ETSI TS 124 577 V18.0.0 (2024-05)

TECHNICAL SPECIFICATION

**5G;
Aircraft-to-Everything (A2X) services in
5G System (5GS) protocol aspects;
Stage 3
(3GPP TS 24.577 version 18.0.0 Release 18)**

Reference

DTS/TSGC-0124577vi00

Keywords

5G

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00   Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Important notice

The present document can be downloaded from:
https://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

If you find a security vulnerability in the present document, please report it through our
Coordinated Vulnerability Disclosure Program:
https://www.etsi.org/standards/coordinated-vulnerability-disclosure

Notice of disclaimer & limitation of liability

Copyright Notification

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM**® and the GSM logo are trademarks registered and owned by the GSM Association.

Legal Notice

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

The present document may refer to technical specifications or reports using their 3GPP identities. These shall be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between 3GPP and ETSI identities can be found under https://webapp.etsi.org/key/queryform.asp.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Foreword

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

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

Version x.y.z

where:

x   the first digit:

1   presented to TSG for information;

2   presented to TSG for approval;

3   or greater indicates TSG approved document under change control.

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

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

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

shall   indicates a mandatory requirement to do something

shall not   indicates an interdiction (prohibition) to do something

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

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

should   indicates a recommendation to do something

should not   indicates a recommendation not to do something

may   indicates permission to do something

need not   indicates permission not to do something

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

can   indicates that something is possible

cannot   indicates that something is impossible

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

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

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

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

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

In addition:

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

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

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

1 Scope

The present document specifies the protocols for aircraft-to-everything (A2X) communication as specified in 3GPP TS 23.256 [3] for A2X services among the UEs over the PC5 interface and over Uu.

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 23.122: "Non-Access-Stratum (NAS) functions related to Mobile Station (MS) in idle mode".

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

[4]   3GPP TS 23.285: "Architecture enhancements for V2X services".

[5]   3GPP TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services); Stage 2".

[6]   3GPP TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3".

[7]   3GPP TS 24.501: " Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3"

[8]   3GPP TS 24.578: "Aircraft-to-Everything (A2X) services in 5G System (5GS); UE policies".

[9]   3GPP TS 24.587: "Vehicle-to-Everything (V2X) services in 5G System (5GS); Protocol aspects; Stage 3".

[10]   3GPP TS 33.256: "Security aspects of Uncrewed Aerial Systems (UAS)".

[11]   3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[12]   3GPP TS 38.300: "NR; NR and NG-RAN Overall Description; Stage 2".

[13]   3GPP TS 38.304: "User Equipment (UE) procedures in Idle mode and RRC Inactive state".

[14]   3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) specification".

[15]   3GPP TS 38.331: "NR; Radio Resource Control (RRC) protocol specification".

[16]   IETF RFC 4862: "Neighbor Discovery for IP version 6 (IPv6)".

[17]   ASTM F3411.19: "Standard Specification for Remote ID and Tracking".

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

[19]   3GPP TS 24.007: "Mobile radio interface signalling layer 3; General aspects".

[20]   IETF RFC 4291: "IP Version 6 Addressing Architecture".

[21]   ISO TS 17419 ITS-AID AssignedNumbers:
http://standards.iso.org/iso/ts/17419/TS17419%20Assigned%20Numbers/TS17419_ITS-AID_AssignedNumbers.pdf

[22]   IETF RFC 4566: "SDP: Session Description Protocol".

[23]   IETF RFC 768: "User Datagram Protocol".

[24]   IETF RFC 793: "Transmission Control Protocol."

[25]   IETF RFC 1035: "DOMAIN NAMES - IMPLEMENTATION AND SPECIFICATION".

[26]   3GPP TS 24.008: "Mobile radio interface Layer 3 specification; Core network protocols; Stage 3".

[27]   3GPP TS 23.247: "Architectural enhancements for 5G multicast-broadcast services".

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].

E-UTRA-PC5: PC5 reference point over E-UTRA. The term E-UTRA-PC5 used in the present document corresponds to the term LTE PC5 defined in 3GPP TS 23.256 [3].

NR-PC5: PC5 reference point over NR. The term NR-PC5 used in the present document corresponds to the term NR PC5 defined in 3GPP TS 23.256 [3].

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.256 [3] apply:

A2X communication

A2X message

A2X service

For the purposes of the present document, the following terms and definitions given in 3GPP TS 38.331 [15] apply:

MBS Radio Bearer

3.2   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].

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.256 [3] apply:

A2X   Aircraft-to-everything

4   General description

The present specification defines means for transport of A2X messages, A2X Communication, and procedures for A2X services including BRID, DDAA, direct C2 communication and GBDAAA.

The A2X messages are generated and consumed by upper layers of the UE e.g., A2X application. A2X message can contain IP data or non-IP data. For IP data, only IPv6 is used for A2X messages sent over PC5. IPv4 is not supported in this release of specification for A2X messages sent over PC5.

The A2X message can be transported using A2X communication over PC5 or over Uu. A2X communication over PC5 supports both broadcast mode and unicast mode. Groupcast mode over PC5 and relay communication over PC5 is not supported in this release of specification. A2X communication over Uu supports both broadcast mode and unicast mode.

5 Provisioning of parameters for A2X configuration

5.1 General

A2X communication is configured using A2X configuration parameters and related procedures which allow configuration of necessary A2X configuration parameters.

5.2 Configuration and precedence of A2X configuration parameters

5.2.1 General

UE's usage of A2X communication is controlled by A2X configuration parameters.

The A2X configuration parameters consist of the configuration parameters for A2X communication over PC5 and A2X communication over Uu.

5.2.2 Precedence of A2X configuration parameters

The A2X configuration parameters can be:

   a) pre-configured in the ME;

   b) configured in the UICC;

   c) provided as a A2XP using the UE policy delivery service as specified in 3GPP TS 24.501 [7] annex D;

   d) provided by a A2X application server via A2X1 reference point; or

   e) a combination of case a), b), c) or d) above.

The UE shall use the A2X configuration parameters in the following order of decreasing precedence:

   a) the A2X configuration parameters provided as a A2XP using the UE policy delivery service as specified in annex D of 3GPP TS 24.501 [7];

   b) the A2X configuration parameters provided by a A2X application server via A2X1 reference point;

   c) the A2X configuration parameters configured in the UICC; and

   d) the A2X configuration parameters pre-configured in the ME.

5.2.3 Configuration parameters for A2X communication over PC5

The configuration parameters for A2X communication over PC5 consist of:

   a) a validity timer for the validity of the configuration parameters for A2X communication over PC5;

   b) a list of PLMNs and RATs in which the UE is authorized to use A2X communication over PC5 when the UE is served by E-UTRA or served by NR. Each entry of the list contains a PLMN ID and RATs in which the UE is authorized to use A2X communication over PC5;

c) an indication of whether the UE is authorized to use A2X communication over PC5 when the UE is not served by E-UTRA and not served by NR;

d) list of RATs in which the UE is authorized to use A2X communication over PC5 and the radio parameters of the RAT for A2X communication over PC5 applicable per altitude range per geographical area with an indication of whether these radio parameters of the RAT are "operator managed" or "non-operator managed" when the UE is not served by E-UTRA and not served by NR;

e) optionally, a list of A2X service identifier to PC5 RAT(s) and Tx profiles mapping rules. Each mapping rule contains one or more A2X service identifiers, PC5 RAT(s) and:

   1) if the PC5 RAT(s) include E-UTRA-PC5, Tx profiles corresponding to the E-UTRA-PC5;

   2) if the PC5 RAT(s) include NR-PC5, NR Tx profile corresponding to the NR-PC5 for broadcast mode A2X communication over PC5; or

   3) if the PC5 RAT(s) include NR-PC5, NR Tx profile corresponding to transmitting and receiving initial signalling of the A2X PC5 unicast link establishment;

f) configuration parameters for privacy support, consisting of:

   1) a list of A2X services requiring privacy. Each entry of the list contains one or more A2X service identifiers and one or more geographical areas where the privacy is required; and

   2) a privacy timer value as specified in 3GPP TS 24.578 [8] clause 5.3;

g) configuration parameters for a A2X communication over PC5 in E-UTRA-PC5, consisting of:

   1) a list of A2X service identifier to destination layer-2 ID mapping rules. Each mapping rule contains one or more A2X service identifiers and the destination layer-2 ID;

   2) optionally, a default destination layer-2 ID;

   3) a list of PPPP to PDB mapping rules. Each mapping rule contains a ProSe Per-Packet Priority (PPPP) and a Packet Delay Budget (PDB);

   4) optionally, list of A2X service identifier to A2X E-UTRA frequency mapping rules. Each mapping rule contains one or more A2X service identifiers and the A2X E-UTRA frequencies with associated altitude ranges and geographical areas;

   5) optionally, a list of the A2X services authorized for ProSe Per-Packet Reliability (PPPR). Each entry of the list contains one or more A2X service identifiers and a ProSe Per-Packet Reliability (PPPR) value; and

NOTE 1: For the A2X service identifier(s) indicating direct C2 communication service, configuration parameters for A2X communication over PC5 in E-UTRA-PC5 are not applicable.

h) configuration parameters for a A2X communication over PC5 in NR-PC5, consisting of:

   1) optionally, a list of A2X service identifier to A2X NR frequency mapping rules. Each mapping rule contains one or more A2X service identifiers and the A2X NR frequencies with associated altitude ranges and geographical areas;

   2) a list of A2X service identifier to destination layer-2 ID for broadcast mapping rules. Each mapping rule contains one or more A2X service identifiers and the destination layer-2 ID for broadcast;

   3) optionally, a default destination layer-2 ID for broadcast;

   4) a list of A2X service identifier to default destination layer-2 ID for unicast initial signalling mapping rules. Each mapping rule contains one or more A2X service identifiers and the default destination layer-2 ID for initial signalling to establish unicast connection;

   5) a list of A2X service identifier to PC5 QoS parameters mapping rules. The PC5 QoS parameters are specified in clause 5.4.2 of 3GPP TS 23.287 [5];

6) an AS configuration, including a list of SLRB mapping rules applicable when the UE is not served by E-UTRA and is not served by NR. Each SLRB mapping rule contains a PC5 QoS profile and an SLRB. The PC5 QoS profile contains the following parameters:

   i) the PC5 QoS profile contains a PQI;

NOTE 2: PQI values for A2X communications over PC5 and their one-to-one mapping to PC5 QoS characteristics are defined in clause 6.2.4.1 of 3GPP TS 23.256 [3].

   ii) if the PQI of the PC5 QoS profile identifies a GBR QoS, the PC5 QoS profile contains a PC5 flow bit rates consisting of a guaranteed flow bit rate (GFBR) and a maximum flow bit rate (MFBR);

   iii) if the PQI of the PC5 QoS profile identifies a non-GBR QoS, the PC5 QoS profile contains the PC5 link aggregated bit rate consisting of a per link aggregate maximum bit rate (PC5 LINK-AMBR); and

NOTE 3: PC5 link aggregated bit rate is only used for unicast mode communications over PC5.

   iv) the PC5 QoS profile can contain the priority level, the averaging window, and the maximum data burst volume. If one or more of the priority level, the averaging window or the maximum data burst volume are not contained in the PC5 QoS profile, their default values apply;

7) a list of NR-PC5 unicast security policies. Each entry in the list contains an NR-PC5 unicast security policy composed of:

   i) one or more A2X service identifiers;

   ii) the signalling integrity protection policy for the A2X service identifier(s);

   iii) the signalling ciphering policy for the A2X service identifier(s);

   iv) the user plane integrity protection policy for the A2X service identifier(s);

   v) the user plane ciphering policy for the A2X service identifier(s); and

   vi) one or more geographical areas where the NR-PC5 unicast security policy applies;

8) a list of A2X service identifier to default mode of communication mapping rules. Each mapping rule contains one or more A2X service identifiers and the default mode of communication (one of unicast or broadcast); and

9) for broadcast mode and initial signalling of the A2X PC5 unicast link establishment, PC5 DRX configurations (see 3GPP TS 38.331 [15]), including the mapping of PC5 QoS profile(s) to PC5 DRX cycle(s) and the default PC5 DRX configuration, when the UE is not served by E-UTRA and not served by NR.

5.2.4 Configuration parameters for broadcast remote ID (BRID)

NOTE: In this release of the specification, no specific configuration parameters for BRID over PC5 and BRID over Uu are defined.

5.2.5 Configuration parameters for direct detect and avoid (DDAA)

The configuration parameters for DDAA consist of:

a) a list of A2X service identifier(s) for DAA deconflicting policy to indicate whether unicast mode communications over PC5 or broadcast mode communications over PC5 is used.

5.2.6 Configuration parameters for direct C2 communication over PC5

The configuration parameters for direct C2 communication over PC5 consist of:

a) a list of PLMNs in which the UE is authorized to use direct C2 communication over PC5 when the UE is served by NG-RAN. Each entry of the list contains a PLMN ID in which the UE is authorized to use direct C2 communication over PC5; and

b) an indication of whether the UE is authorized to use direct C2 communication over PC5 when the UE is not served by NG-RAN.

5.2.6A Configuration parameters for ground based detect and avoid for an area (GBDAAA)

NOTE: In this release of the specification, no specific configuration parameters for GBDAAA are defined.

5.2.7 Configuration parameters for A2X communication over Uu

The configuration parameters for A2X communication over Uu consist of:

a) a validity timer for the validity of the configuration parameters for A2X communication over Uu;

b) optionally, a list of A2X service identifier to PDU session parameters mapping rules. Each mapping rule contains one or more A2X service identifiers of a the A2X service and one or more parameters for establishment of a PDU session for A2X communication over Uu for the A2X services:

   1) one of the "IPv4", "IPv6", "IPv4v6" or "Unstructured" PDU session types;

   2) an SSC mode;

   3) a list of zero or more S-NSSAIs;

   4) a list of zero or more DNNs; and

   5) one of the UDP or TCP transport layer protocol if the PDU session type is "IPv4", "IPv6" or "IPv4v6"; and

c) a list of PLMNs in which the UE is configured to use A2X communication over Uu. For each PLMN, the list contains:

   1) for transfer of a A2X message of a A2X service identified by a A2X service identifier:

     i) a list of A2X service identifier to A2X application server address mapping rules, applicable when the UE is registered to the PLMN. Each mapping rule contains:

       A) one or more A2X service identifiers;

       B) a A2X application server address for unicast consisting of:

         -   an FQDN, or an IP address; and

         -   a UDP port for uplink transport, a UDP port for downlink transport, a TCP port for bidirectional transport or any combination of them;

       C) optionally a geographical area; and

       D) optionally, one or more A2X MBS configuration(s) for receiving A2X communication over Uu via MBS per A2X service identier consisting of:

         -   an MBS session announcement; and

         -   an A2X MBS configuration SDP body; and

     ii) optionally, per type of data (IP and non-IP) and A2X message family (in case of non-IP) and optionally a geographical area, one or more default A2X application server addresses for the unicast A2X communication over Uu applicable when the UE is registered to the PLMN. Each A2X application server address consists of:

       A) an FQDN, or an IP address; and

       B) a UDP port for uplink transport, a UDP port for downlink transport, a TCP port for bidirectional transport or any combination of them; and

      iii) optionally, one or more default A2X MBS configuration(s) for receiving A2X communication over Uu using MBS consisting of:

        A) an MBS session announcement; and

        B) an A2X MBS configuration SDP body;

  2) for transfer of a A2X message of a A2X service not identified by a A2X service identifier:

    i) a list of the A2X application servers per optional geographical area where usage of those A2X application servers applies, applicable when the UE is registered to the PLMN. Each entry of the list contains:

      A) a A2X application server address consisting of an FQDN, or an IP address; and

      B) optionally, a geographical area;

    ii) optionally, one or more A2X MBS configuration(s) for receiving A2X communication over Uu via MBS consisting of:

      A) an MBS session announcement; and

      B) an SDP body;

  3) optionally, a list of the A2X service identifier for BRID reception. Each mapping rule contains:

    i) one or more A2X service identifiers; and

  4) optionally, A2X AS MBS configuration for receiving A2X application server information using MBS consisting of:

    i) a MBS session announcement for receiving A2X application server information via MBS; and

    ii) A2X AS MBS configuration SDP body.

5.3 Procedures

5.3.1 General

The procedure for provisioning of parameters for A2X configuration allows the UE to obtain information necessary for A2X communication.

5.3.2 UE-requested A2X policy provisioning procedure

5.3.2.1 General

The UE-requested A2X policy provisioning procedure enables the UE to request A2X policy from the PCF in the following cases:

  a) if the T5341 for a UE policy for A2X communication over PC5 expires;

  b) if the T5342 for a UE policy for A2X communication over Uu expires; or

  c) if there are no valid configuration parameters, e.g., for the current area, or due to abnormal situation.

The UE shall follow the principles of PTI handling for UE policy delivery service procedures defined in 3GPP TS 24.501 [7] clause D.1.2.

5.3.2.2 UE-requested A2X policy provisioning procedure initiation

In order to initiate the UE-requested A2X policy provisioning procedure, the UE shall create a UE POLICY PROVISIONING REQUEST message (see example in figure 5.3.2.2.1). The UE:

  a) shall allocate a PTI value currently not used and set the PTI IE to the allocated PTI value;

b) shall include the Requested UE policies IE indicating whether the UE policies for A2X communication over PC5, the UE policies for A2X communication over Uu or both are requested;

c) shall transport the UE POLICY PROVISIONING REQUEST message using the NAS transport procedure as specified in 3GPP TS 24.501 [7] clause 5.4.5; and

d) shall start timer T5040.
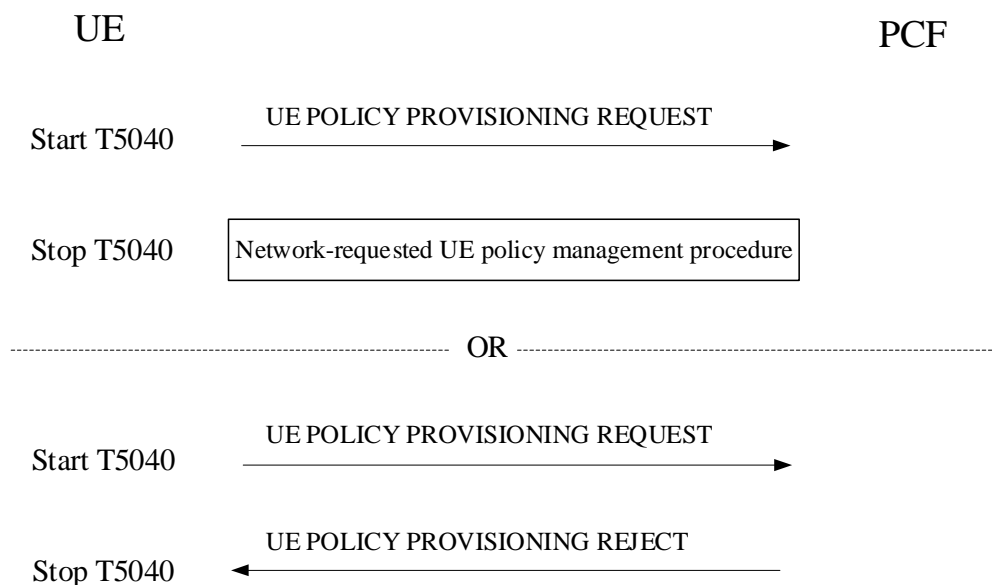
Figure 5.3.2.2.1: UE-requested A2X policy provisioning procedure

5.3.2.3 UE-requested A2X policy provisioning procedure accepted by the network

Handling in 3GPP TS 24.587 [9] clause 5.3.2.3 shall apply.

If new UE policies for A2X communication over PC5 are included in the MANAGE UE POLICY COMMAND message, the UE shall stop timer T5341 if it is running and start timer T5341 with the value included in the UE policies for A2X communication over PC5, and start using the new UE policies for A2X communication over PC5 included in the MANAGE UE POLICY COMMAND message.

If new UE policies for A2X communication over Uu are included in the MANAGE UE POLICY COMMAND message, the UE shall stop timer T5342 if it is running and start timer T5342 with the value included in the UE policies for A2X communication over Uu, and start using the new UE policies for A2X communication over Uu included in the MANAGE UE POLICY COMMAND message.

5.3.2.4 UE-requested A2X policy provisioning procedure not accepted by the network

Handling in 3GPP TS 24.587 [9] clause 5.3.2.4 shall apply.

5.3.2.5 Abnormal cases on the network side

Handling in 3GPP TS 24.587 [9] clause 5.3.2.5 shall apply.

