**SA WG2 Meeting #140e *S2-200xxxx***

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**Source: InterDigital**

**Title: Update to Solution #21: Connectivity setup for C2 communication and association between UAV and UAV-C**

**Document for: Approval**

**Agenda Item: 8.7**

**Work Item / Release: [FS\_ID\_UAS] / [Rel-17]**

*Abstract: This contribution proposes the update to Solution #21.*

# 1. Discussion

# 2. Proposal

It is proposed to capture the following update to Solution #21 in TR 23.754.

**\* \* \* \* First Change \* \* \* \***

## Solution #21: Connectivity setup for C2 communication and association between UAV and UAV-C

### 6.21.1 Introduction

This solution addresses Key Issue #6 and #7, i.e.:

* How are an UAV and an UAV-C associated as an UAS and how do the UAV and UAV-C receive the UAS association information?
* How does the UAV or UAV-C establish dedicated UP connection (UAV3 or UAV5) for C2 communication between each other?

### 6.21.2 Functional Description

This solution assumes that the UAV and the UAV-C have established User Plane paths (UAV9) with the USS/UTM and have successfully been authenticated and authorized by the USS/UTM for UAV operations (based on KI#1,2 and 3 solutions).

The UAV and the UAV-C may be served by the same or different PLMNs and the solution is applicable to both EPS and 5GS network.

The following UAS related identifier definitions are used:

**- UAV Permanent Id (UPID):** this corresponds e.g. to a manufacturer H/W id, serial number. It is used as a long-term identifier for UAV authentication along associated credentials (e.g., certificate).

**- UAS Temporary Id (UTID):** allocated by USS/UTM after successful UAV authentication and authorization by USS/UTM or following successful pairing authorization by USS/UTM of UAV with UAV-C. The UTID (e.g., corresponds to FAA Session ID) may be used for UAS remote identification and tracking. UTID is assumed to be a pseudonym, i.e., different from UPID for privacy protection reasons, unless otherwise mandated by local regulations. The UTID is assumed to be CAA Level ID. The same UTID may be shared between a UAV and UAV-C pair forming a UAS, or UAV and UAV-C may have separate UTIDs.

The main building blocks of the solution are:

**1. Association Triggering**: The association between the UAV and the UAV-C is triggered by the UAV or UAV-C issuing an Association Request to the USS/UTM (application layer signaling). The Association Request may contain the peer device identifier (e.g., UPID). Alternatively, the USS/UTM may detect that both the UAV and UAV-C are present in the network and may trigger the association procedure according to its internal logic (e.g., based on online presence and "ready" operational status). If available, a preferred or desired peer device identifier may be provided by UAV or UAV-C to USS/UTM during a prior Authentication and Authorization by USS/UTM phase.

**2. Association authorization:** the USS/UTM checks certain information to authorize the association. For example, the USS/UTM may check that UPID requested by UAV-C above corresponds to an authorized and available UAV and the UAV’s owner/pilot certificate matches that of the UAV-C. If the association request is authorized, the USS/UTM allocates a UTID identifying the UAV-UAV-C pairing and informs the UAV, the UAV-C and their serving network about the association information, such as the UTID. Association authorization by USS/UTM is enabled to fulfill the service requirements of association and authorization to operate i.e. respectively [R-5.1-001] and [R-5.1-010] from TS 22.125 [5]. These requirements imply that the network should not authorize C2 traffic with any random UAV-C but strictly with the one that is successfully paired with the UAV.

**3. UP path establishment for C2 communication:** both UAV and UAV-C initiate the UP connection establishment (e.g. PDU Session establishment) for C2 communication with their serving network upon being informed that an association is authorized by USS/UTM. The UP connection establishment may include the indication that the establishment request is for C2 communication and may include the associated UTID. When the UP connection is successfully set up, the serving network may update the USS/UTM with trusted UP connection information such as the transport information for C2 communication, e.g. IP address. At this point the UP connections are ready but the UAV or UAV-C can’t exchange C2 communication over it yet, they need to wait for further USS/UTM authorization for C2 communication (e.g., obtain peer IP address after authorization of flight plan).

If the UAV or UAV-C has previously established UP connection for UAV operations (e.g. connectivity to UTM/USS for authentication), the UAV or UAV-C may use the existing UP connection (with potential modification) for C2 communication. If the UAV-C is non-networked UAV-C, the UP connection establishment for C2 is not needed.

In another alternative, the UE may pre-establish limited UP connections before the UAS association is requested and authorized.

**4. C2 communication authorization:** when the UP connections of the UAV and UAV-C are established, the USS/UTM may authorize the C2 communication and notify the UAV, UAV-C and their serving network (e.g., provide respective peer IP address). Upon this authorization, the serving network may modify the UP connection to make it fully functional for C2 communication. The UAV and the UAV-C can start exchanging C2 communication after this authorization.

