy.

3. The UAE server records the DAA support event with current timestamp. UAE server requests UAE client location information from the SEAL location services. The UAE server records the received location information with current timestamp. The UAE server sends the DAA support information to the UAS application specific server.

NOTE: The UAE server needs to provide trusted and timely network based location information to the USS which can be used as critical input for USS to handle or record DAA situations. The USS can provide deconflicting instructions to the UAV based on provided location information or handle properly potential flight path deviation due to DAA that is deconflicted locally.

4. The UAS application specific server provides a DAA support information acknowledgement to the UAE server. The UAS application specific server may include more information in the acknowledgement (e.g. other UAVs detected information by network).

5. The UAE server provides a DAA support information acknowledgement to the UAE client, and the UAE client provides the application layer (i.e. UAS Client) with the consolidated information from the UAS application specific server.

##### 7.6.2.4.2 Server initiated DAA support

Figure 7.6.2.4.2-1 illustrates the procedure with UAS application server initiated DAA support.

Pre-conditions:

1. UAS application specific server has provided DAA configuration parameters to the UAE client.



Figure 7.6.2.4.2-1: Server initiated DAA support

1. The UAS application specific server has discovered a conflict related to DAA (e.g. presence of other UAVs in proximity of the UAV), and will provide the UAE client with relevant information.

NOTE: An example of such a conflict is that an UAV with U2X capabilities, see clause 7.6.2.4.1 step 0, provides information about objects in proximity to the UAS application specific server. The UAS application specific server can, based on this, e.g. provide information to one or more surrounding UAVs that does not have U2X capability.

2. The UAS application specific server sends a DAA support information to the UAE server which includes information of other UAVs in the proximity of the UAV. The UAE server verifies that the request is authorized as described above before sending the DAA support information to the UAE client.

3. The UAE server sends a DAA support information from the UAS application specific server to the UAE client. Coordination with Real-Time UAV connection status monitoring and location reporting is performed by the UAE server, see 3GPP TS 23.255 [3] clause 7.5 and 3GPP TS 23.434 [5], clause 9.3.

Further, UAE client provides the application layer with the consolidated information from the UAS application specific server.

4. The UAE client sends to the UAE server a DAA support information acknowledge.

5. The UAE server sends the DAA support information acknowledge to the UAS application specific server.

### 7.6.3 Solution evaluation

Key Issue #4 outlines the following to be investigated further with respect to the impact on the application layer functional model for UAS:

a) Whether and how the UAE layer and/or SEAL services can be enhanced to support DAA services and applications for collision avoidance considering the Stage 1 requirements.

b) How the UAE layer can support DAA scenarios where UAVs belong to multiple PLMNs.

This solution addresses the bullet a) and bullet  b) in Key Issue #4:

A summary of the UAE layer capabilities are:

1) Management for provison of DAA-policies from the UAS application specific server the UAS application client is provided by the UAE layer.

2) UAE layer provides support for handling of DAA support information.

3) Provision of support for DAA is PLMN-agnostic.

## 7.7 Solution #5: Support for DAA applications

### 7.7.1 Architecture enhancements

None.

### 7.7.2 Solution description

#### 7.7.2.1 General

This solution aims to address the gaps identified in Key Issue #4 “Support for detect and avoid services and applications”. The solution proposes two aspects for the UAE layer support for DAA applications:

- Providing real-time location update about UAVs to UASS (UTM/USS).

- Providing dynamic information of UAVs in an application defined area to the host UAV and/or UASS (UTM/USS).

It is considered that the DAA application logic which mainly includes decision making for collision avoidance and its related signalling between the UAV and UASS (USS) is out of scope of 3GPP.

#### 7.7.2.2 Enhanced real-time tracking of location information of UAVs to USS

This procedure enables the USS to subscribe for real-time location information of UAVs from UAE server.