5.3.2.6 Abnormal cases on the UE

Handling in 3GPP TS 24.587 [9] clause 5.3.2.6 shall apply.

6 A2X communication

This clause describes the procedures at the UE, and between UEs, for A2X communication over PC5. As specified in 3GPP TS 23.256 [3] clause 4.2.1.2.1, both LTE-PC5 and NR-PC5 are supported leveraging V2X mechanisms defined in TS 23.287 [5].

6.1 A2X communication over PC5

6.1.1 General

This clause describes the procedures at the UE, and between UEs, for A2X communication over PC5.

The UE shall support requirements for securing A2X communication over PC5.

Both IP based and non-IP based A2X communication over PC5 are supported. For IP based A2X communication, only IPv6 is used. IPv4 is not supported in this release of the present document.

A2X communication over NR-PC5 supports broadcast mode and unicast mode. Groupcast mode for A2X communication over NR-PC5 is not supported in this version of the specifications. If upper layer of the UE indicates the mode of communication, the UE shall set the mode of communication based on the request of the upper layer. Otherwise, the UE shall set the mode of communication based on the mapping rules between the A2X service identifier and the default mode of communication defined in clause 5.2.3.

A2X communication over NR-PC5 between the UEs served by different PLMNs is possible when the UEs use the same sidelink carrier. UEs that use the UE autonomous resources selection based on pre-configuration for NR-PC5 can communicate over NR-PC5 independent of the serving PLMN; these UEs shall support the procedures described in clauses 6.1.2 and 6.1.3, so that the UEs served by different PLMNs can perform A2X communications over NR-PC5 when "not served by E-UTRA" and "not served by NR". A UE, to perform these procedures, shall reliably locate itself in the corresponding geographical area and altitude. Otherwise, the UE is not authorized to transmit.

> NOTE : It is out of scope of the present specification to define how the UE can locate itself in a specific geographical area and altitude. When the UE is in coverage of a 3GPP RAT, it can for example, use information derived from the serving PLMN. When the UE is not in coverage of a 3GPP RAT, it can use other techniques, e.g. Global Navigation Satellite System (GNSS). User provided location is not a valid input.

A2X communication over LTE-PC5 in EPS uses only the autonomous resources selection mode. The network scheduled operation mode is not supported for A2X as specified in TS 23.256 [3] clause 4.2.1.2.1.

A2X communication over LTE-PC5 between the UEs served by different PLMNs is not supported in this release of the specification.

6.1.2 Unicast mode A2X communication over NR-PC5

6.1.2.1 Overview

This clause describes the PC5 signalling protocol procedures between two UEs for unicast mode of A2X communication. The following PC5 signalling protocol procedures are defined:

a) A2X PC5 unicast link establishment;

b) A2X PC5 unicast link modification;

c) A2X PC5 unicast link release;

d) A2X PC5 unicast link identifier update;

e) A2X PC5 unicast link authentication;

f) A2X PC5 unicast link security mode control;

g)   A2X PC5 unicast link keep-alive; and

h)   A2X PC5 unicast link re-keying procedure.

6.1.2.2   A2X PC5 unicast link establishment procedure

6.1.2.2.1   General

Depending on the type of the A2X PC5 unicast link establishment procedure (i.e. UE oriented Layer-2 link establishment or Service oriented Layer-2 link establishment in 3GPP TS 23.287 [5]), the A2X PC5 unicast link establishment procedure is used to establish an A2X PC5 unicast link between two UEs or to establish multiple A2X PC5 unicast links. The UE sending the request message is called the "initiating UE" and the other UE is called the "target UE". If the request message does not indicate the specific target UE (i.e. target user info is not included in the request message), and multiple target UEs are interested in the A2X service(s) indicated in the request message, then the initiating UE shall handle corresponding response messages received from those target UEs. The maximum number of A2X NR-PC5 unicast links established in a UE at a time shall not exceed an implementation-specific maximum number of established A2X NR-PC5 unicast links.

NOTE: The recommended maximum number of established A2X NR-PC5 unicasts link is 8.

6.1.2.2.2   A2X PC5 unicast link establishment procedure initiation by initiating UE

The initiating UE shall meet the following pre-conditions before initiating this procedure:

a)   a request from upper layers to transmit the packet for A2X service over PC5;

b)   the communication mode is unicast mode (e.g. pre-configured as specified in clause 5.2.3 or indicated by upper layers);

c)   the link layer identifier for the initiating UE (i.e. layer-2 ID used for unicast communication) is available (e.g. pre-configured or self-assigned) and is not being used by other existing A2X PC5 unicast links to the same link layer identifier for the destination UE within the initiating UE;

d)   the link layer identifier for the destination UE (i.e. the unicast layer-2 ID of the target UE or the broadcast layer-2 ID) is available to the initiating UE (e.g. pre-configured, obtained as specified in clause 5.2.3 or known via prior A2X communication);

NOTE 1:   In the case where different A2X services are mapped to distinct default destination layer-2 IDs, when the initiating UE intends to establish a single unicast link that can be used for more than one A2X service identifiers, the UE can select any of the default destination layer-2 ID for unicast initial signalling.

e)   the initiating UE is either authorised for A2X communication over PC5 in NR-PC5 in the serving PLMN, or has a valid authorization for A2X communication over PC5 in NR-PC5 when not served by E-UTRA and not served by NR. The UE considers that it is not served by E-UTRA and not served by NR if the following conditions are met:

  1)   not served by NR and not served by E-UTRA for A2X communication over PC5;

  2)   in limited service state as specified in 3GPP TS 23.122 [2], if the reason for the UE being in limited service state is one of the following;

    i)   the UE is unable to find a suitable cell in the selected PLMN as specified in 3GPP TS 38.304 [13];

    ii)   the UE received a REGISTRATION REJECT message or a SERVICE REJECT message with the 5GMM cause #11 "PLMN not allowed" as specified in 3GPP TS 24.501 [7]; or

    iii) the UE received a REGISTRATION REJECT message or a SERVICE REJECT message with the 5GMM cause #7 "5GS services not allowed" as specified in 3GPP TS 24.501 [7]; or

  3)   in limited service state as specified in 3GPP TS 23.122 [2] for reasons other than i), ii) or iii) above, and located in an altitude range and a geographical area for which the UE is provisioned with "non-operator managed" radio parameters as specified in clause 5.2.3;

f) there is no existing A2X PC5 unicast link for the pair of peer application layer IDs, or there is an existing A2X PC5 unicast link for the pair of peer application layer IDs and:

1) the network layer protocol of the existing A2X PC5 unicast link is not identical to the network layer protocol required by the upper layer in the initiating UE for this A2X service; or

2) the security policy (either signalling security policy or user plane security policy) corresponding to the A2X service identifier is not compatible with the security policy of the existing A2X PC5 unicast link; and

g) the number of established A2X PC5 unicast links is less than the implementation-specific maximum number of established A2X NR-PC5 unicast links allowed in the UE at a time.

After receiving the service data or request from the upper layers, the initiating UE shall derive the PC5 QoS parameters and assign the PQFI(s) for the PC5 QoS flows(s) to be established as specified in clause 6.1.2.12.

In order to initiate the A2X PC5 unicast link establishment procedure, the initiating UE shall create an A2X DIRECT LINK ESTABLISHMENT REQUEST message. The initiating UE:

a) shall include the source user info set to the initiating UE's application layer ID received from upper layers;

b) shall include the A2X service identifier(s) received from upper layer;

c) shall include the target user info set to the target UE's application layer ID if received from upper layers or if the destination layer-2 ID is the unicast layer-2 ID of target UE;

d) shall include the Key establishment information container if the NR-PC5 unicast signalling integrity protection policy is set to "signalling integrity protection required" or "signalling integrity protection preferred", and may include the Key establishment information container if the NR-PC5 unicast signalling integrity protection policy is set to "signalling integrity protection not needed";

NOTE 2: The Key establishment information container is provided by upper layers.

e) shall include a Nonce_1 set to the 128-bit nonce value generated by the initiating UE for the purpose of session key establishment over this A2X PC5 unicast link if the NR-PC5 unicast signalling integrity protection policy is set to "signalling integrity protection required" or "signalling integrity protection preferred";

f) shall include its UE security capabilities indicating the list of algorithms that the initiating UE supports for the security establishment of this A2X PC5 unicast link;

g) shall include the MSB of $K_{NRP-sess}$ ID chosen by the initiating UE as specified in 3GPP TS 33.256 [10] if the NR-PC5 unicast signalling integrity protection policy is set to "signalling integrity protection required" or "signalling integrity protection preferred";

h) may include a K_{NRP} ID if the initiating UE has an existing K_{NRP} for the target UE; and

i) shall include its UE A2X PC5 unicast signalling security policy set to the NR-PC5 unicast signalling security policy. In the case where the different A2X services are mapped to the different PC5 unicast signalling security policies, when the initiating UE intends to establish a single unicast link that can be used for more than one A2X service, each of the signalling security polices of those A2X services shall be compatible, e.g. "signalling integrity protection not needed" and "signalling integrity protection required" are not compatible.

After the A2X DIRECT LINK ESTABLISHMENT REQUEST message is generated, the initiating UE shall pass this message to the lower layers for transmission along with:

a) the initiating UE's layer-2 ID for unicast communication and the destination layer-2 ID used for unicast initial signalling;

b) the NR Tx profile corresponding to the initial signalling of the A2X PC5 unicast link establishment and that is associated with the A2X service identifier (see clause 5.2.3), if available;

NOTE 3: The NR Tx profile is used by lower layers to determine the PC5 DRX parameter values (see 3GPP TS 38.300 [12]) for transmitting and receiving initial signalling of the A2X PC5 unicast link establishment.

and start timer T5300. The UE shall not send a new A2X DIRECT LINK ESTABLISHMENT REQUEST message to the same target UE identified by the same application layer ID while timer T5300 is running. If the target user info IE is

not included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message (i.e. A2X service oriented A2X PC5 unicast link establishment procedure), the initiating UE shall handle multiple A2X DIRECT LINK ESTABLISHMENT ACCEPT messages, if any, received from different target UEs for the establishment of multiple A2X PC5 unicast links before the expiry of timer T5300.

NOTE 4: In order to ensure successful A2X PC5 unicast link establishment, T5300 should be set to a value larger than the sum of T5304 and T5310.
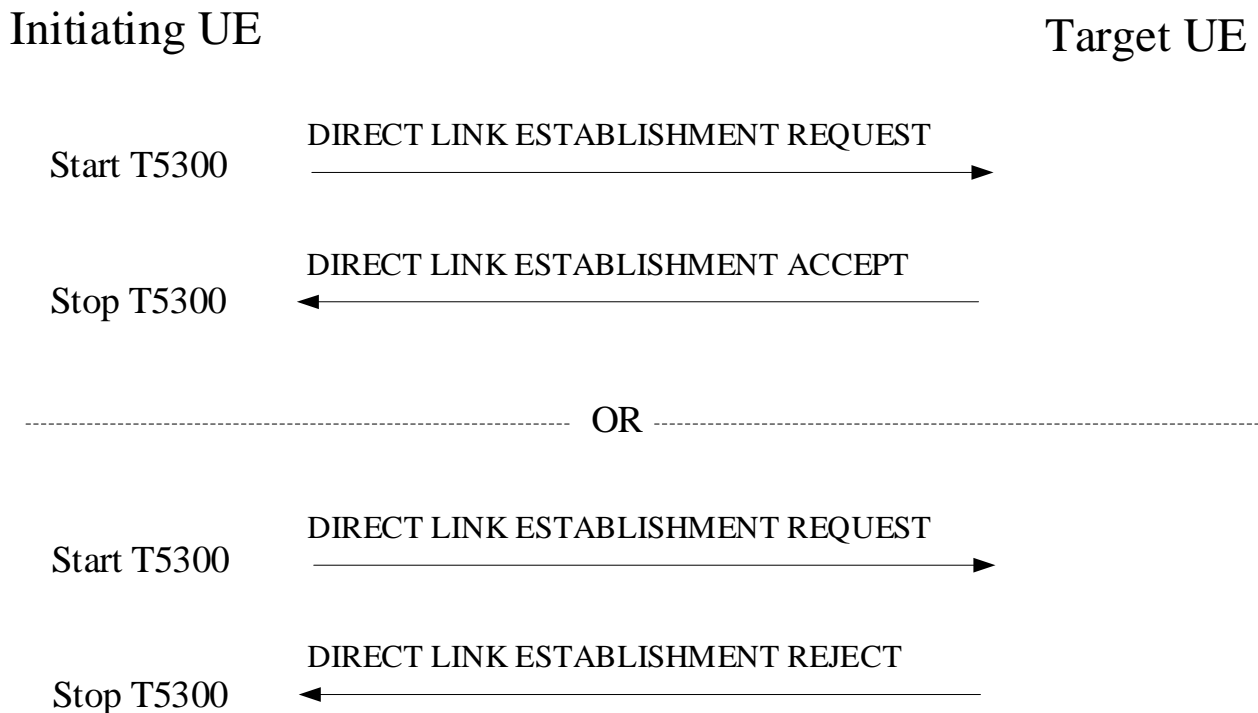
Figure 6.1.2.2.2: UE oriented A2X PC5 unicast link establishment procedure
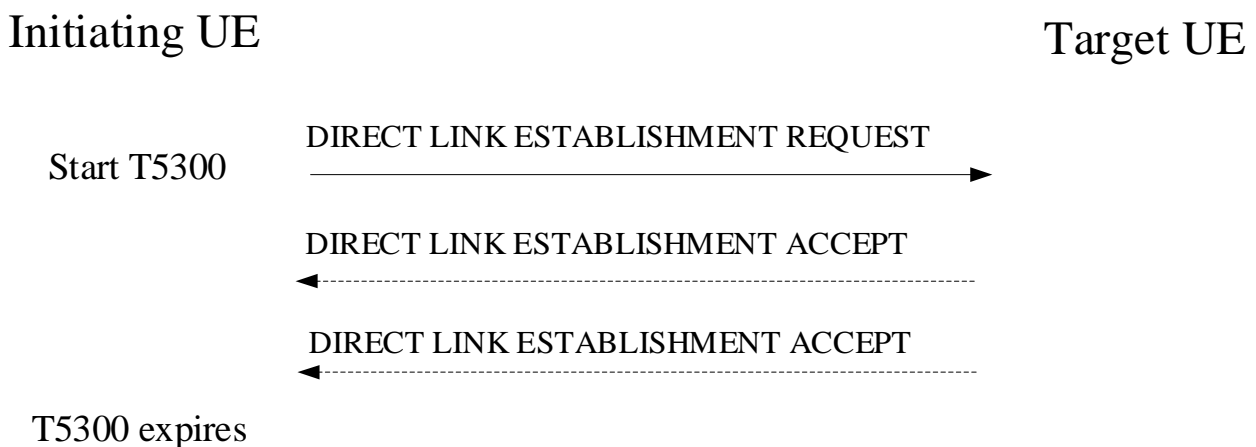
Figure 6.1.2.2.3: Service oriented A2X PC5 unicast link establishment procedure

6.1.2.2.3   A2X PC5 unicast link establishment procedure accepted by the target UE

The target UE shall pass the NR Tx profile corresponding to the initial signalling of the A2X PC5 unicast link establishment and that is associated with the A2X service identifier the target UE is interested in (see clause 5.2.3), if available, to the lower layers.

NOTE 1: The NR Tx profile is used by lower layers to determine the PC5 DRX parameter values (see 3GPP TS 38.300 [12]) for transmitting and receiving initial signalling of the A2X PC5 unicast link establishment.

Upon receipt of an A2X DIRECT LINK ESTABLISHMENT REQUEST message, if the target UE accepts this request, the target UE shall uniquely assign a PC5 link identifier, create an A2X PC5 unicast link context and assign a layer-2 ID for this A2X PC5 unicast link. The newly assigned layer-2 ID replaces the target layer-2 ID as received on the A2X DIRECT LINK ESTABLISHMENT REQUEST message. Then the target UE shall store this assigned layer-2 ID and the source layer-2 ID used in the transport of this message provided by the lower layers in the A2X PC5 unicast link context. The target UE may initiate A2X PC5 unicast link authentication procedure as specified in clause 6.1.2.6 and shall initiate A2X PC5 unicast link security mode control procedure as specified in clause 6.1.2.7.

NOTE 2: The target UE may reuse the target UE's layer-2 ID used in the transport of the A2X DIRECT LINK ESTABLISHMENT REQUEST message provided by the lower layers in case that the target UE's layer-2 ID has been used in previous A2X PC5 unicast link with the same peer.

If:

a) the target user info IE is included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message and this IE includes the target UE's application layer ID; or

b) the target user info IE is not included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message and the target UE is interested in the A2X service(s) identified by the A2X service identifier IE in the A2X DIRECT LINK ESTABLISHMENT REQUEST message;

then the target UE shall either:

a) identify an existing K_{NRP} based on the K_{NRP} ID included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message; or

b) if K_{NRP} ID is not included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message, the target UE does not have an existing K_{NRP} for the K_{NRP} ID included in A2X DIRECT LINK ESTABLISHMENT REQUEST message or the target UE wishes to derive a new K_{NRP}, derive a new K_{NRP}. This may require performing one or more A2X PC5 unicast link authentication procedures as specified in clause 6.1.2.6.

NOTE 3: How many times the A2X PC5 unicast link authentication procedure needs to be performed to derive a new K_{NRP} depends on the authentication method used.

After an existing K_{NRP} was identified or a new K_{NRP} was derived, the target UE shall initiate an A2X PC5 unicast link security mode control procedure as specified in clause 6.1.2.7.

Upon successful completion of the A2X PC5 unicast link security mode control procedure, in order to determine whether the A2X DIRECT LINK ESTABLISHMENT REQUEST message can be accepted or not, in case of IP communication, the target UE checks whether there is at least one common IP address configuration option supported by both the initiating UE and the target UE.

If the target UE accepts the A2X PC5 unicast link establishment procedure, the target UE shall create an A2X DIRECT LINK ESTABLISHMENT ACCEPT message. The target UE:

a) shall include the source user info set to the target UE's application layer ID received from upper layers;

b) shall include PQFI(s), the corresponding PC5 QoS parameters and the A2X service identifier(s) that the target UE accepts;

c) shall include an IP address configuration IE set to one of the following values if IP communication is used:

1) "IPv6 router" if IPv6 address allocation mechanism is supported by the target UE, i.e. acting as an IPv6 router; or

2) "IPv6 address allocation not supported" if IPv6 address allocation mechanism is not supported by the target UE;

d) shall include a link local IPv6 address IE formed locally based on IETF RFC 4862 [16] if IP address configuration IE is set to "IPv6 address allocation not supported" and the received A2X DIRECT LINK SECURITY MODE COMPLETE message included a link local IPv6 address IE; and

e) shall include the configuration of UE A2X PC5 unicast user plane security protection based on the agreed user plane security policy, as specified in 3GPP TS 33.256 [10].

After the A2X DIRECT LINK ESTABLISHMENT ACCEPT message is generated, the target UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication, and shall start timer T5305 if at least one of A2X service identifiers for the A2X PC5 unicast links satisfies the privacy requirements as specified in clause 5.2.3.

After sending the A2X DIRECT LINK ESTABLISHMENT ACCEPT message, the target UE shall provide the following information along with the layer-2 IDs to the lower layer, which enables the lower layer to handle the coming PC5 signalling or traffic data:

a) the PC5 link identifier self-assigned for this A2X PC5 unicast link;

b) PQFI(s) and its corresponding PC5 QoS parameters; and

c) an indication of activation of the PC5 unicast user plane security protection for the A2X PC5 unicast link, if applicable.

If the target UE accepts the A2X PC5 unicast link establishment request, then the target UE may perform the PC5 QoS flow establishment over A2X PC5 unicast link as specified in clause 6.1.2.12.

6.1.2.2.4 A2X PC5 unicast link establishment procedure completion by the initiating UE

If the Target user info IE is included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message, upon receipt of the A2X DIRECT LINK ESTABLISHMENT ACCEPT message, the initiating UE shall stop timer T5300. If the Target user info IE is not included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message the initiating UE may keep the timer T5300 running and continue to handle multiple response messages (i.e. the A2X DIRECT LINK ESTABLISHMENT ACCEPT message) from multiple target UEs.

For each of the A2X DIRECT LINK ESTABLISHMENT ACCEPT message received, the initiating UE shall uniquely assign a PC5 link identifier and create an A2X PC5 unicast link context for each of the A2X PC5 unicast link(s). Then the initiating UE shall store the source layer-2 ID and the destination layer-2 ID used in the transport of this message provided by the lower layers in the A2X PC5 unicast link context(s) to complete the establishment of the A2X PC5 unicast link with the target UE(s). From this time onward the initiating UE shall use the established link(s) for A2X communication over PC5 and additional PC5 signalling messages to the target UE(s).