The definition of phases above for pairing and controlling of connectivity between UAV and UAV Controller is needed to support various operational scenarios. For example, the UAV and UAV-C may come online and be authorized by USS/UTM at different times. In another scenario, it may be necessary to enable pairing and limited connectivity before a flight plan is finally submitted and authorized by USS/UTM to enable IP connectivity for C2 communication.

NOTE: A UAV-C may control multiple UAVs. For each UAV/UAV-C pair, the same procedure described here may apply.

### 6.21.3 Procedures

In the procedure, it is assumed that the UAV and the UAV-C are served by the same USS/UTM via different PLMNs which could be either EPC or 5GC. It is also assumed that the UAV and the UAV-C has successfully registered with the 3GPP network and established UP connectivity with the USS/UTM.



Figure 6.21.3-1: Procedure for UAV/UAV-C association and C2 communication path setup

1. The UAV and the UAV-C perform authentication and authorization procedure with the USS/UTM. After successful authentication and authorization, the USS/UTM maintains a context for the UAV and UAV-C respectively which may contain their identifiers, such as UAV UE ID (3GPP identifiers) and UPID (e.g. drone serial number). Note that UAV-C may not be connected through a PLMN and in that case the PLMN related procedures described here on the UAV-C side may not be needed.

If the UAV or UAV-C has been previously authenticated and authorized for UAV operations, this step is not mandatory each time for establishing C2 communication.

2. The UAV-C initiates an Association Request and indicates the peer UPID in the request. Other information such as flight plan information may be submitted at this time or at a later stage.

3. The USS/UTM checks whether the association request can be authorized, e.g. by checking whether the owner certificates match each other. If the association request is approved, the USS/UTM allocates a UTID for the associated UAV and UAV-C respectively.

4. The USS/UTM sends an association notification message to the serving PLMNs of the UAV and UAV-C. The USS/UTM may have stored the information of the UAV or networked UAV-C’s serving PLMN during the previous UAV authentication/authorization procedure. The notification message may contain the UAV/UAV-C UE ID and the allocated UTID of UAV or UAV-C. If the UE has already established the UP connectivity for UAV operation (e.g. for communication with UTM), the PLMN may modify the existing UP connection to enable it for C2 communication. In this case, Step 6 is optional.

5. The USS/UTM may also send an association notification message to the UAV and UAV-C via user plane. The network may forward the association information message (including UTID) to the UE via control plane signalling.

6. Upon receiving the association notification, the UAV and the UAV-C may initiate UP connectivity setup for C2 communication. The APN or DNN used for the connectivity establishment may be dedicated for C2 communication and configured in the UE (e.g. via URSP rule). In the connectivity request the UAV/UAV-C may indicate the connectivity is used for C2 communication and include the associated UTID. The serving network may accept the connectivity establishment but may indicate to the UAV and UAV-C that the connectivity is limited pending further authorization.

7. The serving PLMNs acknowledge the association notification to the USS/UTM and may inform the USS/UTM of the established UP connectivity info for C2 communication, such as the transport address (UAV/UAV-C IP addresses). The transport addresses of the UAV(or UAV-C) will be forwarded by the USS/UTM to the serving network of its peer-device (in Step 8), for the network to set up proper forwarding rules; or forwarded to the application in the peer-device (in Step11). Also, the IP address received from the network is considered trusted by USS/UTM as opposed to if it was send directly by the UAV. The serving PLMN provides the UTID to the USS/UTM for the latter to retrieve the corresponding UAV context. In the case of networked UAV-C the UTID may be used to further locate the specific UAS context, as the UAV-C may control multiple UAVs simultaneously.

8. The USS/UTM updates the UAS context with the received UP connectivity info (e.g. peer transport addresses) for C2 communication.

9. At this point, the USS/UTM may authorize the C2 communication between the UAV and UAV-C and send a notification message to the UAV and UAV-C’s serving PLMNs. Based on the UAV IP addresses received in the message, the network may set up proper forwarding rules to enable UAV/UAV-C communication.

10. The UAV and UAV-C’s serving PLMNs may modify the UP connectivity to make it fully functional for C2 communication.

11. The USS/UTM may optionally send an application layer notification via user plane to the UAV and UAV-C to inform them that they are now authorized for C2 communication. The application layer trigger may be used by USS/UTM to synchronize when UAV and UAV can start sending C2 traffic.

12. The UAV and UAV-C may now start exchanging C2 communication.

### 6.21.4 Impacts on existing entities and interfaces

The solution has the following impacts on existing entities and interfaces:

- UDM/HSS

- Additional subscription information related to the UAV

- AMF/MME

- Handle subscription information for UAV

- Handle information from UTM/USS for association authorization and C2 communication authorization

- SMF/MME/PGW-C

- Handle dedicated APN/DNN for UAV communication

- Handle UAV communication indication in connectivity establishment request

- Modify the UP connectivity to enable C2 communication

### 6.21.5 Evaluation

Editor's note: This clause provides an evaluation of the solution.

**\* \* \* \* End of Change \* \* \* \***