1. UASS (UTM/USS) performs the subscription with UAE server to obtain real-time location information from UAE server as specified in clause 7.5.2.2 of 3GPP TS 23.255 [3] with the following modifications:

a. In step 1, the subscription request can be enhanced such that the UASS can subscribe for a list of UAV IDs instead of a single UAV ID.

2. Upon successful step 1 operation, the UAE server provides the notifications to UASS (USS) as per the subscription request as specified in clause 7.5.2.3 of 3GPP TS 23.255 [3] with the following modifications:

a. The notification message from UAE server to UASS (USS) can be enhanced to contain one or more location information of the UAVs instead of the location information of a single UAV.

#### 7.7.2.3 Tracking dynamic UAVs in an application defined area relative to a host UAV

##### 7.7.2.3.1 General

The UAE server can be responsible for tracking a host UAV’s dynamic information (i.e., information of other dynamic UAVs in an application defined area relative to a host UAV). As per a proximity range set by the application layer, the UAE layer supports providing the dynamic information (i.e. other UAVs’ location information) to the UASS (UTM/USS) and/or to the host UAV.

This feature utilizes the following procedures:

- UASS or the host UAV subscription for host UAV’s dynamic information with UAE server.

- UAE server tracking host UAV’s UE location with support from SEAL’s location management server.

- UAE server management of dynamic UE location based group.

- UAE server obtaining dynamic information from the UAVs in proximity range of the host UAV.

- UAE server notification of host UAV’s dynamic information to the UASS and/or to the host UAV.

NOTE: The details of the usage of dynamic information of host UAV by UASS or by the host UAV is out of scope of this specification.

##### 7.7.2.3.2 Subscription for host UAV dynamic information

Figure 7.7.2.3.2-1 describes the procedure for subscription for host UAV’s dynamic information.

Pre-condition:

- UASS has registered with UAE server 1 which is responsible for the host UAV.

- The UAV ID and application defined proximity range information are configured on the host UAV.



Figure 7.7.2.3.2-1: Subscription for host UAV dynamic information

1. The UASS or UAE client of host UAV sends a subscribe host UAV dynamic information request to the UAE server 1. The request includes the UAV ID of the host UAV, application defined proximity range information.

2. The UAE server 1 stores the subscription information.

3. The UAE server 1 sends subscription response to the UASS.

4. The UAE server 1 obtains and initiates tracking the host UAV location from the location management server 1 as specified in 3GPP TS 23.434 [5].

##### 7.7.2.3.3 Management of dynamic UE location based group

Figure 7.7.2.3.3-1 describes the procedure for management of dynamic UE location based group.

Pre-condition:

- UAE server 1 has received an updated location of the host UAV as per procedure specified in 3GPP TS 23.434 [5].

- UAE server 1 is configured with UAE server 2..N information of other UAS operator and their supported region of operation.



Figure 7.7.2.3.3-1: Management of dynamic UE location group

1. Dynamic UE location based group creation or update is triggered (e.g. notified of the UE location of host UAV) via the step 4 in clause 7.7.2.3.2 for the UAV ID of the host UAV.

2. UAE server 1 uses its associated LMS 1 to obtain the dynamic UE list and the corresponding location information in the proximity area of the host UAV by providing the application defined proximity range and the UE location of the host UAV as specified in clause 9.3.10 of 3GPP TS 23.434 [5].

3. UAE server 1 determines the list of other UAE servers 2..N operating in the same location.

4. For each UAE server determined in step 3, UAE server 1 requests the dynamic UE list and its corresponding location information for the application defined proximity range by providing the UE location of the host UAV.

5. The UAE server(s) 2..N obtain UE information corresponding to the UE location and application defined proximity range from its corresponding LMS 2..N as specified in 3GPP TS 23.434 [5].

6. As per the agreement between the UAS operators, if the UAV IDs are not shareable, then UAE server(s) 2..N may replace the UAV IDs with temporary UAV IDs.

7. The UAE server(s) 2..N sends get response with UE list in the UE location and application defined proximity range to UAE server 1.