After receiving the A2X DIRECT LINK ESTABLISHMENT ACCEPT message, the initiating UE shall provide the following information along with the layer-2 IDs to the lower layer, which enables the lower layer to handle the coming PC5 signalling or traffic data:

a) the PC5 link identifier self-assigned for this A2X PC5 unicast link;

b) PQFI(s) and its corresponding PC5 QoS parameters.

c) an indication of activation of the PC5 unicast user plane security protection for the A2X PC5 unicast link, if applicable.

The initiating UE shall start timer T5305 if at least one of A2X service identifiers for the A2X PC5 unicast links satisfies the privacy requirements as specified in clause 5.2.3.

In addition, the initiating UE may perform the PC5 QoS flow establishment over A2X PC5 unicast link as specified in clause 6.1.2.12.

Upon expiry of the timer T5300, if the A2X DIRECT LINK ESTABLISHMENT REQUEST message did not include the Target User Info IE, and the initiating UE received at least one A2X DIRECT LINK ESTABLISHMENT ACCEPT message, it is up to the UE implementation to consider the A2X PC5 unicast link establishment procedure as complete or to restart the timer T5300.

6.1.2.2.5 A2X PC5 unicast link establishment procedure not accepted by the target UE

If the A2X DIRECT LINK ESTABLISHMENT REQUEST message cannot be accepted, the target UE shall send an A2X DIRECT LINK ESTABLISHMENT REJECT message. The A2X DIRECT LINK ESTABLISHMENT REJECT message contains a PC5 signalling protocol cause IE set to one of the following cause values:

#1   direct communication to the target UE not allowed;

#3   conflict of layer-2 ID for unicast communication is detected;

#5   lack of resources for A2X PC5 unicast link; or

#111   protocol error, unspecified.

If the target UE is not allowed to accept the A2X DIRECT LINK ESTABLISHMENT REQUEST message, e.g. based on operator policy or configuration parameters for A2X communication over PC5 as specified in clause 5.2.3, the target UE shall send an A2X DIRECT LINK ESTABLISHMENT REJECT message containing PC5 signalling protocol cause value #1 "direct communication to the target UE not allowed".

For a received A2X DIRECT LINK ESTABLISHMENT REQUEST message from a layer-2 ID (for unicast communication), if the target UE already has an existing link established to a UE using this layer-2 ID or is currently processing an A2X DIRECT LINK ESTABLISHMENT REQUEST message from the same layer-2 ID, and with one of following parameters different from the existing link or the link for which the link establishment is in progress:

a) the source user info;

b) type of data (e.g. IP or non-IP): or

c) security policy,

the target UE shall send an A2X DIRECT LINK ESTABLISHMENT REJECT message containing PC5 signalling protocol cause value #3 "conflict of layer-2 ID for unicast communication is detected".

NOTE: The type of data (e.g. IP or non-IP) is indicated by the optional IP address configuration IE included in the corresponding A2X DIRECT LINK SECURITY MODE COMPLETE message, i.e. the type of data for the requested link is IP type if this IE is included, and the type of data for the requested link is non-IP if this IE is not included.

If the A2X PC5 unicast link establishment fails due to the congestion problems, the implementation-specific maximum number of established A2X NR-PC5 unicast links has been reached, or other temporary lower layer problems causing resource constraints, the target UE shall send an A2X DIRECT LINK ESTABLISHMENT REJECT message containing PC5 signalling protocol cause value #5 "lack of resources for A2X PC5 unicast link". If the A2X PC5 unicast link establishment fails due to other reasons, the target UE shall send an A2X DIRECT LINK ESTABLISHMENT REJECT message containing PC5 signalling protocol cause value #111 "protocol error, unspecified".

After sending the A2X DIRECT LINK ESTABLISHMENT REJECT message, the target UE shall provide the following information along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication to the lower layer:

a) an indication of deactivation of the PC5 unicast security protection and deletion of security context for the A2X PC5 unicast link, if applicable.

Upon receipt of the A2X DIRECT LINK ESTABLISHMENT REJECT message, if the Target user info is included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message, the initiating UE shall stop timer T5300 and abort the A2X PC5 unicast link establishment procedure. If the PC5 signalling protocol cause value in the A2X DIRECT LINK ESTABLISHMENT REJECT message is #1 "direct communication to the target UE not allowed" or #5 "lack of resources for A2X PC5 unicast link", then the UE shall not attempt to start the A2X PC5 unicast link establishment procedure with the same target UE at least for a time period T.

NOTE: The length of time period T is UE implementation specific and can be different for the case when the UE receives PC5 signalling protocol cause value #1 "direct communication to the target UE not allowed" or when the UE receives PC5 signalling protocol cause value #5 "lack of resources for A2X PC5 unicast link".

After receiving the A2X DIRECT LINK ESTABLISHMENT REJECT message, the initiating UE shall provide the following information along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication to the lower layer:

a) an indication of deactivation of the PC5 unicast security protection and deletion of security context for the A2X PC5 unicast link, if applicable.

6.1.2.2.6 Abnormal cases

6.1.2.2.6.1 Abnormal cases at the initiating UE

If timer T5300 expires and the Target user info IE is included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message, the initiating UE shall retransmit the A2X DIRECT LINK ESTABLISHMENT REQUEST message and restart timer T5300. After reaching the maximum number of allowed retransmissions, the initiating UE shall abort the A2X PC5 unicast link establishment procedure and may notify the upper layer that the target UE is unreachable.

Upon expiry of the timer T5300, if the A2X DIRECT LINK ESTABLISHMENT REQUEST message did not include the Target User Info IE and the initiating UE did not receive any A2X DIRECT LINK ESTABLISHMENT ACCEPT message, the initiating UE may retransmit the A2X DIRECT LINK ESTABLISHMENT REQUEST message and restart timer T5300. If the A2X DIRECT LINK ESTABLISHMENT REQUEST message did not include the Target User Info IE and the initiating UE did not receive any A2X DIRECT LINK ESTABLISHMENT ACCEPT message, then after reaching the maximum number of allowed retransmissions, the initiating UE shall abort the A2X PC5 unicast link establishment procedure and may notify the upper layer that no target UE is available.

> NOTE: The maximum number of allowed retransmissions is UE implementation specific.

If the need to establish a link no longer exists before the procedure is completed, the initiating UE shall abort the procedure.

When the initiating UE aborts the A2X PC5 unicast link establishment procedure, the initiating UE shall provide the following information along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication to the lower layer:

a) an indication of deactivation of the PC5 unicast security protection and deletion of security context for the A2X PC5 unicast link, if applicable.

6.1.2.2.6.2 Abnormal cases at the target UE

For a received A2X DIRECT LINK ESTABLISHMENT REQUEST message from a source layer-2 ID (for unicast communication), if the target UE already has an existing link established to the UE known to use the same source layer-2 ID, the same source user info, the same type of data (IP or non-IP) and the same security policy, the UE shall process the new request. However, the target UE shall only delete the existing link context after the new link establishment procedure succeeds.

> NOTE: The type of data (e.g. IP or non-IP) is indicated by the optional IP address configuration IE included in the corresponding A2X DIRECT LINK SECURITY MODE COMPLETE message, i.e the type of data for the requested link is IP type if this IE is included, and the type of data for the requested link is non-IP if this IE is not included.

6.1.2.3 A2X PC5 unicast link modification procedure

6.1.2.3.1 General

The purpose of the A2X PC5 unicast link modification procedure is to modify the existing A2X PC5 unicast link to:

a) add new PC5 QoS flow(s) to the existing A2X PC5 unicast link;

b) modify existing PC5 QoS flow(s) for updating PC5 QoS parameters of the existing PC5 QoS flow(s);

c) modify existing PC5 QoS flow(s) for associating new A2X service(s) with the existing PC5 QoS flow(s);

d) modify existing PC5 QoS flow(s) for removing the associated A2X service(s) from the existing PC5 QoS flow(s); or

e) remove existing PC5 QoS flow(s) from the existing A2X PC5 unicast link.

In this procedure, the UE sending the A2X DIRECT LINK MODIFICATION REQUEST message is called the "initiating UE" and the other UE is called the "target UE".

6.1.2.3.2 A2X PC5 unicast link modification procedure initiated by initiating UE

The initiating UE shall meet the following pre-conditions before initiating this procedure for adding a new A2X service to the existing A2X PC5 unicast link:

a) there is an A2X PC5 unicast link between the initiating UE and the target UE; and

b) the pair of application layer IDs and the network layer protocol of this A2X PC5 unicast link are identical to those required by the application layer in the initiating UE for this A2X service.

c) the security policy corresponding to the A2X service identifier(s) (e.g. ITS-AID of the new A2X service) is aligned with the security policy of the existing A2X PC5 unicast link.

After receiving the service data or request from the upper layers, the initiating UE shall perform the PC5 QoS flow match as specified in clause 6.1.2.13. If there is no matched PC5 QoS flow, the initiating UE shall derive the PC5 QoS parameters and assign the PQFI(s) for the PC5 QoS flows(s) to be established as specified in clause 6.1.2.12.

If the A2X PC5 unicast link modification procedure is to add new PC5 QoS flow(s) to the existing A2X PC5 unicast link, the initiating UE shall create an A2X DIRECT LINK MODIFICATION REQUEST message. In this message, initiating UE:

a) shall include the PQFI(s) and the corresponding PC5 QoS parameters, including the A2X service identifier(s); and

b) shall include the link modification operation code set to "Add new PC5 QoS flow(s) to the existing A2X PC5 unicast link ".

If the A2X PC5 unicast link modification procedure is to modify the PC5 QoS parameters for existing PC5 QoS flow(s) in the existing A2X PC5 unicast link, the initiating UE shall create an A2X DIRECT LINK MODIFICATION REQUEST message. In this message, the initiating UE:

a) shall include the PQFI(s) and the corresponding PC5 QoS parameters, including the A2X service identifier(s); and

b) shall include the link modification operation code set to "Modify PC5 QoS parameters of the existing PC5 QoS flow(s)".

If the A2X PC5 unicast link modification procedure is to associate new A2X service(s) with existing PC5 QoS flow(s), the initiating UE shall create an A2X DIRECT LINK MODIFICATION REQUEST message. In this message, the initiating UE:

a) shall include the PQFI(s) and the corresponding PC5 QoS parameters, including the A2X service identifier(s); and

b) shall include the link modification operation code set to "Associate new A2X service(s) with existing PC5 QoS flow(s)".

If the A2X PC5 unicast link modification procedure is to remove the associated A2X service(s) from existing PC5 QoS flow(s), the initiating UE shall create an A2X DIRECT LINK MODIFICATION REQUEST message. In this message, the initiating UE:

a) shall include the PQFI(s) and the corresponding PC5 QoS parameters including the A2X service identifier(s); and

b) shall include the link modification operation code set to "Remove A2X service(s) from existing PC5 QoS flow(s)".

If the A2X PC5 unicast link modification procedure is to remove any PC5 QoS flow(s) from the existing A2X PC5 unicast link, the initiating UE shall create an A2X DIRECT LINK MODIFICATION REQUEST message. In this message, the initiating UE:

a) shall include the PQFI(s); and

b) shall include the link modification operation code set to "Remove existing PC5 QoS flow(s) from the existing A2X PC5 unicast link".

After the A2X DIRECT LINK MODIFICATION REQUEST message is generated, the initiating UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication, and start timer T5301. The UE shall not send a new A2X DIRECT LINK MODIFICATION REQUEST message to the same target UE while timer T5301 is running.
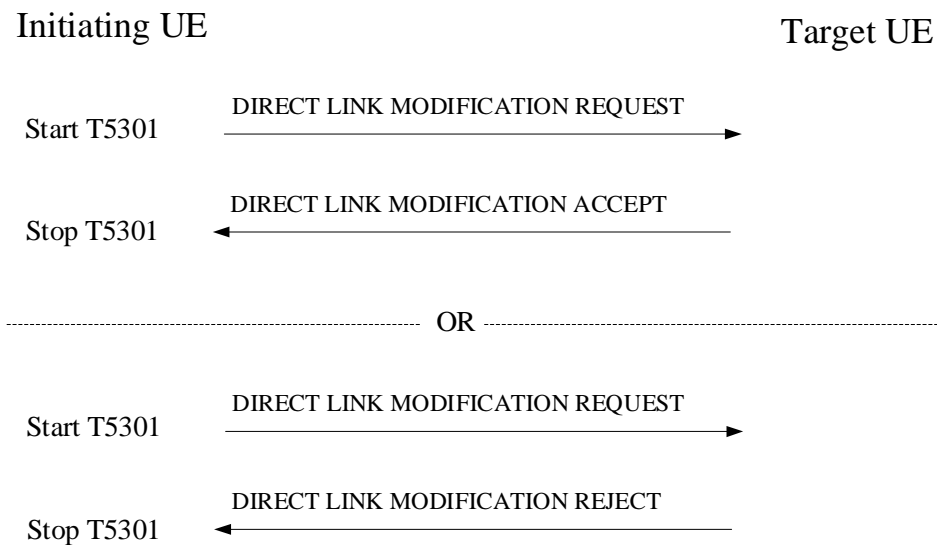
Figure 6.1.2.3.2: A2X PC5 unicast link modification procedure

6.1.2.3.3　　　　A2X PC5 unicast link modification procedure accepted by the target UE

If the A2X DIRECT LINK MODIFICATION REQUEST message is accepted, the target UE shall respond with the A2X DIRECT LINK MODIFICATION ACCEPT message.

If the A2X DIRECT LINK MODIFICATION REQUEST message is to add a new A2X service, add new PC5 QoS flow(s) or modify any existing PC5 QoS flow(s) in the A2X PC5 unicast link, the target UE shall include in the A2X DIRECT LINK MODIFICATION ACCEPT message:

a) the PQFI(s), the corresponding PC5 QoS parameters and the A2X service identifier(s) that the target UE accepts.

If the A2X DIRECT LINK MODIFICATION REQUEST message is to remove an existing A2X service from the A2X PC5 unicast link, the target UE shall delete the A2X service identifier received in the A2X DIRECT LINK MODIFICATION REQUEST message and the corresponding PQFI(s) and PC5 QoS parameters from the profile associated with the A2X PC5 unicast link.

If the A2X DIRECT LINK MODIFICATION REQUEST message is to remove existing PC5 QoS flow(s) from the A2X PC5 unicast link, the target UE shall delete the PQFI(s) and the corresponding PC5 QoS parameters from the profile associated with the A2X PC5 unicast link.

If the A2X DIRECT LINK MODIFICATION REQUEST message is to add a new A2X service, add new PC5 QoS flow(s) or modify any existing PC5 QoS flow(s) in the A2X PC5 unicast link, after sending the A2X DIRECT LINK MODIFICATION ACCEPT message, the target UE shall provide the added or modified PQFI(s) and corresponding PC5 QoS parameters along with PC5 link identifier to the lower layer.

If the A2X DIRECT LINK MODIFICATION REQUEST message is to remove an existing A2X service or to remove the existing PC5 QoS flow(s) from the A2X PC5 unicast link, after sending the A2X DIRECT LINK MODIFICATION ACCEPT message, the target UE shall provide the removed PQFI(s) along with the PC5 link identifier to the lower layer.

If the target UE accepts the A2X PC5 unicast link modification request, then the target UE may perform the PC5 QoS flow establishment over A2X PC5 unicast link as specified in clause 6.1.2.12 and perform the PC5 QoS flow match over A2X PC5 unicast link as specified in clause 6.1.2.13.

6.1.2.3.4 A2X PC5 unicast link modification procedure completion by the initiating UE

Upon receipt of the A2X DIRECT LINK MODIFICATION ACCEPT message, the initiating UE shall stop timer T5301.

Upon receipt of the A2X DIRECT LINK MODIFICATION ACCEPT message, if the A2X DIRECT LINK MODIFICATION REQUEST message is to add a new A2X service, add new PC5 QoS flow(s) or modify any existing PC5 QoS flow(s) in the A2X PC5 unicast link, the initiating UE shall provide the added or modified PQFI(s) and corresponding PC5 QoS parameters along with PC5 link identifier to the lower layer.

Upon receipt of the A2X DIRECT LINK MODIFICATION ACCEPT message, if the A2X DIRECT LINK MODIFICATION REQUEST message is to remove an existing A2X service or to remove the existing PC5 QoS flow(s) from the A2X PC5 unicast link, the initiating UE shall provide the removed PQFI(s) along with the PC5 link identifier to the lower layer.

In addition, the initiating UE may perform the PC5 QoS flow establishment over A2X PC5 unicast link as specified in clause 6.1.2.12.

6.1.2.3.5 A2X PC5 unicast link modification procedure not accepted by the target UE

If the A2X PC5 unicast link modification request cannot be accepted, the target UE shall send an A2X DIRECT LINK MODIFICATION REJECT message. The A2X DIRECT LINK MODIFICATION REJECT message contains a PC5 signalling protocol cause IE set to one of the following cause values:

#5   lack of resources for A2X PC5 unicast link;

#11   required service not allowed;

#12   security policy not aligned; or

#111   protocol error, unspecified.

If the target UE is not allowed to accept this request, .e.g. because the A2X service to be added is not allowed per the operator policy or configuration parameters for A2X communication over PC5 as specified in clause 5.2.3, the target UE shall send an A2X DIRECT LINK MODIFICATION REJECT message with PC5 signalling protocol cause value #11 "required service not allowed".

If the A2X PC5 unicast link modification fails due to the congestion problems or other temporary lower layer problems causing resource constraints, the target UE shall send an A2X DIRECT LINK MODIFICATION REJECT message with PC5 signalling protocol cause value #5 "lack of resources for A2X PC5 unicast link".

If the link modification operation code is set to "Associate new A2X service(s) with existing PC5 QoS flow(s)", and the security policy corresponding to the A2X service identifier(s) (e.g. ITS-AID of the new A2X service) is not aligned with the security policy applied to the existing A2X PC5 unicast link, then the target UE shall send an A2X DIRECT LINK MODIFICATION REJECT message with PC5 signalling protocol cause value #12 "security policy not aligned".

For other reasons causing the failure of link modification, the target UE shall send an A2X DIRECT LINK MODIFICATION REJECT message with PC5 signalling protocol cause value #111 "protocol error, unspecified".

Upon receipt of the A2X DIRECT LINK MODIFICATION REJECT message, the initiating UE shall stop timer T5301 and abort the A2X PC5 unicast link modification procedure. If the PC5 signalling protocol cause value in the A2X DIRECT LINK MODIFICATION REJECT message is #11 "required service not allowed" or #5 "lack of resources for A2X PC5 unicast link" or #12 "security policy not aligned", then the initiating UE shall not attempt to start A2X PC5 unicast link modification with the same target UE to add the same A2X service, or to add or modify the same PC5 QoS flow(s) at least for a time period T.

NOTE: The length of time period T is UE implementation specific and can be different for the case when the UE receives PC5 signalling protocol cause value #11 "required service not allowed" or when the UE receives PC5 signalling protocol cause value #5 "lack of resources for A2X PC5 unicast link" or when the UE receives PC5 signalling protocol cause value #12 "security policy not aligned". The length of time period T is not less than 30 minutes.

6.1.2.3.6 Abnormal cases at the initiating UE

The following abnormal cases can be identified:

a) If timer T5301 expires, the initiating UE shall retransmit the A2X DIRECT LINK MODIFICATION REQUEST message and restart timer T5301. After reaching the maximum number of allowed retransmissions, the initiating UE shall abort the A2X PC5 unicast link modification procedure and may notify the upper layer that the target UE is unreachable.

NOTE 1: The maximum number of allowed retransmissions is UE implementation specific.

NOTE 2: After reaching the maximum number of allowed retransmissions, whether the initiating UE releases this A2X PC5 unicast link depends on its implementation.

b) For the same A2X PC5 unicast link, if the initiating UE receives an A2X DIRECT LINK RELEASE message after the initiation of UE-requested A2X PC5 unicast link modification procedure, the initiating UE shall stop the timer T5301 and abort the A2X PC5 unicast link modification procedure and proceed with the A2X PC5 unicast link release procedure.

c) For the same A2X PC5 unicast link, if the initiating UE receives an A2X DIRECT LINK MODIFICATION REQUEST message during the A2X PC5 unicast link modification procedure, the initiating UE shall stop the timer T5301 and abort the A2X PC5 unicast link modification procedure. Following handling is implementation dependent, e.g., the initiating UE waits for an implementation dependent time for initiating a new A2X PC5 unicast link modification procedure, if still needed.