8. If UAE server 1 has no dynamic UE location group for the UAV ID, the UAE server 1 creates a dynamic UE location based group with the UE list received from its LMS and other UAE server(s) 2..N. Further UAE server 1 stores the dynamic UE location based group. Otherwise, the UAE server 1 updates the dynamic UE location group with the latest UE information. The UAVs whose locations are no more within the application defined proximity range are removed from the dynamic UE location group.

##### 7.7.2.3.4 Obtaining dynamic information of the UEs in proximity range

###### 7.7.2.3.4.1 Subscription procedure within UAS operator

Figure 7.7.2.3.4.1-1 describes the subscription procedure within UAS operator to obtain dynamic information from the UEs in application defined proximity range.

Pre-condition:

- UAE server 1 is tracking the host UAV and has created the dynamic UE location based group as per procedure in clause 7.7.2.3.3.



Figure 7.7.2.3.4.1-1: Subscription procedure within UAS operator

1. The UAE server 1 managing the dynamic UE location group sends subscribe dynamic information request to the UAE clients who are part of the dynamic UE location group. These UAE clients (UAVs) belong to the same UAS operator as the host UAV. The request consists of reporting configuration (e.g. frequency of reporting, event based).

2. The UAE client(s) store the subscription information.

3. The UAE client(s) send a subscription response to the UAE server 1.

###### 7.7.2.3.4.2 Subscription procedure across UAS operators

Figure 7.7.2.3.4.2-1 describes the subscription procedure across UAS operators to obtain dynamic information from the UEs in application defined proximity range.

Pre-condition:

- UAE server 1 has created the dynamic UE location based group as per procedure in clause 7.7.2.3.3.



Figure 7.7.2.3.4.2-1: Subscription procedure across UAS operators

1. The UAE server 1 managing the dynamic UE location group sends subscribe dynamic information request to the UAE server(s) who’s UAVs are part of the dynamic UE location group. The request consists of temporary UAV IDs, reporting configuration (e.g. frequency of reporting, event based).

2. As per the agreement between UAS operators, if UAV IDs are not shareable, then UAE server 2 determines the UAV IDs corresponding to the temporary UAV IDs provided in step 1.

3. The UAE server 2 performs subscription procedure as specified in clause 7.7.2.3.4.1 with the UAE client(s).

4. The UAE server 2 sends a subscription response to the UAE server 1.

NOTE: UAE server 1 initiates this procedure with other UAE servers operating in the area.

##### 7.7.2.3.5 Notification procedure

Figure 7.7.2.3.5-1 describes the notification procedure of dynamic information from the UEs in application defined proximity range.

Pre-condition:

- UAE server 2 has received the notification of dynamic information from its subscribed UAE client(s).



Figure 7.7.2.3.5-1: Notification procedure

1. As per subscription procedure in clause 7.7.2.3.4.1 and clause 7.7.2.3.4.2, the UAE client(s) and UAE server 2 (of another UAS operator) send notification of dynamic information to the UAE server 1. The notification includes the nearby UE information (e.g. UAVs), distance with nearby UEs, UEs location information. As per agreement between UAS operators, if UAV IDs are not shareable, then UAE server 2 includes the temporary UAV IDs in the notification.

2. The UAE server 1 aggregates information from different UAE clients to create the host UAV dynamic information.

##### 7.7.2.3.6 Notification of host UAV dynamic information

Pre-conditions:

- UASS has performed subscription as per procedure in clause 7.7.2.3.2 with UAE server 1.

- UAE server 1 has prepared the host UAV dynamic information as per procedure in clause 7.7.2.3.5.



Figure 7.7.2.3.6: Notification for host UAV dynamic information

1. The UAE server 1 sends notification of host UAV dynamic information to the subscribed entity (i.e. UASS and/or to the subscribed UAE client of the host UAV). The notification includes the aggregated information of all the UEs in the application defined proximity range of the host UAV and the location of the host UAV.

2. The UASS or the UAE client of the host UAV updates the host UAV dynamic information with the host UAV dynamic information received in step 1. The UAE client provides the host UAV dynamic information to the UAS Client.

### 7.7.3 Solution evaluation

This solution addresses Key Issue #4 by defining UAV(s) tracking capabilities at UAE layer. It is a viable solution for the UASS (UTM/USS) or host UAV to manage DAA scenarios by utilizing the UAE layer capabilities of real time UAV location tracking and availing host UAV dynamic information in an application defined area.

# 8 Deployment scenarios

## 8.1 General

There is no deployment scenario described in this Technical Report.

# 9 Overall evaluation

There is no architecture enhancement described in this Technical Report.

## 9.1 Architecture enhancements

## 9.2 Key issue evaluations

### 9.2.1 General

This clause compares and evaluates all proposed solutions against each of the key issues listed in clause 4.

All the key issues, solutions and architecture enhancements specified in this technical report are listed in Table 9.2.1-1.

Table 9.2.1-1 provides a mapping of the key issues to the related solutions. It also indicates whether the solution requires enhancement to the Release-17 architecture and lists the dependencies on other working groups.

Table 9.2.1-1 Key issue and solutions

| Key issues (evaluation clause reference) | Solution | Architectural enhancement  (clause reference) | Enhancements required | Dependency on other working groups |
| --- | --- | --- | --- | --- |
| KI #1 Direct communication between UAVs | Solution #3: Support for C2 direct mode feasibility reporting | 7.5 | None | SA2 |
| KI #2: Support for multi-USS deployments | Solution #1: Change of USS during flight NOTE | 7.3 | None | None |
| Solution #2: Support for USS re-mapping for a UAS | 7.4 | None | None |
| KI #3: Coordination between Uu and PC5 for direct UAV-to-UAV or UAV-to-UAV-C communication | Solution #3: Support for C2 direct mode feasibility reporting | 7.5 | None | SA2 |
| KI #4: Support for detect and avoid services and applications | Solution #4: UAE layer support for DAA | 7.6 | None | None |
| Solution #5: Support for DAA applications | 7.7 | None | None |
| NOTE: Change of DN/EDN to avoid disruption while in flight due to change of USS is not covered by this solution. | | | | |

### 9.2.2 Evaluation of key issue #1: Direct communication between UAVs

Key Issue #1 outlines the following to be investigated:

a) How the UAE layer can be enhanced to support usage of direct communication between UAVs.

b) Whether and how the UAE layer functionality related to C2 communication support can be enhanced if PC5 is used for direct communication.

Solution #3 is selected as the basis for normative work, based on the following principles and with the following constraints:

1) Provision of enhancement of C2 related functionality.

2) Allowance of PC5 feasibility monitoring.

This solution is dependent on the support for ProSe/PC5 for C2 communication, see 3GPP TR 23.700-58 [6].

This solution will be considered feasible only if the concluded solution in 3GPP TR 23.700-58 [6] works in the same manner as required by the solution specified in clause 7.5.

Enhancements to the procedures in of 3GPP TS 23.255 [3] clause 7.4.2 to fulfill the objectives of this solution will be considered during normative work (if concluded).

### 9.2.3 Evaluation of key issue #2: Support for multi-USS deployments

Key Issue #2 outlines the following to be investigated:

a) Whether and how the UAE layer can be enhanced to support change of USS/UTM during flight.

b) Whether and how the UAE layer needs to be enhanced to assist the traffic steering of UAS application traffic to different DN/EDN to avoid application service disruption while in-flight.

Solution #1 focuses on bullet a) including handling of management and policy for multi-USS deployments. By the policy for multi-USS configuration parameters, the USS will decide the level of control the UAE layer can take on behalf of the USS.

Solution #2 re-use the management and policy-framework from solution #1, with additions for mapping between USS service areas and 3GPP infrastructure information (i.e., DNAI).