NOTE 3: The implementation dependent timer value needs to be set to avoid further collisions (e.g. random timer value).

6.1.2.4 A2X PC5 unicast link release procedure

6.1.2.4.1 General

The A2X PC5 unicast link release procedure is used to release an A2X PC5 unicast link between two UEs. The link can be released from either end point. The UE sending the A2X DIRECT LINK RELEASE REQUEST message is called the "initiating UE" and the other UE is called the "target UE".

If the UE receives an indication of radio link failure from the lower layer, the UE shall release the A2X PC5 unicast link locally and may delete the K_{NRP} ID associated with this link after an implementation specific time.

6.1.2.4.2 A2X PC5 unicast link release procedure initiation by initiating UE

The initiating UE shall initiate the procedure if a request from upper layers to release an A2X PC5 unicast link with the target UE which uses a known layer-2 ID (for unicast communication) is received and there is an existing A2X PC5 unicast link between these two UEs.

The initiating UE may initiate the procedure if the target UE has been non-responsive, e.g. no response in the A2X PC5 unicast link modification procedure, A2X PC5 unicast link identifier update procedure, A2X PC5 unicast link re-keying procedure or A2X PC5 unicast link keep-alive procedure.

The initiating UE may initiate the procedure to release an established A2X PC5 unicast link if the UE has reached the maximum number of established A2X PC5 unicast links and there is a need to establish a new A2X PC5 unicast link. In this case, which A2X PC5 unicast link is to be released is up to UE implementation.

The initiating UE may initiate the procedure to release an established A2X PC5 unicast link upon expiry of the timer T5303.

In order to initiate the A2X PC5 unicast link release procedure, the initiating UE shall create an A2X DIRECT LINK RELEASE REQUEST message with a PC5 signalling protocol cause IE indicating one of the following cause values:

#1 direct communication to the target UE not allowed;

#2 direct communication to the target UE no longer needed;

#4 direct connection is not available anymore;

#5 lack of resources for A2X PC5 unicast link; or

#111   protocol error, unspecified.

The initiating UE shall include the new 2 MSBs of K_{NRP} ID in the A2X DIRECT LINK RELEASE REQUEST message.

After the A2X DIRECT LINK RELEASE REQUEST message is generated, the initiating UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication, and shall stop T5305 if running. The initiating UE shall start timer T5302.

Initiating UE   Target UE

Start T5302   DIRECT LINK RELEASE REQUEST
          ───►

                     DIRECT LINK RELEASE ACCEPT
Stop T5302   ◄───
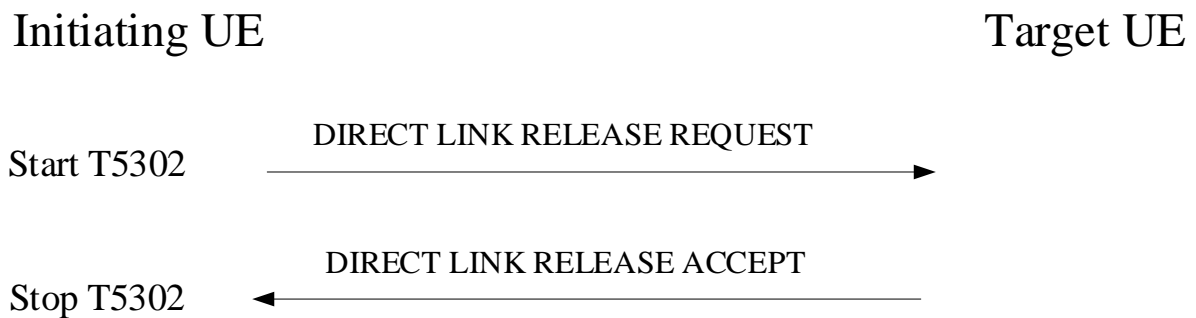
Figure 6.1.2.4.2.1: A2X PC5 unicast link release procedure

6.1.2.4.3   A2X PC5 unicast link release procedure accepted by the target UE

Upon receiving an A2X DIRECT LINK RELEASE REQUEST message, the target UE shall stop all running timers for this A2X PC5 unicast link and abort any other ongoing PC5 signalling protocol procedures on this A2X PC5 unicast link. The target UE shall respond with an A2X DIRECT LINK RELEASE ACCEPT message. The target UE shall include the new 2 LSBs of K_{NRP} ID in the A2X DIRECT LINK RELEASE ACCEPT message. After the message is sent, the target UE shall release the A2X PC5 unicast link by performing the following behaviors:

   a) inform the lower layer along with the PC5 link identifier that the A2X PC5 unicast link has been released; and

   b) delete the A2X PC5 unicast link context of the A2X PC5 unicast link after an implementation specific time.

The target UE shall form the new K_{NRP} ID from the new 2 MSBs of K_{NRP} ID received in the A2X DIRECT LINK RELEASE REQUEST message and the new 2 LSBs of K_{NRP} ID included in the A2X DIRECT LINK RELEASE ACCEPT message. The target UE shall replace the existing K_{NRP} ID with the new K_{NRP} ID. The target UE may include the new K_{NRP} ID in A2X DIRECT LINK ESTABLISHMENT REQUEST message with the initiating UE as specified in clause 6.1.2.2.2.

6.1.2.4.4   A2X PC5 unicast link release procedure completion by the initiating UE

Upon receipt of the A2X DIRECT LINK RELEASE ACCEPT message, the initiating UE shall stop timer T5302 and shall release the A2X PC5 unicast link by performing the following actions:

   a) inform the lower layer along with the PC5 link identifier that the A2X PC5 unicast link has been released; and

   b) delete the A2X PC5 unicast link context of the A2X PC5 unicast link after an implementation specific time.

The initiating UE shall form the new K_{NRP} ID from the 2 MSBs of K_{NRP} ID included in the A2X DIRECT LINK RELEASE REQUEST message and the 2 LSBs of K_{NRP} ID received in the A2X DIRECT LINK RELEASE ACCEPT message. The initiating UE shall replace the existing K_{NRP} ID with the new K_{NRP} ID. The initiating UE may include the new K_{NRP} ID in A2X DIRECT LINK ESTABLISHMENT REQUEST message with the target UE as specified in clause 6.1.2.2.2.

6.1.2.4.5 Abnormal cases

6.1.2.4.5.1 Abnormal cases at the initiating UE

If retransmission timer T5302 expires and the PC5 signalling protocol cause included in the PC5 signalling protocol cause IE in the A2X DIRECT LINK RELEASE REQUEST message was #4 "direct connection is not available anymore", the initiating UE shall release the A2X PC5 unicast link locally and delete the K_{NRP} ID associated with this link. From this time onward the initiating UE shall no longer send or receive any messages via this link.

If retransmission timer T5302 expires and the PC5 signalling protocol cause included in the PC5 signalling protocol cause IE in the A2X DIRECT LINK RELEASE REQUEST message was not #4 "direct connection is not available anymore", the initiating UE shall initiate the transmission of the A2X DIRECT LINK RELEASE REQUEST message again and restart timer T5302.

If no response is received from the target UE after reaching the maximum number of allowed retransmissions, the initiating UE shall release the A2X PC5 unicast link locally and delete the K_{NRP} ID associated with this link. From this time onward the initiating UE shall no longer send or receive any messages via this link.

NOTE: The maximum number of allowed retransmissions is UE implementation specific.

6.1.2.5 A2X PC5 unicast link identifier update procedure

6.1.2.5.1 General

The A2X PC5 unicast link identifier update procedure is used to update and exchange the new identifiers (e.g. application layer ID, layer-2 ID, security information and IP address/prefix) between two UEs for an A2X PC5 unicast link before using the new identifiers. The UE sending the A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message is called the "initiating UE" and the other UE is called the "target UE".

6.1.2.5.2 A2X PC5 unicast link identifier update procedure initiation by initiating UE

The initiating UE shall initiate the procedure if:

a) the initiating UE receives a request from upper layers to change the application layer ID and there is an existing A2X PC5 unicast link associated with this application layer ID; or

b) the privacy timer (see clause 5.2.3) of the initiating UE's layer-2 ID expires for an existing A2X PC5 unicast link.

If the A2X PC5 unicast link identifier update procedure is triggered by a change of the initiating UE's application layer ID, the initiating UE shall create an A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message. In this message, the initiating UE

a) shall include the initiating UE's new application layer ID received from upper layer;

b) shall include the initiating UE's new layer-2 ID assigned by itself;

c) shall include the new MSB of $K_{NRP-sess}$ ID, or set to all zeros if the selected integrity protection algorithm is the null integrity protection algorithm; and

d) shall include the new IP address/prefix if IP communication is used.

If the A2X PC5 unicast link identifier update procedure is triggered by the expiry of the initiating UE's privacy timer T5305 as specified in clause 5.2.3, the initiating UE shall create an A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message. In this message, the initiating UE

a) shall include the initiating UE's new layer-2 ID assigned by itself;

b) shall include the new MSB of $K_{NRP-sess}$ ID;

c) may include the initiating UE's new application layer ID if received from upper layer; and

d) shall include the new IP address/prefix if IP communication is used and changed.

After the A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message is generated, the initiating UE shall pass this message to the lower layers for transmission along with the initiating UE's old layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication, and start timer T5306. The UE shall not send a new A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message to the same target UE while timer T5306 is running.
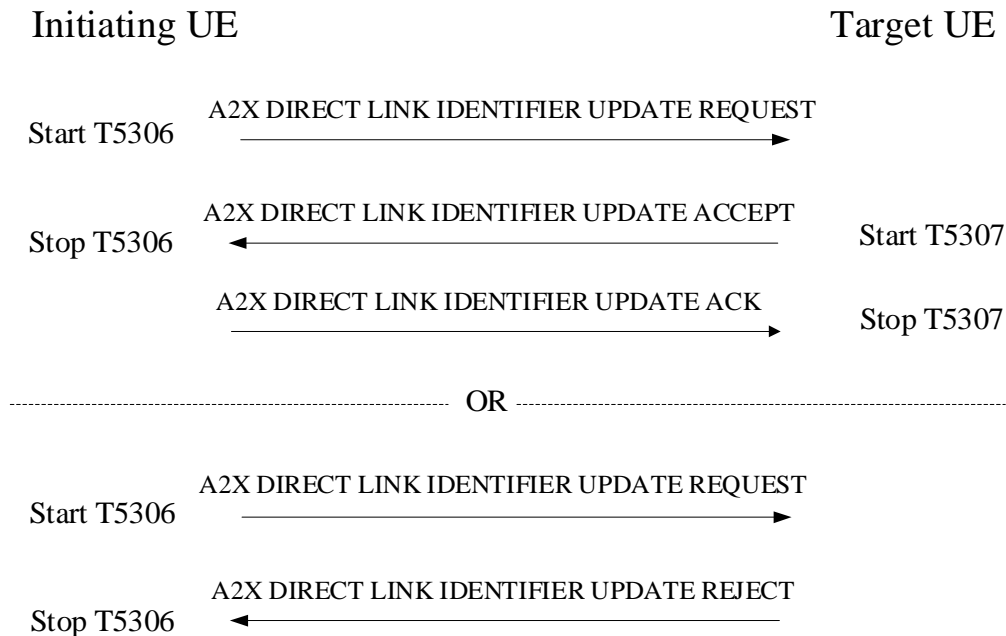

Figure 6.1.2.5.2.1: A2X PC5 unicast link identifier update procedure

6.1.2.5.3 A2X PC5 unicast link identifier update procedure accepted by the target UE

Upon receipt of an A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message, if the target UE determines:

a) the A2X PC5 unicast link associated with this request message is still valid; and

b) the timer T5307 for the A2X PC5 unicast link identified by this request message is not running,

then the target UE accepts this request, and responds with an A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message.

The target UE shall create the A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message. In this message, the target UE:

a) shall include the target UE's new layer-2 ID assigned by itself;

b) shall include the new LSB of $K_{NRP-sess}$ ID;

c) shall include the initiating UE's new MSB of $K_{NRP-sess}$ ID;

d) shall include the initiating UE's new layer-2 ID;

e) shall include the target UE's new application layer ID if received from upper layer;

f) shall include the initiating UE's new IP address/prefix if received from the initiating UE and IP communication is used;

g) shall include the initiating UE's new application layer ID if received from the initiating UE; and

h) shall include the target UE's new IP address/prefix if IP communication is used and changed.

After the A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message is generated, the target UE shall pass this message to the lower layers for transmission along with the initiating UE's old layer-2 ID for unicast communication

and the target UE's old layer-2 ID for unicast communication, and start timer T5307. The UE shall not send a new A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message to the same initiating UE while timer T5307 is running.

Before target UE receives the traffic using the new layer-2 IDs, the target UE shall continue to receive the traffic with the old layer-2 IDs (i.e. initiating UE's old layer-2 ID and target UE's old layer-2 ID) from initiating UE.

Before target UE receives the A2X DIRECT LINK IDENTIFIER UPDATE ACK message from initiating UE, the target UE shall keep sending traffic to the initiating UE using the old layer-2 IDs (i.e. initiating UE's old layer-2 ID for unicast communication and target UE's old layer-2 ID for unicast communication).

6.1.2.5.4   A2X PC5 unicast link identifier update procedure acknowledged by the initiating UE

Upon receipt of the A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message, the initiating UE shall stop timer T5306 and respond with an A2X DIRECT LINK IDENTIFIER UPDATE ACK message. In this message, the initiating UE:

a) shall include the target UE's new layer-2 ID;

b) shall include the target UE's new LSB of $K_{NRP-sess}$ ID;

c) shall include the target UE's new application layer ID, if received; and

d) shall include the target UE's new IP address/prefix, if received.

After the A2X DIRECT LINK IDENTIFIER UPDATE ACK message is generated, the initiating UE shall pass this message to the lower layers for transmission along with the initiating UE's old layer-2 ID for unicast communication and the target UE's old layer-2 ID for unicast communication and shall stop timer T5305 if running and start a timer T5305 as configured if at least one of A2X service identifiers for the A2X PC5 unicast link satisfying the privacy requirements as specified in clause 5.2.3.

Upon sending the A2X DIRECT LINK IDENTIFIER UPDATE ACK message, the initiating UE shall update the associated A2X PC5 unicast link context with the new identifiers and pass the new layer-2 IDs (i.e. initiating UE's new layer-2 ID for unicast communication and target UE's new layer-2 ID for unicast communication if changed) along with the PC5 link identifier down to the lower layer. Then the initiating UE shall use the new layer-2 IDs (i.e. initiating UE's new layer-2 ID for unicast communication and target UE's new layer-2 ID for unicast communication if changed) to transmit the A2X PC5 signalling message and A2X PC5 user plane data.

The initiating UE shall continue to receive traffic with the old layer-2 IDs (i.e. initiating UE's old layer-2 ID for unicast communication and target UE's old layer-2 ID for unicast communication) from the target UE until it receives traffic with the new layer-2 IDs (i.e. initiating UE's new layer-2 ID and target UE's new layer-2 ID if changed) from the target UE.

6.1.2.5.5   A2X PC5 unicast link identifier update procedure completion by the target UE

Upon receipt of the A2X DIRECT LINK IDENTIFIER UPDATE ACK message, the target UE shall update the associated A2X PC5 unicast link context with the new identifiers, pass the new layer-2 IDs (i.e. initiating UE's new layer-2 ID and target UE's new layer-2 ID if changed) down to the lower layer, stop timer T5307 and timer T5305 if running and start a timer T5305 as configured if at least one of A2X service identifiers for the A2X PC5 unicast link satisfying the privacy requirements as specified in clause 5.2.3. Then the target UE shall use the new layer-2 IDs (i.e. initiating UE's new layer-2 ID for unicast communication and target UE's new layer-2 ID for unicast communication if changed) to transmit the A2X PC5 signalling message and A2X PC5 user plane data.

6.1.2.5.6   A2X PC5 unicast link identifier update procedure not accepted by the target UE

If the A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message cannot be accepted, the target UE shall send an A2X DIRECT LINK IDENTIFIER UPDATE REJECT message. The A2X DIRECT LINK IDENTIFIER UPDATE REJECT message contains a PC5 signalling protocol cause IE set to one of the following cause values:

#3 conflict of layer-2 ID for unicast communication is detected; or

#111   protocol error, unspecified.

For a received A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message from a layer-2 ID (for unicast communication), if the target UE already has an existing link using this layer-2 ID or is currently processing an A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message from the same layer-2 ID, but with user info different from the user info IE included in this new incoming message, the target UE shall send an A2X DIRECT LINK IDENTIFIER UPDATE REJECT message with PC5 signalling protocol cause value #3 "conflict of layer-2 ID for unicast communication is detected".

> NOTE: After receiving the A2X DIRECT LINK IDENTIFIER UPDATE REJECT message, whether the initiating UE initiates the A2X PC5 unicast link release procedure or initiates another A2X PC5 unicast link identifier update procedure with a new layer-2 ID depends on UE implementation.

For other reasons causing the failure of link identifier update, the target UE shall send an A2X DIRECT LINK IDENTIFIER UPDATE REJECT message with PC5 signalling protocol cause value #111 "protocol error, unspecified".

Upon receipt of the A2X DIRECT LINK IDENTIFIER UPDATE REJECT message, the initiating UE shall stop timer T5306 and abort this A2X PC5 unicast link identifier update procedure.

6.1.2.5.7 Abnormal cases

6.1.2.5.7.1 Abnormal cases at the initiating UE

The following abnormal cases can be identified:

a) If timer T5306 expires, the initiating UE shall retransmit the A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message and restart timer T5306. After reaching the maximum number of allowed retransmissions, the initiating UE shall abort the A2X PC5 unicast link identifier update procedure and may notify the upper layer that the target UE is unreachable.

> NOTE 1: The maximum number of allowed retransmissions is UE implementation specific.

> NOTE 2: After reaching the maximum number of allowed retransmissions, whether the initiating UE releases this A2X PC5 unicast link depends on its implementation.

b) For the same A2X PC5 unicast link, if the initiating UE receives an A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message during the A2X PC5 unicast link identifier update procedure, the initiating UE shall stop the timer T5306 and abort the A2X PC5 unicast link identifier update procedure. Following handling is implementation dependent, e.g., the initiating UE waits for an implementation dependent time for initiating a new A2X PC5 unicast link identifier update procedure, if still needed.

> NOTE 3: The implementation dependent timer value needs to be set to avoid further collisions (e.g. random timer value).

c) For the same A2X PC5 unicast link, if the initiating UE receives an A2X DIRECT LINK REKEYING REQUEST message after initiating the A2X PC5 unicast link identifier update procedure, the initiating UE shall ignore the A2X DIRECT LINK REKEYING REQUEST message and proceed with the A2X PC5 unicast link identifier update procedure.

d) For the same A2X PC5 unicast link, if the initiating UE receives an A2X DIRECT LINK RELEASE REQUEST message after the initiation of A2X PC5 unicast link identifier update procedure, the initiating UE shall stop the timer T5306 and abort the A2X PC5 unicast link identifier update procedure and proceed with the A2X PC5 unicast link release procedure.

6.1.2.5.7.2 Abnormal cases at the target UE

The following abnormal cases can be identified:

a) If timer T5307 expires, the target UE shall retransmit the A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message and restart timer T5307. After reaching the maximum number of allowed retransmissions, the target UE shall abort the A2X PC5 unicast link identifier update procedure and may notify the upper layer that the initiating UE is unreachable.

> NOTE 1: The maximum number of allowed retransmissions is UE implementation specific.

NOTE 2: After reaching the maximum number of allowed retransmissions, whether the target UE releases this A2X PC5 unicast link depends on its implementation.

b) If A2X DIRECT LINK IDENTIFIER UPDATE REQUEST is received when the timer T5307 is running, the target UE shall stop the timer T5307 and abort the ongoing A2X PC5 unicast link identifier update procedure. The target UE shall handle the new A2X DIRECT LINK IDENTIFIER UPDATE REQUEST as specified in clause 6.1.2.5.3.

c) After sending the A2X DIRECT LINK IDENTIFIER UPDATE ACK message to the target UE, if another A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message from the target UE is received before the traffic from the target UE with the new layer-2 IDs is received, the initiating UE shall retransmit the A2X DIRECT LINK IDENTIFIER UPDATE ACK message along with the initiating UE's old layer-2 ID and the target UE's old layer-2 ID

NOTE 3: It is up to implementation to handle the failure of traffic delivery for new layer-2 IDs if such traffic has been sent before the initiating UE retransmits the A2X DIRECT LINK IDENTIFIER UPDATE ACK message.

d) After sending the A2X DIRECT LINK IDENTIFIER UPDATE ACK message to the target UE, if the initiating UE keeps receiving traffic from the target UE with the old layer-2 IDs and traffic from the target UE with the new layer-2 IDs is not received during an implementation specific time which is greater than the value of timer T5307, the initiating UE shall abort the A2X PC5 unicast link identifier update procedure and may release the A2X PC5 unicast link.