Solution #1 and solution #2 complements each other to address both bullet a) and bullet b) using a common policy framework.

A policy-based approach with the execution as requested by the USS via the UAE Client / UAE server in solution #1 and a UAE Server centric approach in solution #2 are compatible with each other and can be combined into a “UAE layer assisted / USS controlled” based solution covering all possible scenarios and requirements of key issue #2. This approach is in line with the principles and functionality specified in 3GPP TS 23.255 [3] for C2 comunication mode selection/switching.

Solution #1 and solution #2 are selected as the basis for normative work, based on the following combined UAE layer assisted / USS controlled principles:

1) The Multi-USS capabilities of the UAE client and the UAE server are provided to the USS.

2) The UAE server and the UAE client are provided with policies from the USS for multi-USS deployments.

3) The USS is always in control of the decision for USS change during flight. The solutions enable the USS to explicitly make the decision to change the USS or provide/revoke permissions to the UAE client to make the decision on behalf of the USS based upon configuration provided by the USS when communication with the USS is lost.

NOTE: Possible actions by the UAE server due to loss of contact with the USS will be discussed during the normative phase.

4) The UAE server uses information provided by the USS in the policies for multi-USS deployment and the UAV location from the 3GPP network when providing a notification to the USS about a possible change of USS. This is based on the policy from the USS. The USS can initiate change of USS if this is required.

5) The UAE client notifies the UAE server when, based on policy from the USS, it detects condition for change of USS. The UAE server provides an indication to the USS to enable the USS to make the decision of change of USS.

The UAE client may also trigger an immediate/autonomous change of USS, but only in emergency situations.

6) The UAE server can, based on UAV tracking information from SEAL LMS and detection of UAV mobility to the DNAI associated with the USS, inform the USS about possible change of USS. Based on this, the USS can initiate a change of USS.

7) For cases where UAE server cannot determine the conditions for change of USS, the UAE server relies on UAE client assistance as above.

8) The UAE server performs traffic influence for the change of USS.

### 9.2.4 Evaluation of key issue #3: Coordination between Uu and PC5 for direct UAV-to-UAV or UAV-to-UAV-C communication

Key Issue #3 outlines the following to be investigated:

1) How the UAE layer can be enhanced to make coordination between network based communication (Uu) and direct communication (PC5) for communications between UAVs or between UAV and UAV-C.

Due to the overlap between Key Issue #1 and Key Issue #3, a common solution for both Kis are provided.

Solution #3 is selected as the basis for normative work, based on the following principles and with the following constraints:

1) Provision of enhancement of C2 related functionality.

2) Allowance of PC5 feasibility monitoring.

This solution is dependent on the support for ProSe/PC5 for C2 communication, see 3GPP TR 23.700-58 [6].

This solution will be considered feasible only if the concluded solution in 3GPP TR 23.700-58 [6] works in the same manner as required by the solution specified in clause 7.5.

Enhancements to the procedures in of 3GPP TS 23.255 [3] clause 7.4.2 to fulfill the objectives of this solution will be considered during normative work (if concluded).

### 9.2.5 Evaluation of key issue #4: Support for detect and avoid services and applications

Key Issue #4 outlines the following to be investigated:

a) Whether and how the UAE layer and/or SEAL services can be enhanced to support DAA services and applications for collision avoidance considering the Stage 1 requirements.

b) How the UAE layer can support DAA scenarios where UAVs belong to multiple PLMNs.

Solution #4 addresses bullet a) by including provisioning of the policy for DAA from the UAS server via the UAE layer to the UAS application and support from the UAE layer to the DAA decision making process in the UAS client.

Bullet b) is also supported by Solution #4 by the fact that both the UAS application layer and the UAE layer are PLMN-agnostic.

Solution #5 addresses bullet a) where UAE server provides capabilities for real-time UAV(s) tracking by the UAS application specific server or UAV. The UAS application specific server can provide an application defined area or proximity range with respect to a host UAV to obtain host UAV dynamic information which includes the information of other UAVs in the proximity range which can be a potential collision object for the host UAV. This information is utilized by UASS or the UAV to manage the DAA scenario. The application process of DAA is up to the UAV client and the UASS (UTM/USS) and how they use the UAE layer provided information is out of scope of the specification.

Solution#5 adressess bullet b) where UAE server supports capabilities of UAV tracking for the UAVs which belong to any UAS operator or connected via any PLMN operator.

Solution #4 and Solution 5 are selected as the basis for normative work, based on the following UAE layer assisted / USS controlled principles:

1) The DAA capability of the UAE client is provided to the server.

2) The UAS client, the UAE client and the UAE server are provided with DAA policies from the USS.

3) UAE layer will support providing information for the DAA decision making process.

4) The UAS application specific server can provide application defined area or proximity range and detects potential collision object for a host UAV in flight.

The UAS application layer is always in control of the decision for DAA.

# 10 Conclusions

## 10.1 Architecture enhancements

There is no architecture enhancement described in this Technical Report, see subclause 9.1.

## 10.2 Solutions

The overall evaluation of Key Issue #1, is described in clause 9.2.2. This refer to selection of Solution #3 as the basis for normative work.

The overall evaluation of Key Issue #2 is described in clause 9.2.3. This refer to selection of Solution #1 and solution #2 as the basis for normative work.

The overall evaluation of Key Issue #3 is described in clause 9.2.4. This refer to selection of Solution #3 as the basis for normative work.

The overall evaluation of Key Issue #4 is described in clause 9.2.5. This refer to selection of Solution #4 and Solution 5 as the basis for normative work.

Annex A (informative):  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **Tdoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2021-10 | SA6#45-bis-e |  |  |  |  | TS skeleton (version 0.0.0) approved in S6-212198  Implementation of the following pCRs approved by SA6:  S6-212199, S6-212200 | 0.1.0 |
| 2021-11 | SA6#46-e |  |  |  |  | Implementation of the following pCRs approved by SA6:  S6-212717, S6-212833 | 0.2.0 |
| 2022-02 | SA6#47-e |  |  |  |  | Implementation of the following pCRs approved by SA6:  S6-220286, S6-220287, S6-220471 | 0.3.0 |
| 2022-04 | SA6#48-e |  |  |  |  | Implementation of the following pCRs approved by SA6:  S6-220814, S6-220821, S6-220964 | 0.4.0 |
| 2022-05 | SA6#49-e |  |  |  |  | Implementation of the following pCRs approved by SA6:  S6-221321, S6-221323, S6-221325, S6-221326, S6-221471 | 0.5.0 |
| 2022-07 | SA6#49-bis-e |  |  |  |  | Implementation of the following pCR approved by SA6:  S6-221868 | 0.6.0 |
| 2022-09 | SA6#50-e |  |  |  |  | Implementation of the following pCRs approved by SA6:  S6-222151, S6-222365, S6-222366, S6-222424, S6-222587, S6-222603 | 0.7.0 |
| 2022-09 | SA#97-e | SP-220910 |  |  |  | Presentation for information at SA#97-e | 1.0.0 |
| 2022-10 | SA6#51-e |  |  |  |  | Implementation of the following pCR approved by SA6:  S6-222773 | 1.1.0 |
| 2022-11 | SA6#52 |  |  |  |  | Implementation of the following pCRs approved by SA6:  S6-223100, S6-223221, S6-223580, S1-223590, S6-223615, S6-223620 | 1.2.0 |
| 2022-11 | SA6#52 |  |  |  |  | Update of ToC | 1.2.1 |
| 2022-12 | SA#98-e | SP-221221 |  |  |  | Submitted for Approval at SA#98-e | 2.0.0 |
| 2022-12 | SA#98-e | SP-221221 |  |  |  | MCC Editorial update for publication after TSG SA approval (SA#98‑e) | 18.0.0 |