6.1.2.6 A2X PC5 unicast link authentication procedure

6.1.2.6.1 General

The A2X PC5 unicast link authentication procedure is used to perform mutual authentication of UEs establishing an A2X PC5 unicast link and to derive a new K_{NRP} shared between two UEs during an A2X PC5 unicast link establishment procedure or an A2X PC5 unicast link re-keying procedure. After successful completion of the A2X PC5 unicast link authentication procedure, the new K_{NRP} is used for security establishment during the A2X PC5 unicast link security mode control procedure as specified in clause 6.1.2.7. The UE sending the A2X DIRECT LINK AUTHENTICATION REQUEST message is called the "initiating UE" and the other UE is called the "target UE".

6.1.2.6.2 A2X PC5 unicast link authentication procedure initiation by the initiating UE

The initiating UE shall meet one of the following pre-conditions when establishing the non-null signalling integrity protection based on the decision of the initiating UE, before initiating the A2X PC5 unicast link authentication procedure:

a) the target UE has initiated an A2X PC5 unicast link establishment procedure toward the initiating UE by sending an A2X DIRECT LINK ESTABLISHMENT REQUEST message and:

1) the A2X DIRECT LINK ESTABLISHMENT REQUEST message:

i) includes a target user info IE which includes the application layer ID of the initiating UE; or

ii) does not include a target user info IE and the initiating UE is interested in the A2X service identified by the A2X service identifier in the A2X DIRECT LINK ESTABLISHMENT REQUEST message; and

2) the K_{NRP} ID is not included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message or the initiating UE does not have an existing K_{NRP} for the K_{NRP} ID included in A2X DIRECT LINK ESTABLISHMENT REQUEST message or the initiating UE derives a new K_{NRP}; or

b) the target UE has initiated an A2X PC5 unicast link re-keying procedure toward the initiating UE by sending an A2X DIRECT LINK REKEYING REQUEST message and the A2X DIRECT LINK REKEYING REQUEST message includes a Re-authentication indication.

In order to initiate the A2X PC5 unicast link authentication procedure, the initiating UE shall create an A2X DIRECT LINK AUTHENTICATION REQUEST message. In this message, the initiating UE:

a) shall include the key establishment information container IE.

NOTE: The Key establishment information container is provided by upper layers.

After the A2X DIRECT LINK AUTHENTICATION REQUEST message is generated, the initiating UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication.

The initiating UE shall start timer T5304. The UE shall not send a new A2X DIRECT LINK AUTHENTICATION REQUEST message to the same target UE while timer T5304 is running.

Initiating UE   Target UE

Start T5304   A2X DIRECT LINK AUTHENTICATION REQUEST
                                                                    ───────────────►

                     A2X DIRECT LINK AUTHENTICATION RESPONSE
                 ◄───
Stop T5304

────────────────────────────────── OR ──────────────────────────────

Start T5304   A2X DIRECT LINK AUTHENTICATION REQUEST
                                                                    ───────────────►

                     A2X DIRECT LINK AUTHENTICATION REJECT
                 ◄───
Stop T5304

────────────────────────────────── OR ──────────────────────────────

Start T5304   A2X DIRECT LINK AUTHENTICATION REQUEST
                                                                    ───────────────►

                A2X DIRECT LINK AUTHENTICATION RESPONSE
                 ◄───
Stop T5304

                A2X DIRECT LINK AUTHENTICATION FAILURE
                                                                    ───────────────►

Figure 6.1.2.6.2: A2X PC5 unicast link authentication procedure

6.1.2.6.3 A2X PC5 unicast link authentication procedure accepted by the target UE

Upon receipt of an A2X DIRECT LINK AUTHENTICATION REQUEST message, if a new assigned initiating UE's layer-2 ID is included, the target UE shall replace the original initiating UE's layer-2 ID with the new assigned initiating UE's layer-2 ID for unicast communication. If the target UE determines that the A2X DIRECT LINK AUTHENTICATION REQUEST message can be accepted, the target UE shall create an A2X DIRECT LINK AUTHENTICATION RESPONSE message. The target UE shall check if the number of established A2X PC5 unicast links is less than the implementation-specific maximum number of established A2X NR-PC5 unicast links allowed in the UE at a time. In this message, the target UE:

   a) shall include the Key establishment information container IE.

   NOTE: The key establishment information container is provided by upper layers.

After the A2X DIRECT LINK AUTHENTICATION RESPONSE message is generated, the target UE shall pass this message to the lower layers for transmission along with the target UE's layer-2 ID for unicast communication and the initiating UE's layer-2 ID for unicast communication.

6.1.2.6.4   A2X PC5 unicast link authentication procedure completion by the initiating UE

Upon receiving an A2X DIRECT LINK AUTHENTICATION RESPONSE message, if the initiating UE determines that the A2X DIRECT LINK AUTHENTICATION RESPONSE message can be accepted, the initiating UE shall stop timer T5304.

> NOTE: When the initiating UE derives the new K_{NRP} during the A2X PC5 unicast link authentication procedure depends on the authentication method in use.

6.1.2.6.5   A2X PC5 unicast link authentication procedure not accepted by the target UE

If the A2X DIRECT LINK AUTHENTICATION REQUEST message cannot be accepted, the target UE shall create an A2X DIRECT LINK AUTHENTICATION REJECT message. In this message, the target UE shall include a PC5 signalling protocol cause IE indicating one of the following cause values:

> #6: authentication failure;

> #5: lack of resources for A2X PC5 unicast link.

If this A2X PC5 unicast link authentication procedure is triggered during the A2X PC5 unicast link establishment procedure and the implementation-specific maximum number of established A2X NR-PC5 unicast links has been reached, then the target UE shall send an A2X DIRECT LINK AUTHENTICATION REJECT message containing PC5 signalling protocol cause value #5 "lack of resources for A2X PC5 unicast link".

After the A2X DIRECT LINK AUTHENTICATION REJECT message is generated, the target UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication.

The target UE shall abort the ongoing procedure that triggered the initiation of the A2X PC5 unicast link authentication procedure if the ongoing procedure is the A2X PC5 unicast link establishment procedure and the Target user info is included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message.

Upon receipt of the A2X DIRECT LINK AUTHENTICATION REJECT message, the initiating UE shall stop timer T5304 and abort the ongoing procedure that triggered the initiation of the A2X PC5 unicast link authentication procedure.

6.1.2.6.5A   A2X PC5 unicast link authentication procedure not accepted by the initiating UE

If the A2X DIRECT LINK AUTHENTICATION RESPONSE message cannot be accepted, the initiating UE shall stop timer T5304 and create an A2X DIRECT LINK AUTHENTICATION FAILURE message. In this message, the initiating UE may include the Key establishment information container IE if provided by upper layers.

After the A2X DIRECT LINK AUTHENTICATION FAILURE message is generated, the initiating UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication.

The initiating UE shall abort the ongoing procedure that triggered the initiation of the A2X PC5 unicast link authentication procedure.

Upon receipt of the A2X DIRECT LINK AUTHENTICATION FAILURE message and if the A2X PC5 unicast link authentication procedure was initiated due to an A2X PC5 unicast link establishment procedure that includes a Target user info in the A2X DIRECT LINK ESTABLISHMENT REQUEST message, the target UE shall abort the ongoing procedure that triggered the initiation of the A2X PC5 unicast link authentication procedure and shall indicate to upper layers that authentication has failed.

6.1.2.6.6   Abnormal cases

6.1.2.6.6.1   Abnormal cases at the initiating UE

> a) Timer T5304 expires.

>   The initiating UE shall retransmit the A2X DIRECT LINK AUTHENTICATION REQUEST message and restart timer T5304. After reaching the maximum number of allowed retransmissions, the initiating UE shall

abort the A2X PC5 unicast link authentication procedure and shall abort the ongoing procedure that triggered the initiation of the A2X PC5 unicast link authentication procedure.

NOTE: The maximum number of allowed retransmissions is UE implementation specific.

b) The need to use this A2X PC5 unicast link no longer exists before the A2X PC5 unicast link authentication procedure is completed.

The initiating UE shall abort the procedure and shall abort the ongoing procedure that triggered the initiation of the A2X PC5 unicast link authentication procedure.

6.1.2.7 A2X PC5 unicast link security mode control procedure

6.1.2.7.1 General

The A2X PC5 unicast link security mode control procedure is used to establish security between two UEs during an A2X PC5 unicast link establishment procedure or an A2X PC5 unicast link re-keying procedure. After successful completion of the A2X PC5 unicast link security mode control procedure, the selected security algorithms and their non-null associated keys are used to integrity protect and cipher all A2X PC5 signalling messages exchanged over this A2X PC5 unicast link between the UEs and the security context can be used to protect all PC5 user plane data exchanged over this A2X PC5 unicast link between the UEs. The UE sending the A2X DIRECT LINK SECURITY MODE COMMAND message is called the "initiating UE" and the other UE is called the "target UE".

6.1.2.7.2 A2X PC5 unicast link security mode control procedure initiation by the initiating UE

The initiating UE shall meet the following pre-conditions before initiating the A2X PC5 unicast link security mode control procedure:

a) the target UE has initiated an A2X PC5 unicast link establishment procedure toward the initiating UE by sending an A2X DIRECT LINK ESTABLISHMENT REQUEST message and:

1) the A2X DIRECT LINK ESTABLISHMENT REQUEST message:

    i) includes a target user info IE which includes the application layer ID of the initiating UE; or

    ii) does not include a target user info IE and the initiating UE is interested in the A2X service identified by the A2X service identifier in the A2X DIRECT LINK ESTABLISHMENT REQUEST message; and

2) the initiating UE:

    i) has either identified an existing K_{NRP} based on the K_{NRP} ID included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message or derived a new K_{NRP}; or

    ii) has decided not to activate security protection based on its UE A2X PC5 unicast signalling security policy and the target UE's A2X PC5 unicast signalling security policy; or

b) the target UE has initiated an A2X PC5 unicast link re-keying procedure toward the initiating UE by sending an A2X DIRECT LINK REKEYING REQUEST message and:

1) if the target UE has included a Re-authentication indication in the A2X DIRECT LINK REKEYING REQUEST message, the initiating UE has derived a new K_{NRP}.

If a new K_{NRP} has been derived by the initiating UE, the initiating UE shall generate the 2 MSBs of K_{NRP} ID to ensure that the resultant K_{NRP} ID will be unique in the initiating UE.

The initiating UE shall select security algorithms in accordance with its NR-PC5 unicast security policy and the target UE's UE A2X PC5 unicast signalling security policy. If the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link establishment procedure, the initiating UE shall not select the null integrity protection algorithm if the initiating UE's NR-PC5 unicast security policy or the target UE's UE A2X PC5 unicast signalling integrity protection policy is set to "signalling integrity protection required". If the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link re-keying procedure, the initiating UE:

a) shall not select the null integrity protection algorithm if the integrity protection algorithm currently in use for the A2X PC5 unicast link is different from the null integrity protection algorithm;

b) shall not select the null ciphering protection algorithm if the ciphering protection algorithm currently in use for the A2X PC5 unicast link is different from the null ciphering protection algorithm;

c) shall select the null integrity protection algorithm if the integrity protection algorithm currently in use is the null integrity protection algorithm; and

d) shall select the null ciphering protection algorithm if the ciphering protection algorithm currently in use is the null ciphering protection algorithm.

Then the initiating UE shall:

a) generate a 128-bit Nonce_2 value if the selected integrity protection algorithm is not the null integrity protection algorithm;

b) derive $K_{NRP-sess}$ from K_{NRP}, Nonce_2 and Nonce_1 received in the A2X DIRECT LINK ESTABLISHMENT REQUEST message as specified in 3GPP TS 33.256 [10] if the selected integrity protection algorithm is not the null integrity protection algorithm;

c) derive the NR PC5 encryption key NRPEK and the NR PC5 integrity key NRPIK from $K_{NRP-sess}$ and the selected security algorithms as specified in 3GPP TS 33.256 [10] if the selected integrity protection algorithm is not the null integrity protection algorithm; and

d) create an A2X DIRECT LINK SECURITY MODE COMMAND message. In this message, the initiating UE:

   1) shall include the key establishment information container IE if a new K_{NRP} has been derived at the initiating UE and the authentication method used to generate K_{NRP} requires sending information to complete the authentication procedure;

   NOTE: The key establishment information container is provided by upper layers.

   2) shall include the MSBs of K_{NRP} ID IE if a new K_{NRP} has been derived at the initiating UE;

   3) shall include a Nonce_2 IE set to the 128-bit nonce value generated by the initiating UE for the purpose of session key establishment over this A2X PC5 unicast link if the selected integrity protection algorithms is not the null integrity protection algorithm;

   4) shall include the selected security algorithms;

   5) shall include the UE security capabilities received from the target UE in the A2X DIRECT LINK ESTABLISHMENT REQUEST message or A2X DIRECT LINK REKEYING REQUEST message;

   6) shall include the UE A2X PC5 unicast signalling security policy received from the target UE in the A2X DIRECT LINK ESTABLISHMENT REQUEST message; and

   7) shall include the LSB of $K_{NRP-sess}$ ID chosen by the initiating UE as specified in 3GPP TS 33.256 [10] if the selected integrity protection algorithms is not the null integrity protection algorithm.

If the security protection of this A2X PC5 unicast link is activated by using non-null integrity protection algorithm or non-null ciphering protection algorithm, the initiating UE shall form the $K_{NRP-sess}$ ID from the MSB of $K_{NRP-sess}$ ID received in the A2X DIRECT LINK ESTABLISHMENT REQUEST message or A2X DIRECT LINK REKEYING REQUEST message and the LSB of $K_{NRP-sess}$ ID included in the A2X DIRECT LINK SECURITY MODE COMMAND message. The initiating UE shall use the $K_{NRP-sess}$ ID to identify the new security context.

After the A2X DIRECT LINK SECURITY MODE COMMAND message is generated, the initiating UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication, NRPIK, NRPEK if applicable, $K_{NRP-sess}$ ID, the selected security algorithm as specified in TS 33.265 [10]; an indication of activation of the A2X PC5 unicast signalling security protection for the A2X PC5 unicast link with the new security context, if applicable, and start timer T5310. The initiating UE shall not send a new A2X DIRECT LINK SECURITY MODE COMMAND message to the same target UE while timer T5310 is running.

   NOTE: The A2X DIRECT LINK SECURITY MODE COMMAND message is integrity protected (and not ciphered) at the lower layer using the new security context.

If the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link re-keying procedure, the initiating UE shall provide to the lower layers an indication of activation of the A2X PC5 unicast user plane security protection for the A2X PC5 unicast link with the new security context, if applicable, along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication.

Figure 6.1.2.7.2: A2X PC5 unicast link security mode control procedure

6.1.2.7.3 A2X PC5 unicast link security mode control procedure accepted by the target UE

Upon receipt of an A2X DIRECT LINK SECURITY MODE COMMAND message, if a new assigned initiating UE's layer-2 ID is included and if A2X PC5 unicast link authentication procedure has not been executed, the target UE shall replace the original initiating UE's layer-2 ID with the new assigned initiating UE's layer-2 ID for unicast communication. The target UE shall check the selected security algorithms IE included in the A2X DIRECT LINK SECURITY MODE COMMAND message. If "null integrity algorithm" is included in the selected security algorithms IE, the integrity protection is not offered for the A2X PC5 unicast link and the signalling messages are transmitted unprotected. If "null ciphering algorithm" and an integrity algorithm other than "null integrity algorithm" are included in the selected algorithms IE, the ciphering protection is not offered for the A2X PC5 unicast link and signalling messages are transmitted unprotected. If the target UE's UE A2X PC5 unicast signalling integrity protection policy is set to "signalling integrity protection required", the target UE shall check the selected security algorithms IE in the A2X DIRECT LINK SECURITY MODE COMMAND message does not include the null integrity protection algorithm. If the selected integrity protection algorithm is not the null integrity protection algorithm, the target UE shall:

a) derive $K_{NRP-sess}$ from K_{NRP}, Nonce_1 and Nonce_2 received in the A2X DIRECT LINK SECURITY MODE COMMAND message as specified in 3GPP TS 33.256 [10]; and

b) derive NRPIK from $K_{NRP-sess}$ and the selected integrity algorithm as specified in 3GPP TS 33.256 [10].

If the $K_{NRP-sess}$ is derived and the selected ciphering protection algorithm is not the null ciphering protection algorithm, then the target UE shall derive NRPEK from $K_{NRP-sess}$ and the selected ciphering algorithm as specified in 3GPP TS 33.256 [10].

The target UE shall determine whether or not the A2X DIRECT LINK SECURITY MODE COMMAND message can be accepted by:

a) checking that the selected security algorithms in the A2X DIRECT LINK SECURITY MODE COMMAND message does not include the null integrity protection algorithm if the target UE's UE A2X PC5 unicast signalling integrity protection policy is set to "signalling integrity protection required";

b) asking the lower layers to check the integrity of the A2X DIRECT LINK SECURITY MODE COMMAND message using NRPIK and the selected integrity protection algorithm, if the selected integrity protection algorithm is not the null integrity protection algorithm;

c) checking that the received UE security capabilities have not been altered compared to the values that the target UE sent to the initiating UE in the A2X DIRECT LINK ESTABLISHMENT REQUEST message or A2X DIRECT LINK REKEYING REQUEST message;

    d) if the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link establishment procedure,

        1) checking that the received UE A2X PC5 unicast signalling security policy has not been altered compared to the values that the target UE sent to the initiating UE in the A2X DIRECT LINK ESTABLISHMENT REQUEST message; and

        2) checking that the LSB of $K_{NRP\text{-}sess}$ ID included in the A2X DIRECT LINK SECURITY MODE COMMAND message are not set to the same value as those received from another UE in response to the target UE's A2X DIRECT LINK ESTABLISHMENT REQUEST message; and

    e) if the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link re-keying procedure and the integrity protection algorithm currently in use for the A2X PC5 unicast link is different from the null integrity protection algorithm, checking that the selected security algorithms in the A2X DIRECT LINK SECURITY MODE COMMAND message do not include the null integrity protection algorithm.

If the target UE did not include a K_{NRP} ID in the A2X DIRECT LINK ESTABLISHMENT REQUEST message, the target UE included a Re-authentication indication in the A2X DIRECT LINK REKEYING REQUEST message or the initiating UE has chosen to derive a new K_{NRP}, the target UE shall derive K_{NRP} as specified in 3GPP TS 33.256 [10]. The target UE shall choose the 2 LSBs of K_{NRP} ID to ensure that the resultant K_{NRP} ID will be unique in the target UE. The target UE shall form K_{NRP} ID from the received 2 MSBs of K_{NRP} ID and its chosen 2 LSBs of K_{NRP} ID and shall store the complete K_{NRP} ID with K_{NRP}.

If the target UE accepts the A2X DIRECT LINK SECURITY MODE COMMAND message, the target UE shall create an A2X DIRECT LINK SECURITY MODE COMPLETE message. In this message, the target UE:

    a) shall include the PQFI and the corresponding PC5 QoS parameters;

    b) if IP communication is used and the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link establishment procedure, shall include an IP address configuration IE set to one of the following values:

        1) "IPv6 router" if IPv6 address allocation mechanism is supported by the target UE, i.e. acting as an IPv6 router; or

        2) "IPv6 address allocation not supported" if IPv6 address allocation mechanism is not supported by the target UE;

    c) if IP communication is used, the IP address configuration IE is set to "IPv6 address allocation not supported" and the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link establishment procedure, shall include a link local IPv6 address IE formed locally based on IETF RFC 4862 [16];

    d) if a new K_{NRP} was derived, shall include the 2 LSBs of K_{NRP} ID; and

    e) if the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link establishment procedure, shall include its UE A2X PC5 unicast user plane security policy for this A2X PC5 unicast link. In the case where the different A2X services are mapped to the different A2X PC5 unicast user plane security policies, when more than one A2X service identifier is included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message, each of the user plane security polices of those A2X services shall be compatible, e.g. "user plane integrity protection not needed" and " user plane integrity protection required" are not compatible.

If the selected integrity protection algorithm is not the null integrity protection algorithm, the target UE shall form the $K_{NRP\text{-}sess}$ ID from the MSB of $K_{NRP\text{-}sess}$ ID it had sent in the A2X DIRECT LINK ESTABLISHMENT REQUEST message or A2X DIRECT LINK REKEYING REQUEST message and the LSB of $K_{NRP\text{-}sess}$ ID received in the A2X DIRECT LINK SECURITY MODE COMMAND message. The target UE shall use the $K_{NRP\text{-}sess}$ ID to identify the new security context.

After the A2X DIRECT LINK SECURITY MODE COMPLETE message is generated, the target UE shall pass this message to the lower layers for transmission along with the target UE's layer-2 ID for unicast communication and the initiating UE's layer-2 ID for unicast communication, NRPIK, NRPEK if applicable, $K_{NRP\text{-}sess}$ ID, the selected security algorithm as specified in 3GPP TS 33.256 [10], and an indication of activation of the A2X PC5 unicast signalling security protection for the UE A2X PC5 unicast link with the new security context, if applicable.

NOTE: The A2X DIRECT LINK SECURITY MODE COMPLETE message and further A2X PC5 unicast signalling messages are integrity protected and ciphered (if applicable) at the lower layer using the new security context.

If the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link re-keying procedure, the target UE shall provide to the lower layers an indication of activation of the A2X PC5 unicast user plane security protection for the A2X PC5 unicast link with the new security context, if applicable, along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication.

6.1.2.7.4 A2X PC5 unicast link security mode control procedure completion by the initiating UE

Upon receiving an A2X DIRECT LINK SECURITY MODE COMPLETE message, the initiating UE shall stop timer T5310. If the selected integrity protection algorithm is not the null integrity protection algorithm, the UE checks the integrity of the A2X DIRECT LINK SECURITY MODE COMPLETE message. If the integrity check passes, the initiating UE shall then continue the procedure which triggered the A2X PC5 unicast link security mode control procedure. If the selected integrity protection algorithm is the null integrity protection algorithm, the UE continues the procedure without checking the integrity protection.

After receiving the A2X DIRECT LINK SECURITY MODE COMPLETE message, the initiating UE shall delete the old security context it has for the target UE, if any.

6.1.2.7.5 A2X PC5 unicast link security mode control procedure not accepted by the target UE

If the A2X DIRECT LINK SECURITY MODE COMMAND message cannot be accepted, the target UE shall send an A2X DIRECT LINK SECURITY MODE REJECT message, and the target UE shall abort the ongoing procedure that triggered the initiation of the A2X PC5 unicast link security mode control procedure unless the ongoing procedure is an A2X PC5 unicast link establishment procedure and the Target user info is not included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message. The A2X DIRECT LINK SECURITY MODE REJECT message contains a PC5 signalling protocol cause IE indicating one of the following cause values:

#5 lack of resources for A2X PC5 unicast link;

#7: integrity failure;

#8: UE security capabilities mismatch;

#9: LSB of $K_{NRP\text{-}sess}$ ID conflict;

#10: UE A2X PC5 unicast signalling security policy mismatch; or

#111: protocol error, unspecified.

If this A2X PC5 unicast link security mode control procedure is triggered during the A2X PC5 unicast link establishment procedure and the implementation-specific maximum number of established NR A2X PC5 unicast links has been reached, then the target UE shall send an A2X DIRECT LINK SECURITY MODE REJECT message containing PC5 signalling protocol cause value #5 "lack of resources for A2X PC5 unicast link".

If the A2X DIRECT LINK SECURITY MODE COMMAND message cannot be accepted because the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link establishment procedure, that the selected security algorithms in the A2X DIRECT LINK SECURITY MODE COMMAND message included the null integrity protection algorithm and the target UE's UE A2X PC5 unicast signalling integrity protection policy is set to "signalling integrity protection required", the target UE shall include PC5 signalling protocol cause #10 "UE A2X PC5 unicast signalling security policy mismatch" in the A2X DIRECT LINK SECURITY MODE REJECT message.

If the A2X DIRECT LINK SECURITY MODE COMMAND message cannot be accepted because the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link re-keying procedure, the integrity protection algorithm currently in use for the A2X PC5 unicast link is different from the null integrity protection algorithm and the selected security algorithms in the A2X DIRECT LINK SECURITY MODE COMMAND message include the null integrity protection algorithm, the target UE, the target UE shall include PC5 signalling protocol cause #10 "UE A2X PC5 unicast signalling security policy mismatch" in the A2X DIRECT LINK SECURITY MODE REJECT message.

If the target UE detects that the received UE security capabilities IE in the A2X DIRECT LINK SECURITY MODE COMMAND message has been altered compared to the latest values that the target UE sent to the initiating UE in the A2X DIRECT LINK ESTABLISHMENT REQUEST message or A2X DIRECT LINK REKEYING REQUEST message, the target UE shall include PC5 signalling protocol cause #8 "UE security capabilities mismatch" in the A2X DIRECT LINK SECURITY MODE REJECT message.

If the target UE detects that the LSB of $K_{NRP\text{-}sess}$ ID included in the A2X DIRECT LINK SECURITY MODE COMMAND message are set to the same value as those received from another UE in response to the target UE's A2X DIRECT LINK ESTABLISHMENT REQUEST message, the target UE shall include PC5 signalling protocol cause #9 "LSB of $K_{NRP\text{-}sess}$ ID conflict" in the A2X DIRECT LINK SECURITY MODE REJECT message.

After the A2X DIRECT LINK SECURITY MODE REJECT message is generated, the target UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication.
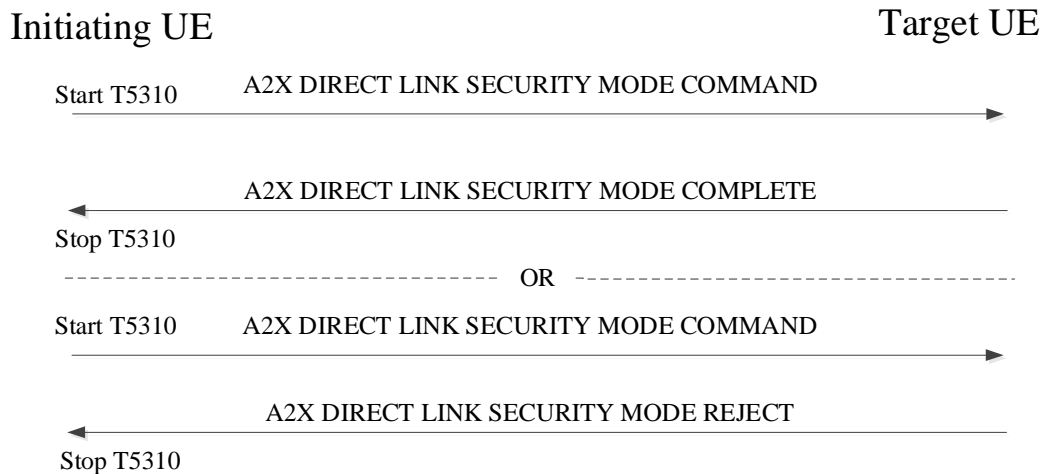
Upon receipt of the A2X DIRECT LINK SECURITY MODE REJECT message, the initiating UE shall stop timer T5310, provide an indication to the lower layer of deactivation of the PC5 unicast security protection and deletion of security context for the A2X PC5 unicast link, if applicable and:

a) if the PC5 signalling protocol cause IE in the A2X DIRECT LINK SECURITY MODE REJECT message is set to #9 "LSB of $K_{NRP\text{-}sess}$ ID conflict", retransmit the A2X DIRECT LINK SECURITY MODE COMMAND message with a different value for the LSB of $K_{NRP\text{-}sess}$ ID and restart timer T5310; or

b) if the PC5 signalling protocol cause IE is set to the value other than #9 "LSB of KNRP-sess ID conflict", abort the ongoing procedure that triggered the initiation of the A2X PC5 unicast link security mode control procedure.

6.1.2.7.6 Abnormal cases

6.1.2.7.6.1 Abnormal cases at the initiating UE

a) Timer T5310 expires.

The initiating UE shall retransmit the A2X DIRECT LINK SECURITY MODE COMMAND message and restart timer T5310. After reaching the maximum number of allowed retransmissions, the initiating UE shall abort the A2X PC5 unicast link security mode control procedure, shall provide an indication to the lower layer of deactivation of the PC5 unicast security protection and deletion of security context for the A2X PC5 unicast link, if applicable, and shall abort the ongoing procedure that triggered the initiation of the A2X PC5 unicast link security mode control procedure.

NOTE: The maximum number of allowed retransmissions is UE implementation specific.

b) The need to use this A2X PC5 unicast link no longer exists before the A2X PC5 unicast link security mode control procedure is completed.

The initiating UE shall abort the procedure, shall provide an indication to the lower layer of deactivation of the PC5 unicast security protection and deletion of security context for the A2X PC5 unicast link, if applicable, and shall abort the ongoing procedure that triggered the initiation of the A2X PC5 unicast link security mode control procedure.

6.1.2.8 A2X PC5 unicast link keep-alive procedure

6.1.2.8.1 General

The A2X PC5 unicast link keep-alive procedure is used to maintain an A2X PC5 unicast link between two UEs, i.e., check that the link between the two UEs is still viable. The UE sending the A2X DIRECT LINK KEEPALIVE REQUEST message is called the "initiating UE" and the other UE is called the "target UE".

The A2X PC5 unicast link keep-alive procedure can be initiated by only one UE or both UEs in the established A2X PC5 unicast link.

NOTE: Whether the A2X PC5 unicast link keep-alive procedure is initiated by only one UE or both UEs in the established A2X PC5 unicast link is UE implementation specific.

6.1.2.8.2 A2X PC5 unicast link keep-alive procedure initiation by the initiating UE

The initiating UE shall meet the following pre-condition before initiating the A2X PC5 unicast link keep-alive procedure:

a) there is a A2X PC5 unicast link between the initiating UE and the target UE.

The initiating UE shall manage a keep-alive timer T5308 and a keep-alive counter for the A2X PC5 unicast link keep-alive procedure. Timer T5308 is used to trigger the periodic initiation of the A2X PC5 unicast link keep-alive procedure. The UE shall start or restart timer T5308 whenever the UE receives an A2X PC5 signalling message or an A2X PC5 user plane data from the target UE over this A2X PC5 unicast link. The UE shall set the keep-alive counter to an initial value of zero after A2X PC5 unicast link establishment.

The initiating UE shall initiate the A2X PC5 unicast link keep-alive procedure when:

a) timer T5308 for this link expires;

b) optionally, a request from the lower layers to check the viability of the A2X PC5 unicast link is received; or

NOTE 1: Whether the lower layers can request the initiation of the A2X PC5 unicast link keep-alive procedure, and what the triggers for the lower layers are to request the initiation of the A2X PC5 unicast link keep-alive procedure, are UE implementation specific.

c) optionally, a request from the upper layers to check the viability of the A2X PC5 unicast link is received.

NOTE 2: Whether the upper layers can request the initiation of the A2X PC5 unicast link keep-alive procedure, and what the triggers for the upper layers are to request the initiation of the A2X PC5 unicast link keep-alive procedure, are UE implementation specific.

In order to initiate the A2X PC5 unicast link keep-alive procedure, the initiating UE shall stop timer T5309, if running, and shall create a A2X DIRECT LINK KEEPALIVE REQUEST message. In this message, the initiating UE:

a) shall include the keep-alive counter for the A2X PC5 unicast link; and

b) may include a maximum inactivity period to indicate the maximum inactivity period of the initiating UE over this A2X PC5 unicast link.

NOTE 3: The value chosen for the maximum inactivity period of the initiating UE is UE implementation specific with the objective to minimize the number of keep-alive procedures as much as possible. It is desirable to have the maximum inactivity period value to be slightly higher than the value of keep-alive timer T5308.

After the A2X DIRECT LINK KEEPALIVE REQUEST message is generated, the initiating UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication, and start timer T5309. The UE shall not send a new A2X DIRECT LINK KEEPALIVE REQUEST message to the same target UE while timer T5309 is running.

```
        Initiating UE                                    Target UE

     Stop T5308
     Start T5309
              ─── A2X DIRECT LINK KEEPALIVE REQUEST ──────►

                                                     Start T5303

              ◄──── A2X DIRECT LINK KEEPALIVE RESPONSE ────

     Stop T5309
     Start T5308
```
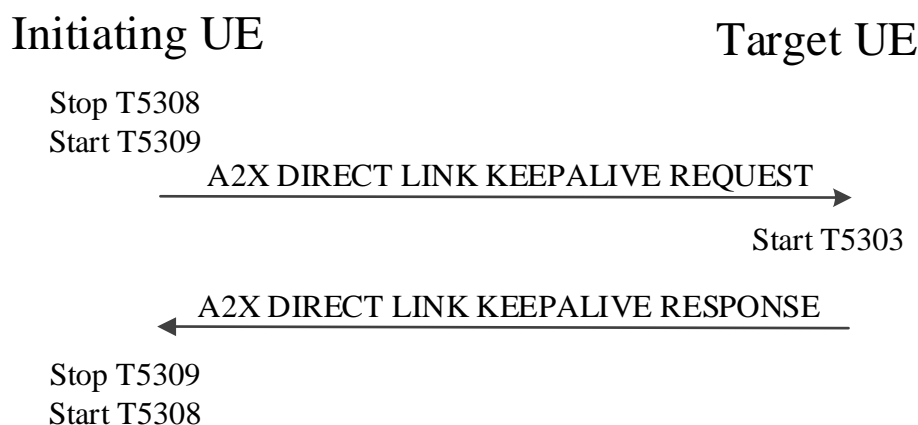
Figure 6.1.2.8.2: A2X PC5 unicast link keep-alive procedure

6.1.2.8.3 A2X PC5 unicast link keep-alive procedure accepted by the target UE

Upon receipt of an A2X DIRECT LINK KEEPALIVE REQUEST message, the target UE shall create an A2X DIRECT LINK KEEPALIVE RESPONSE message. In this message, the target UE:

a) shall include the keep-alive counter set to the same value as that received in the A2X DIRECT LINK KEEPALIVE REQUEST message.

After the A2X DIRECT LINK KEEPALIVE RESPONSE message is generated, the target UE shall pass this message to the lower layers for transmission along with the target UE's layer-2 ID for unicast communication and the initiating UE's layer-2 ID for unicast communication.

If a maximum inactivity period is included in the A2X DIRECT LINK KEEPALIVE REQUEST message, the target UE shall stop T5303, if running, and start T5303 with its value set to the maximum inactivity period. The target UE shall restart T5303 whenever the target UE receives an A2X PC5 signalling message or A2X PC5 user plane data from the initiating UE over this A2X PC5 unicast link.

6.1.2.8.4 A2X PC5 unicast link keep-alive procedure completion by the initiating UE

Upon receipt of an A2X DIRECT LINK KEEPALIVE RESPONSE message, the initiating UE shall stop timer T5309, start timer T5308 and increment the keep-alive counter for the A2X PC5 unicast link.

6.1.2.8.5 Abnormal cases

6.1.2.8.5.1 Abnormal cases at the initiating UE

a) Timer T5309 expires.

The initiating UE shall retransmit the A2X DIRECT LINK KEEPALIVE REQUEST message with the last used value of the keep-alive counter and restart timer T5309. After reaching the maximum number of allowed retransmissions, the initiating UE shall abort the A2X PC5 unicast link keep-alive procedure and locally release the A2X PC5 unicast link.

NOTE: The maximum number of allowed retransmissions is UE implementation specific.

b) The need to use this A2X PC5 unicast link no longer exists before the A2X PC5 unicast link keep-alive procedure is completed.

The initiating UE shall abort the A2X PC5 unicast link keep-alive procedure and initiate an A2X PC5 unicast link release procedure.

c) The initiating UE receives an A2X DIRECT LINK KEEPALIVE RESPONSE message with a keep-alive counter value different from the value which the initiating UE had included in the last sent A2X DIRECT LINK KEEPALIVE REQUEST message.

The initiating UE shall discard the A2X DIRECT LINK KEEPALIVE RESPONSE message.

d) The initiating UE receives an A2X PC5 signalling message other than an A2X DIRECT LINK KEEPALIVE RESPONSE message or an A2X PC5 user plane data from the target UE over this A2X PC5 unicast link while timer T5309 is running.

The initiating UE shall stop timer T5309, abort the A2X PC5 unicast link keep-alive procedure, start timer T5308 and increment the keep-alive counter for the A2X PC5 unicast link.

e) The initiating UE receives an A2X DIRECT LINK KEEPALIVE RESPONSE message when T5309 is not running.

The initiating UE shall discard the A2X DIRECT LINK KEEPALIVE RESPONSE message.

6.1.2.8.5.2 Abnormal cases at the target UE

a) Timer T5303 expires.

The target UE shall:

    1) initiate an A2X PC5 unicast link keep-alive procedure to check the link; or

    2) initiate the A2X PC5 unicast link release procedure.

    Whether the UE chooses 1) or 2) is left to UE implementation.

b) The target UE receives an A2X DIRECT LINK KEEPALIVE REQUEST message with a keep-alive counter value lower than the value which the target UE had included in the last sent A2X DIRECT LINK KEEPALIVE RESPONSE message.

    The target UE shall discard the A2X DIRECT LINK KEEPALIVE REQUEST message.

c) The target UE receives an A2X DIRECT LINK KEEPALIVE REQUEST message if there is a pending A2X PC5 signalling message or A2X PC5 user plane data to be sent to the initiating UE over this A2X PC5 unicast link.

    The target UE:

    1) shall pass this A2X PC5 signalling message to the lower layers for transmission along with the target UE's layer-2 ID for A2X unicast communication and the initiating UE's layer-2 ID for A2X unicast communication, or perform the data transmission over A2X PC5 unicast link as specified in clause 6.1.2.9; and

    2) shall consider transmission of this A2X PC5 signalling message or A2X PC5 user plane data to be an implicit A2X DIRECT LINK KEEPALIVE RESPONSE message and skip generating an A2X DIRECT LINK KEEPALIVE RESPONSE message. If a maximum inactivity period is included in the A2X DIRECT LINK KEEPALIVE REQUEST message, the target UE shall stop T5303, if running, and start T5303 with its value set to the maximum inactivity period.

6.1.2.9 Data transmission over A2X PC5 unicast link

6.1.2.9.1 Transmission

When receiving user data from upper layers to be sent over A2X PC5 unicast link to a specific UE, the transmitting UE shall determine the A2X PC5 unicast link context corresponding to the application layer ID, and then shall tag each outgoing protocol data unit with the following information before passing it to the lower layers for transmission:

a) a layer-3 protocol data unit type (see 3GPP TS 38.323 [14]) set to:

    1) IP packet, if the A2X message contains IP data; or

    2) non-IP packet, if the A2X message contains non-IP data;

b) the A2X PC5 link identifier associated with the A2X PC5 unicast link context;

c) optionally, the source layer-2 ID set to the source layer-2 ID associated with the A2X PC5 unicast link context;

d) optionally, the destination layer-2 ID set to the destination layer-2 ID associated with the A2X PC5 unicast link context; and

e) the PQFI set to the value corresponding to the A2X service identifier and the optional A2X application requirements according to the mapping rules specified in clause 5.2.3.

6.1.2.9.2 Procedure for UE to use provisioned radio resources for A2X communication over PC5

The procedures described for using NR-PC5 in clause 6.1.3.2.3 apply.

6.1.2.10 A2X PC5 unicast link re-keying procedure

6.1.2.10.1 General

The purpose of the A2X PC5 unicast link re-keying procedure is to derive a new $K_{NRP-sess}$ and, optionally, a new K_{NRP} for an existing A2X PC5 unicast link. The UE sending the A2X DIRECT LINK REKEYING REQUEST message is called the "initiating UE" and the other UE is called the "target UE".

> NOTE: There is no benefit in performing the A2X PC5 unicast link re-keying procedure when using the null integrity protection algorithm, hence it is recommended not to trigger it when using the null integrity protection algorithm.

6.1.2.10.2 A2X PC5 unicast link re-keying procedure initiation by the initiating UE

The initiating UE shall meet the following pre-condition before initiating the A2X PC5 unicast link re-keying procedure:

    a) there is an A2X PC5 unicast link between the initiating UE and the target UE; and

        1) if the session key $K_{NRP-sess}$ used to protect A2X PC5 unicast link needs to be refreshed and neither timer T5310 nor T5311 are running;

        2) if the UE wants to refresh K_{NRP} and neither timer T5310 nor T5311 are running; or

        3) if the lower layers indicate that an A2X PC5 unicast link re-keying procedure needs to be performed.

In order to initiate the A2X PC5 unicast link re-keying procedure, the initiating UE shall create an A2X DIRECT LINK REKEYING REQUEST message. In this message, the initiating UE:

    a) shall include the Key establishment information container IE if the null integrity protection algorithm is not in use;

> NOTE 1: The key establishment information container is provided by upper layers.

    b) shall include a Nonce_1 IE set to the 128-bit nonce value generated by the initiating UE for the purpose of session key refresh over this A2X PC5 unicast link if the null integrity protection algorithm is not in use;

    c) shall include its UE security capabilities indicating the list of algorithms that the initiating UE supports for the re-keying of this A2X PC5 unicast link;

    d) shall include the MSB of $K_{NRP-sess}$ ID chosen by the initiating UE as specified in 3GPP TS 33.256 [10] if the null integrity protection algorithm is not in use; and

    e) may include a Re-authentication indication if the initiating UE wants to derive a new K_{NRP}.

After the A2X DIRECT LINK REKEYING REQUEST message is generated, the initiating UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication, and start timer T5311. The UE shall not send a new A2X DIRECT LINK REKEYING REQUEST message to the same target UE while timer T5311 is running.

> NOTE 2: In order to ensure successful A2X PC5 unicast link re-keying, T5311 should be set to a value larger than the sum of T5304 and T5310.

Initiating UE   Target UE

Start T5311   A2X DIRECT LINK REKEYING REQUEST

A2X DIRECT LINK REKEYING RESPONSE

Stop T5311
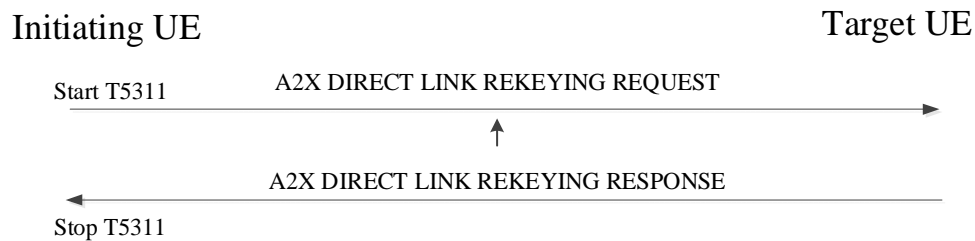
Figure 6.1.2.10.2: A2X PC5 unicast link re-keying procedure

6.1.2.10.3 A2X PC5 unicast link re-keying procedure accepted by the target UE

Upon receipt of an A2X DIRECT LINK REKEYING REQUEST message, if the A2X DIRECT LINK REKEYING REQUEST message includes a Re-authentication indication, the target UE shall derive a new K_{NRP}. This may require performing one or more A2X PC5 unicast link authentication procedures as specified in clause 6.1.2.6.

> NOTE: How many times the A2X PC5 unicast link authentication procedure needs to be performed to derive a new K_{NRP} depends on the authentication method used.

Then the target UE shall initiate an A2X PC5 unicast link security mode control procedure as specified in clause 6.1.2.7.

Upon successful completion of the A2X PC5 unicast link security mode control procedure, the target UE shall create an A2X DIRECT LINK REKEYING RESPONSE message.

After the A2X DIRECT LINK REKEYING RESPONSE message is generated, the target UE shall pass this message to the lower layers for transmission along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication.

6.1.2.10.4 A2X PC5 unicast link re-keying procedure completion by the initiating UE

Upon receipt of the A2X DIRECT LINK REKEYING RESPONSE message, the initiating UE shall stop timer T5311 and check the integrity of the A2X DIRECT LINK REKEYING RESPONSE message using the new NRPIK.

After receiving the A2X DIRECT LINK REKEYING RESPONSE message, the initiating UE shall delete the old security context it has for the target UE.

6.1.2.10.5 Abnormal cases at the initiating UE

The following abnormal cases can be identified:

a) Timer T5311 expires.

The initiating UE shall retransmit the A2X DIRECT LINK REKEYING REQUEST message and restart timer T5311. After reaching the maximum number of allowed retransmissions, the initiating UE shall abort the A2X PC5 unicast link re-keying procedure, shall provide an indication of deactivation of the PC5 unicast security protection and deletion of security context for the A2X PC5 unicast link to the lower layer, if applicable, along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication and may initiate the A2X PC5 unicast link release procedure.

> NOTE: The maximum number of allowed retransmissions is UE implementation specific.

b) The need to use this A2X PC5 unicast link no longer exists before the A2X PC5 unicast link re-keying procedure is completed.

The initiating UE shall abort the procedure and shall provide an indication of deactivation of the PC5 unicast security protection and deletion of security context for the A2X PC5 unicast link to the lower layer, if applicable, along with the initiating UE's layer-2 ID for unicast communication and the target UE's layer-2 ID for unicast communication.

c) For the same A2X PC5 unicast link, if the initiating UE receives an A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message after initiating the A2X PC5 unicast link re-keying procedure, the initiating UE shall stop the timer T5311, abort the A2X PC5 unicast link re-keying procedure and proceed with the A2X PC5 unicast link identifier update procedure.

6.1.2.11   A2X PC5 unicast link security

6.1.2.11.1   Overview

This clause describes the principles for the handling of A2X PC5 unicast security contexts in the UE and the procedures used for the security protection of PC5 signalling messages exchanged between UEs over an A2X PC5 unicast link. Based on the A2X security policies of UEs, security protection for an A2X PC5 unicast link involves integrity protection and ciphering of the PC5 signalling messages, and integrity protection and ciphering of PC5 user plane data. The use of integrity protection and ciphering using null key value or non-null key value over a PC5 unicast link is mandated (see 3GPP TS 33.256 [10]).

The signalling procedures for the control of A2X PC5 unicast security are part of the PC5 signalling protocol and are described in detail in clause 6.1.2.

> NOTE: It is recommended to set the UE A2X PC5 unicast signalling integrity protection policy to "signalling integrity protection required" in order to guarantee security protection over PC5. In this clause, for the ease of description, it is assumed that integrity protection and ciphering are used, unless explicitly indicated otherwise. Operation of an A2X PC5 unicast link without integrity protection or ciphering is achieved by configuring the UE so that it always selects the "null integrity protection algorithm", 5G-IA0, or the "null ciphering algorithm", 5G-EA0.

6.1.2.11.2   Handling of A2X PC5 unicast security contexts

6.1.2.11.2.1   General

The security parameters for authentication, integrity protection and ciphering are tied together in an A2X PC5 unicast security context and identified by a $K_{NRP-sess}$ identifier ($K_{NRP-sess}$ ID). The relationship between the security parameters is defined in 3GPP TS 33.256 [10]. The $K_{NRP-sess}$ ID is self-assigned by the UEs.

Before security can be established by using non-null security protection algorithms, the UEs establishing an A2X PC5 unicast link need to establish an A2X PC5 unicast security context. The A2X PC5 unicast security context is created as the result of an A2X PC5 unicast link authentication procedure and A2X PC5 unicast link security mode control procedure between the UEs.

The A2X PC5 unicast security context is taken into use by the UEs when one of the UEs initiates an A2X PC5 unicast link security mode control procedure.

The creation of a security context also results in the establishment of a key K_{NRP} and its identifier K_{NRP} ID at the UEs.

The A2X PC5 unicast security context can be created using K_{NRP} when a new A2X PC5 unicast link is established without executing a new A2X PC5 unicast link authentication procedure (see clause 6.1.2.11.2.2). For this purpose, the A2X DIRECT LINK ESTABLISHMENT REQUEST message contains a K_{NRP} ID indicating the A2X PC5 unicast security context.

6.1.2.11.2.2   Establishment of secure exchange of PC5 signalling messages

Secure exchange of PC5 signalling messages over an A2X PC5 unicast link is established during the A2X PC5 unicast link establishment procedure by initiating an A2X PC5 unicast link security mode control procedure. After successful completion of the A2X PC5 unicast link security mode control procedure, all PC5 signalling messages exchanged between the UEs are sent integrity protected using the PC5 unicast security algorithms, and except for the A2X DIRECT LINK SECURITY MODE COMMAND message, all PC5 signalling messages exchanged between the UEs are sent ciphered using the PC5 unicast security algorithms. The security exchange of PC5 signalling messages is maintained for the lifetime of the PC5 unicast link.

6.1.2.11.2.3 Change of security keys

When one of the UEs using the A2X PC5 unicast link initiates an A2X PC5 unicast link re-keying procedure to create a new A2X PC5 unicast security context, the PC5 signalling messages exchanged during the A2X PC5 unicast link authentication procedure, if any, are integrity protected and ciphered using the old A2X PC5 unicast security context, i.e. the A2X PC5 unicast security context that was in use before the start of the A2X PC5 unicast link re-keying procedure.

Both UEs shall continue to use the old A2X PC5 unicast security context until the UE which has received the A2X DIRECT LINK REKEYING REQUEST message initiates an A2X PC5 unicast link security mode control procedure. The UE shall send the A2X DIRECT LINK SECURITY MODE COMMAND message integrity protected with the new A2X PC5 unicast security context, but uncyphered. When the peer UE responds with an A2X DIRECT LINK SECURITY MODE COMPLETE message, it shall send the message integrity protected and ciphered with the new PC5 unicast security context.

6.1.2.11.3 Checking of PC5 signalling messages in the UE

If the signalling integrity protection is not activated for A2X PC5 unicast link, all PC5 signalling messages are processed by the UE without integrity protection.

If the signalling non-null integrity protection is activated for A2X PC5 unicast link, except the messages listed below, the UE shall not process any of the PC5 signalling messages that are not integrity protected:

a) A2X DIRECT LINK ESTABLISHMENT REQUEST message;

b) A2X DIRECT LINK ESTABLISHMENT REJECT message;

c) A2X DIRECT LINK AUTHENTICATION REQUEST message;

d) A2X DIRECT LINK AUTHENTICATION RESPONSE message;

e) A2X DIRECT LINK AUTHENTICATION REJECT message;

f) A2X DIRECT LINK SECURITY MODE REJECT message; and

g) A2X DIRECT LINK AUTHENTICATION FAILURE message.

NOTE: These messages are accepted by the receiving UE without protection, as in certain situations they are sent by the peer UE before security can be activated.

Once the secure exchange of PC5 signalling messages has been established, the receiving UE shall not process any PC5 signalling message that does not successfully pass the integrity check. The A2X DIRECT LINK SECURITY MODE COMMAND message shall be processed as specified in clause 6.1.2.7.3. If the signalling non-null ciphering and integrity protections are established and any PC5 signalling message that is received as not integrity protected and not ciphered even though the secure exchange of PC5 signalling messages has been established, then the receiving UE shall discard this message.

6.1.2.12 PC5 QoS flow establishment over A2X PC5 unicast link

In order to establish a PC5 QoS flow establishment over A2X PC5 unicast link, the UE shall derive the PC5 QoS parameters based on the A2X application requirements provided by the upper layers (if available) and the A2X service identifier(s) according to the PC5 QoS mapping rules defined in clause 5.2.3. The UE shall create the PC5 QoS flow(s) based on the derived PC5 QoS parameters. For each PC5 QoS flow to be created, the UE shall perform the following operations:

a) self-assign a PQFI;

b) create a PC5 QoS flow context, which contains:

   1) the PQFI;

   2) the A2X service identifier(s); and

   3) the derived PC5 QoS parameters;

   c) create a new PC5 QoS rule which contains:

      1) a PC5 QoS rule identifier;

      2) the PQFI;

      3) a set of packet filters; and

      4) a precedence value; and

   d) pass the following parameters to the lower layers:

      1) the PQFI;

      2) the PC5 QoS parameters;

      3) the A2X PC5 link identifier;

      4) optionally, the source and destination layer-2 IDs; and

      5) the NR Tx profile corresponding to the initial signalling of the A2X PC5 unicast link establishment and that is associated with the A2X service identifier (see clause 5.2.3).

Two types of packet filters are supported for A2X communication over PC5, i.e. the IP packet filter set and the A2X packet filter set. A PC5 QoS Rule contains either the IP packet filter set or the A2X packet filter set.

The IP packet filter set is defined as content of the packet filter contents field specified in 3GPP TS 24.501 [7] figure 9.11.4.13.4 and table 9.11.4.13.1.

The A2X packet filter set shall support packet filters based on at least any combination of:

   a) A2X Service identifier;

   b) the source layer-2 ID and the destination layer-2 ID; and

   c) application layer ID (e.g. UAV ID).

The UE shall also pass the one or more A2X frequencies associated with the A2X service identifier and the communication mode which is set to unicast mode for the A2X service identifier to the lower layers, if:

   a) the UE is configured with A2X service identifier to A2X frequency mapping rules for A2X communication over PC5 as specified in clause 5.2.3; and

   b) there is one or more A2X frequencies associated with the A2X service identifier at the current altitude in the current geographical area.

6.1.2.13   PC5 QoS flow match over A2X PC5 unicast link

When service data or request from the upper layers is received, the UE determines if there is any existing PC5 QoS flow(s) matching the service data or request, i.e. based on the PC5 QoS rules for the existing PC5 QoS flow(s).

If there is no PC5 QoS rules for the existing PC5 QoS flow(s) matching the service data or request, the UE shall derive the PC5 QoS parameters based on the A2X application requirements provided by the upper layers (if available) and the A2X service identifier(s) according to the PC5 QoS mapping rules defined in clause 5.2.3 and shall perform the following:

   a) if there is no existing PC5 QoS flow that fulfils the derived PC5 QoS parameters, then the UE shall create a new PC5 QoS flow as specified in clause 6.1.2.12;

   b) if there is an existing PC5 QoS flow that fulfils the derived PC5 QoS parameters, then the UE shall update the PC5 packet filter set in the PC5 QoS rule of this PC5 QoS flow, e.g. add the new packet filter in the PC5 QoS rule of this existing PC5 QoS flow; and

   c) the UE shall use the new PC5 QoS flow created as described in bullet a) or the existing PC5 QoS flow with the updated PC5 QoS rules as described in bullet b) to perform the transmission of A2X communication over PC5 as specified in clause 6.1.2.9.

If there is a PC5 QoS rule for the existing PC5 QoS flow matching the service data or request, the UE shall use this existing PC5 QoS flow to perform transmission of A2X communication over PC5 as specified in clause 6.1.2.9.

6.1.3   Broadcast mode A2X communication over PC5

6.1.3.1   Overview

This clause describes the A2X communication over PC5 reference point in broadcast mode operation. The UE is configured with the related information as described in clause 5.2.3.

6.1.3.2   Transmission of broadcast mode A2X communication over PC5

6.1.3.2.1   Initiation

6.1.3.2.1.1   Requirements for A2X communication over PC5

When the upper layers request the UE to send a A2X message of a A2X service identified by a A2X service identifier using A2X communication over PC5, the request from the upper layers includes:

   a) the A2X message;

   b) the A2X service identifier of the A2X service for the A2X message;

   c) the type of data in the A2X message (i.e. IP or non-IP);

   d) if the A2X message contains non-IP data, the A2X message family (see clause 12A.2) of data in the A2X message;

   e) optionally the communication mode which is set to broadcast mode; and

   f) optionally the A2X application requirements (e.g. priority requirement, reliability requirement, delay requirement).

Upon a request from upper layers to send a A2X message of a A2X service identified by a A2X service identifier using A2X communication over PC5, if:

   a) the UE is configured with A2X service identifier to A2X frequency mapping rules for A2X communication over PC5 as specified in clause 5.2.3; and

   b) there is one or more A2X frequencies associated with the A2X service identifier of the A2X service for the A2X message in the current altitude range and geographical area,

then the UE passes the one or more A2X frequencies associated with the A2X service identifier of the A2X service and the communication mode which is set to broadcast mode for the A2X message to the lower layers.

Then, if any of the following conditions are met:

   a) the following conditions are met:

      1) the UE is served by NR or served by E-UTRA for NR-PC5 A2X communication;

      2) the UE intends to use the radio resources (i.e. carrier frequency) provided by a serving cell;

      3) the registered PLMN is in the list of PLMNs in which the UE is authorized to use A2X communication over PC5 when the UE is served by NR or served by E-UTRA for A2X communication over PC5 as specified in clause 5.2.3; and

      4) the A2X service identifier of the A2X service is included in the list of A2X services authorized for A2X communication over PC5 as specified in clause 5.2.3 or the UE is configured with a default destination layer-2 ID for A2X communication over PC5 as specified in clause 5.2.3;

   b) the following conditions are met:

      1) the UE is:

    i)   not served by NR and not served by E-UTRA for A2X communication over PC5;

    ii) in limited service state as specified in 3GPP TS 23.122 [2], if the reason for the UE being in limited service state is one of the following:

        A) the UE is unable to find a suitable cell in the selected PLMN as specified in 3GPP TS 38.304 [13];

        B) the UE received a REGISTRATION REJECT message or a SERVICE REJECT message with the 5GMM cause #11 "PLMN not allowed" as specified in 3GPP TS 24.501 [7]; or

        C) the UE received a REGISTRATION REJECT message or a SERVICE REJECT message with the 5GMM cause #7 "5GS services not allowed" as specified in 3GPP TS 24.501 [7]; or

    iii) in limited service state as specified in 3GPP TS 23.122 [2] for reasons other than A), B) or C) above, and located in an altitude range and a geographical area for which the UE is provisioned with "non-operator managed" radio parameters as specified in clause 5.2.3;

  2) the UE is authorized to use A2X communication over PC5 when the UE is not served by NR and not served by E-UTRA for A2X communication as specified in clause 5.2.3; and

  3) the A2X service identifier of the A2X service is included in the list of A2X services authorized for A2X communication over PC5 as specified in clause 5.2.3 or the UE is configured with a default destination layer-2 ID for A2X communication over PC5 as specified in clause 5.2.3;

then the UE shall proceed as specified in clause 6.1.3.2.1.2, else the UE shall not perform transmission of A2X communication over PC5.

6.1.3.2.1.2   PC5 QoS flow match and establishment

When determining if any existing PC5 QoS flow match the request from upper layers, UE shall proceeds as follows:

  a) according to the PC5 QoS mapping rules specified in clause 5.2.3, the UE shall use the PC5 QoS parameters corresponding to the A2X service identifier and optionally A2X application requirements;

  b) according to the A2X service identifier to destination layer-2 ID for broadcast mapping rules specified in clause 5.2.3, the UE shall use the destination layer-2 ID corresponding to the A2X service identifier;

  c) if there is no existing context for the destination layer-2 ID, then:

    1) build a new context for the destination layer-2 ID;

    2) self-assign a new source layer-2 ID; and

    3) pass the source layer-2 ID and the destination layer-2 ID to lower layers.

  d) if in the context for the destination layer-2 ID, there is no PC5 QoS rule for the existing PC5 QoS flow(s) matching the service data or request, the UE shall derive the PC5 QoS parameters based on the A2X application requirements provided by the upper layers (if available) and the A2X service identifier(s) (e.g. PSID or ITS-AID) according to the PC5 QoS mapping rules defined in clause 5.2.3 and shall perform the following:

    1) if there is no existing PC5 QoS flow that fulfils the derived PC5 QoS parameters, then the UE shall create a new PC5 QoS flow by performing the following operations:

        i) self-assign a new PQFI;

        ii) create a new PC5 QoS flow context which contains:

           - the PQFI;

           - the A2X service identifier(s); and;

           - the derived PC5 QoS parameters;

        iii) create a new PC5 QoS rule which contains:

           - a PC5 QoS rule identifier;

- the PQFI;

- a set of packet filters; and

- a precedence value; and

iv) pass the following parameters to the lower layers:

- the PQFI;

- the PC5 QoS parameters;

- the source layer-2 ID and the destination layer-2 ID; and

- the NR Tx Profile corresponding to the A2X service identifier, if all the A2X service identifier(s) for the given destination layer-2 ID have NR Tx profiles available, as determined for the respective A2X service identifier based on the configuration parameters and conditions described in clause 5.2.3;

NOTE: When the PC5 DRX operation is needed based on the provided NR Tx Profile, the lower layers use PC5 QoS parameters to determine the PC5 DRX parameter values (see 3GPP TS 38.300 [12]) for transmission operation over PC5 reference point.

2) if there is an existing PC5 QoS flow that fulfils the derived PC5 QoS parameters, then the UE shall update the PC5 packet filter set in the PC5 QoS rule of this PC5 QoS flow, e.g. add the new packet filter in the PC5 QoS rule of this existing PC5 QoS flow; and

3) the UE shall use the new PC5 QoS flow created as described in bullet 1) or the existing PC5 QoS flow with the updated PC5 QoS rules as described in bullet 2) to perform the transmission of A2X communication over PC5 as specified in clause 6.1.3.2.2; and

e) if in the context for the destination layer-2 ID, there is a PC5 QoS rule for the existing PC5 QoS flow matching the service data or request, the UE shall use this existing PC5 QoS flow to perform transmission of A2X communication over PC5 as specified in clause 6.1.3.2.2.

Two types of packet filters are supported for A2X communication over PC5, i.e. the IP packet filter set and the A2X packet filter set. A PC5 QoS Rule contains either the IP packet filter set or the A2X packet filter set.

The IP packet filter set is defined as content of the packet filter contents field specified in 3GPP TS 24.501 [7] figure 9.11.4.13.4 and table 9.11.4.13.1.

The A2X packet filter set shall support packet filters based on at least any combination of:

- A2X service identifier (e.g. PSID or ITS-AID);

- the source layer-2 ID and the destination layer-2 ID; and

- Application Layer ID (e.g. UAV ID);

6.1.3.2.2 Transmission

The UE shall include the A2X message in a protocol data unit with the following parameters:

a) a layer-3 protocol data unit type (see 3GPP TS 38.323 [14]) set to:

1) IP packet, if the A2X message contains IP data; or

2) non-IP packet, if the A2X message contains non-IP data;

b) the source layer-2 ID set to the layer-2 ID self-assigned by the UE for A2X communication over PC5;

c) the destination layer-2 ID set to:

1) the destination layer-2 ID associated with the A2X service identifier of the A2X service in this list of A2X services authorized for A2X communication over PC5 as specified in clause 5.2.3, if the A2X service identifier of the A2X service is included in the list of A2X services authorized for A2X communication over PC5 as specified in clause 5.2.3; or

2) the default destination layer-2 ID configured to the UE for A2X communication over PC5 as specified in clause 5.2.3, if the A2X service identifier of the A2X service is not included in the list of A2X services authorized for A2X communication over PC5 and the UE is configured with a default destination layer-2 ID for A2X communication over PC5;

d) if the A2X message contains non-IP data, an indication to set the non-IP type field of the non-IP type PDU to the value corresponding to the A2X message family (see clause 12A.2 and clause 12A.3) used by the A2X service as indicated by upper layers;

e) if the A2X message contains IP data, the source IP address set to the source IP address self-assigned by the UE for A2X communication over PC5;

f) the PQFI set to the value corresponding to the PC5 QoS Rules as specified in clause 6.1.3.2.1;

g) if E-UTRA-PC5 is used for A2X communication over PC5, the UE is configured with A2X service identifier to Tx Profile mapping rules for A2X communication over PC5 as specified in clause 5.2.3, the Tx Profile associated with the A2X service identifier as specified in clause 5.2.3; and

h) if NR-PC5 is used for A2X communication over PC5, the UE is configured with A2X service identifier to NR Tx Profile mapping rules for A2X communication over PC5 as specified in clause 5.2.3 and all the A2X service identifier(s) for the given destination layer-2 ID have NR Tx profiles available, the NR Tx Profile associated with the A2X service identifier as specified in clause 5.2.3;

then UE shall request radio resources for A2X communication over PC5 as specified in 3GPP TS 38.300 [12], and pass the A2X message on the PC5 QoS Flow identified by the PQFI to lower layers for transmission. The PC5 QoS Rules corresponding to the PQFIs map A2X messages with the same A2X service identifier and with the same PC5 QoS parameters to the same PC5 QoS Flow, and apply PQFI to A2X messages.

If the UE is camped on a serving cell indicating that A2X communication over PC5 is supported by the network, but not broadcasting any carrier frequencies and radio resources for A2X communication over PC5 as specified in 3GPP TS 38.331 [15], the UE shall request radio resources for A2X communication over PC5 as specified in 3GPP TS 24.501 [7].

If the UE has an emergency PDN connection, the UE shall send an indication to the lower layers to prioritize transmission over the emergency PDN connection as compared to transmission of A2X communication over PC5.

6.1.3.2.3 Procedure for UE to use provisioned radio resources for A2X communication over PC5

When the UE is not served by NR and not served by E-UTRA for A2X communication and is authorized to use A2X communication over PC5, the UE shall identify the RAT to be used for A2X communication over PC5 according to the list of RATs in which the UE is authorized to use A2X communication over PC5. If both E-UTRA-PC5 and NR-PC5 for A2X are authorized to the UE for A2X communication over PC5, the UE selects a RAT used for A2X communication over PC5 according to local policy. The UE shall select the corresponding radio parameters to be used for A2X communication over PC5 as follows:

a) if the UE can determine itself located at an altitude range in a geographical area, and the UE is provisioned with radio parameters for the altitude range at the geographical area, the UE shall select the radio parameters associated with that altitude range in that geographical area; or

b) in all other cases, the UE shall not initiate A2X communication over PC5.

It is out of scope of the present specification to define how the UE can locate itself in a specific geographical area and altitude range. When the UE is in coverage of a 3GPP RAT it can for example use information derived from the serving PLMN. When the UE is not in coverage of a 3GPP RAT it can use other techniques, e.g. Global Navigation Satellite System (GNSS). The UE shall not consider user provided location as a valid input to locate itself in a specific geographical area or altitude range.

If the UE intends to use "non-operator managed" radio parameters as specified in clause 5.2.3, the UE shall initiate A2X communication over PC5 with the selected radio parameters.

If the UE intends to use "operator managed" radio parameters as specified in clause 5.2.3, before initiating A2X communication over PC5, the UE shall check with lower layers whether the selected radio parameters can be used in the current location without causing interference to other cells as specified in 3GPP TS 38.331 [15] when NR-PC5 to be

used for A2X communication over PC5 and specified in 36.331 [11] when E-UTRA-PC5 to be used for A2X communication over PC5, and:

    a) if the lower layers indicate that the usage would not cause any interference, the UE shall initiate A2X communication over PC5; or

    NOTE: If the lower layers find that there exists a cell operating the provisioned radio resources (i.e., carrier frequency), and the cell belongs to the registered PLMN or a PLMN equivalent to the registered PLMN, and the UE is authorized for A2X communication over PC5 in this PLMN, the UE can use the radio parameters indicated by the cell as specified in 3GPP TS 38.331 [15] when NR-PC5 to be used for A2X communication over PC5 and specified in 3GPP TS 36.331 [11] when E-UTRA-PC5 to be used for A2X communication over PC5.

    b) else if the lower layers report that one or more PLMNs operate in the provisioned radio resources (i.e. carrier frequency) then:

        1) if the following conditions are met:

            i) none of the PLMNs reported by the lower layers is the registered PLMN or equivalent to the registered PLMN;

            ii) at least one of the PLMNs reported by the lower layers is in the list of authorized PLMNs for A2X communication over PC5 and provides radio resources for A2X communication over PC5 as specified in 3GPP TS 38.331 [15] when NR-PC5 to be used for A2X communication over PC5 and specified in 3GPP TS 36.331 [11] when E-UTRA-PC5 to be used for A2X communication over PC5; and

            iii) the UE does not have an emergency PDU session in 5GS and does not have an emergency PDN connection in EPS;

        then the UE shall:

            i) if in 5GMM-IDLE mode (in case of 5GC) or in EMM-IDLE mode (in case of EPC), perform PLMN selection triggered by A2X communication over PC5 as specified in 3GPP TS 23.122 [2]; or

            ii) else if

               A) in 5GMM-CONNECTED mode (in case of 5GC), either:

                  AA) perform a Deregistration procedure as specified in 3GPP TS 24.501 [7] and then perform PLMN selection triggered by A2X communication over PC5 as specified in 3GPP TS 23.122 [2]; or

                  AB) not initiate A2X communication over PC5.

              Whether the UE performs AA) or AB) above is left up to UE implementation; or

               B) in EMM-CONNECTED mode (in case of EPC), either:

                  BA) perform a detach procedure as specified in 3GPP TS 24.301 [6] and then perform PLMN selection triggered by A2X communication over PC5 as specified in 3GPP TS 23.122 [2]; or

                  BB) not initiate A2X communication over PC5.

              Whether the UE performs BA) or BB) above is left up to UE implementation; or

        2) else the UE shall not initiate A2X communication over PC5.

If the registration to the selected PLMN is successful, the UE shall proceed with the procedure to initiate A2X communication over PC5 as specified in clause 6.1.3.2.1.

If the UE is performing A2X communication over PC5 using radio parameters associated with an altitude range and a geographical area and moves out of that altitude range or that geographical area, the UE shall stop performing A2X communication over PC5 and then:

a) if the UE is not served by NR and not served by E-UTRA for A2X communication over PC5 or the UE intends to use radio resources for A2X communication over PC5 other than those operated by the serving cell, the UE shall select appropriate radio parameters for the new altitude range and geographical area as specified above; or

b) if the UE is served by NR or served by E-UTRA for A2X communication over PC5 and intends to use radio resources for A2X communication over PC5 operated by the serving cell, the UE shall proceed with the procedure to initiate A2X communication over PC5 when served by NR or served by E-UTRA for A2X communication over PC5.

6.1.3.2.4   Privacy of A2X transmission over PC5

Upon initiating transmission of A2X communication over PC5, if:

a) the A2X service identifier of a A2X service requesting transmission of A2X communication over PC5 is in the list of A2X services which require privacy for A2X communication over PC5 as specified in clause 5.2.3; and

b) the UE is located in a geographical area in which this A2X service requires privacy for A2X communication over PC5 as specified in clause 5.2.3, or the UE is not provisioned any geographical areas in which this A2X services requires privacy for A2X communication over PC5,

then the UE shall proceed as follows:

a) if timer T5320 is not running, start timer T5320 and set its timer value as the privacy timer value as specified in clause 5.2.3;

b) upon:

1) getting an indication from upper layers that the application layer identifier has been changed; or

2) timer T5320 expiry,

then:

1) change the value of the source layer-2 ID self-assigned by the UE for the A2X communication over PC5;

2) if the A2X message contains IP data, change the value of the source IP address self-assigned by the UE for A2X communication over PC5;

3) provide an indication to upper layers that the source layer-2 ID and/or the source IP address are changed;

4) pass the changed source layer-2 ID and destination layer-2 ID, along with the corresponding PQFI down to the lower layer;

5) restart timer T5320; and

6) upon stopping transmission of the A2X communication over PC5, stop timer T5320.

6.1.3.3   Reception of broadcast mode A2X communication over PC5

The UE may be configured by upper layers with one or more destination layer-2 ID(s) for reception of A2X messages over PC5. The receiving UE shall determine the PC5 QoS parameters for this broadcast A2X service in the same way described in clause 6.1.3.2.1.2 and shall determine the NR Tx Profile as described in clause 5.2.3, and shall provide:

a) the PC5 QoS parameters;

b) the NR Tx Profile corresponding to the A2X service identifier, if all the A2X service identifier(s) for the given destination layer-2 ID have NR Tx profiles available; and

c) the destination layer-2 ID(s);

to lower layers. When the UE derives new PC5 QoS parameters for a destination layer-2 ID that has been provided to lower layers (e.g., due to a change in application requirements), the UE shall provide the new PC5 QoS parameters for that destination layer-2 ID to lower layers. For each received protocol data unit over PC5, the receiving UE shall check if the destination layer-2 ID of the received protocol data unit matches one of the configured destination Layer-2 IDs. If yes, the UE shall then check whether the protocol data unit type as defined 3GPP TS 38.323 [14] provided by the lower

layers for the received packet is set to IP packet or non-IP packet, and pass the protocol data unit to the corresponding upper layer entity.

NOTE: When the PC5 DRX operation is needed based on the provided NR Tx Profile if any, the lower layers use PC5 QoS parameters and the destination layer-2 ID(s) to determine the PC5 DRX parameter values (see 3GPP TS 38.300 [12]) for reception operation over PC5 reference point.

6.2 A2X communication over Uu

6.2.1 General

This clause describes the procedures at the UE and the A2X application server, for A2X communication over Uu.

There are no additional security or privacy procedures of A2X communication over Uu beyond those specified in 3GPP TS 33.501 [21] for Uu connectivity with 5GCN.

Both IP based and non-IP based A2X communication over Uu are supported.

A2X messages carried over Uu are sent or received over unicast only in uplink, and sent or received over unicast or MBS in downlink in this release of the specification. Furthermore, A2X messages are carried over Uu using user data over user plane. For this, the UE first performs the UE-requested PDU session establishment procedure to establish user-plane resouces as specified in 3GPP TS 24.501 [6].

Procedures for A2X communication over Uu for A2X services not identified by a A2X service identifier are out of scope of the present version of the present specification.

NOTE: The upper layers are responsible for re-assembly of A2X messages and that is out of scope of 3GPP.

6.2.2 Transmission of A2X communication over Uu from UE to A2X application server

The upper layers can request the UE to send a A2X message of a A2X service identified by a A2X service identifier using A2X communication over Uu. The request from the upper layers includes:

a) the A2X message;

b) the A2X service identifier of the A2X service for the A2X message;

c) the type of data in the A2X message (IP or non-IP); and

d) if the A2X message contains non-IP data, the A2X message family (see clause 9.2) of data in the A2X message.

Upon a request from upper layers to send a A2X message of a A2X service identified by a A2X service identifier using A2X communication over Uu:

a) if the registered PLMN of the UE is not in the list of PLMNs in which the UE is configured to use A2X communication over Uu as specified in clause 5.2.7, the UE shall determine that the transmission of A2X communication over Uu from UE to A2X application server is not configured and shall not continue with the rest of the steps; and

b) if the A2X service identifier is included in the list of A2X service identifier to PDU session parameters mapping rules specified in clause 5.2.7;

then:

1) the UE shall determine the mapping rule in the list of A2X service identifier to PDU session parameters mapping rules specified in clause 5.2.7, such that the mapping rule contains the A2X service identifier provided by upper layers;

2) the UE shall consider the PDU session type, the SSC mode (if indicated in determined mapping rule), an S-NSSAI (if indicated in determined mapping rule) and a DNN (if indicated in determined mapping rule) indicated in the determined mapping rule as the UE local configuration and request information of the PDU

session via which to send a PDU according to 3GPP TS 24.526 [22]. The UE shall use the transport layer protocol, if indicated in the determined mapping rule, to transport the A2X message;

3) if the PDU session is of "IPv4", "IPv6" or "IPv4v6" PDU session type:

  i) if the A2X service identifier is included in the list of A2X service identifier to A2X application server address mapping rules as specified in clause 5.2.7, then:

    A) the UE shall discover the A2X application server address for uplink transport as described in clause 6.2.6. If the A2X application server address cannot be discovered, the UE shall determine that the transmission of A2X communication over Uu from UE to A2X application server is not possible and shall not continue with the rest of the steps;

    B) if UDP is to be used for the determined A2X application server address, the UE shall generate a UDP message as described in IETF RFC 768 [23]. In the UDP message, the UE shall include the A2X message provided by upper layers in the data octets field. The UE shall send the UDP message to the determined A2X application server address; and

    C) if TCP is to be used for the determined A2X application server address:

      1) if a TCP connection with the determined A2X application server address is not established yet, the UE shall establish a TCP connection with the determined A2X application server address; and

      2) the UE shall generate one or more TCP message(s) as described in IETF RFC 793 [24]. In the one or more TCP message(s), the UE shall include the A2X message provided by upper layers in the data octets filed. The UE shall send the one or more TCP message(s) to the determined A2X application server address via the TCP connection; and

4) if the PDU session is of "Unstructured" PDU session type and the type of data in the A2X message is non-IP, the UE shall generate a UDP message as described in IETF RFC 768 [23]. In the UDP message, the UE shall encapsulate the A2X message provided by upper layers in the data octets field. The UE shall send the UDP message to the determined A2X application server address.

6.2.3 Reception of A2X communication over Uu from UE to A2X application server

If the A2X application server is configured with one or more UDP ports for uplink transport or one or more TCP ports for bidirectional transport, of A2X message(s) of A2X service(s) identified by A2X service identifier(s) using the A2X communication over Uu as specified in clause 6.2.7:

1) if the A2X application server is configured with a UDP port for uplink transport, the A2X application server shall extract a A2X message of the A2X service from a UDP message received on a local IP address and a UDP port; and

2) if the A2X application server is configured with a TCP port for bidirectional transport, the A2X application server shall listen for incoming TCP connection(s) on a local IP address and the TCP port, shall accept the incoming TCP connection(s), shall receive one or more TCP message(s)via the accepted TCP connection(s) and shall extract a A2X message of the A2X service from the received one or more TCP message(s).

If the A2X application server is configured to handle data of "Unstructured" PDU Session type for transport of A2X message(s) of A2X service(s) identified by A2X service identifier(s) using A2X communication over Uu as specified in clause 6.2.7, the A2X application server shall receive one or more UDP message(s) as data of a point-to-point tunnel established over N6 and shall extract a A2X message and a A2X message family (if the A2X message is non-IP based) from the received UDP message.

6.2.4 Transmission of A2X communication over Uu from A2X application server to UE

The A2X application server shall be configured with a multicast IP address and one or more UDP ports for transport of the A2X communication over Uu to the UE via MBS.

The A2X application server shall be configured with UDP port(s), TCP port(s) or any combination of them for transport of the A2X communication over Uu to the UE via unicast.

If the A2X application server supports A2X messages of IP type of data and of non-IP type of data, then the A2X application server shall be configured with different UDP ports or TCP ports for A2X messages of different types of data.

If the A2X application server supports A2X messages of several A2X message families, then the A2X application server shall be configured with different UDP ports or TCP ports for A2X messages of different A2X message families.

In order to transport a A2X message of a A2X service identified by a A2X service identifier via unicast, if the A2X application server determines to use UDP for transmission of the A2X message identified by a A2X service identifier, the A2X application server shall generate a UDP message. If the A2X message is of "Unstructured" PDU Session type, then the A2X application server shall encapsulate the A2X message into IP type data. In the UDP message, the A2X application server:

a) shall set data octets field to the A2X message if the A2X message is of IP type;

a) shall set data octets field to the encapsulated IP type data if the A2X message is of "Unstructured" PDU Session type; and

c) shall set the destination IP address and the destination UDP port to the UE's IP address and the configured UDP port associated the type of data of the A2X message and the A2X message family of the data of the A2X message (in case of non-IP).

The A2X application server sends the UDP message as the user plane data to the UE.

In order to transport a A2X message of a A2X service identified by a A2X service identifier via MBS, the A2X application server shall generate a UDP message. In the UDP message, the A2X application server:

a) shall set data octets field to the A2X message; and

b) shall set the destination IP address and the destination UDP port to the configured multicast IP address and the configured UDP port associated with the type of data of the A2X message and the A2X message family of the data of the A2X message (in case of non-IP).

The A2X application server sends the UDP message as the user plane data to the UE.

In order to transport a A2X message of a A2X service identified by a A2X service identifier via unicast, if the A2X application server determines to use TCP for transmission of the A2X message identified by a A2X service identifier, the A2X application server establishes a TCP connection with the UE if no TCP connection exists, then the A2X application server shall generate one or more TCP message(s). In the one or more TCP message(s), the A2X application server:

a) shall set data octets field to the A2X message; and

b) shall set the destination IP address and the destination TCP port to the UE's IP address and the configured TCP port associated the type of data of the A2X message and the A2X message family of the data of the A2X message (in case of non-IP).

The A2X application server sends the one or more TCP message(s) as the user plane data to the UE.

6.2.5 Reception of A2X communication over Uu from A2X application server to UE

The upper layers can request the UE to receive a A2X message of a A2X service identified by a A2X service identifier using A2X communication over Uu. The request from the upper layers includes:

a) the A2X service identifier of the A2X service for the A2X message to be received;

b) the type of data in the A2X message to be received (IP or non-IP); and

c) if the A2X message to be received contains non-IP data, the A2X message family (see clause 9.2) of data in the A2X message to be received.

Upon a request from upper layers to receive a A2X message of a A2X service identified by a A2X service identifier using A2X communication over Uu, in order to receive the A2X message of the A2X service identified by the A2X service identifier via unicast:

a) if the registered PLMN of the UE is not in the list of PLMNs in which the UE is configured to use A2X communication over Uu as specified in clause 5.2.7, the UE shall determine that the transmission of A2X communication over Uu from A2X application server to UE is not configured and shall not continue with the rest of the steps; and

b) if the A2X service identifier is included in the list of A2X service identifier to PDU session parameters mapping rules specified in clause 5.2.7;

then:

1) the UE shall determine the mapping rule in the list of A2X service identifier to PDU session parameters mapping rules specified in clause 5.2.7, such that the mapping rule contains the A2X service identifier provided by upper layers;

2) the UE shall establish a PDU session with the PDU session type, the SSC mode (if indicated in determined mapping rule), an S-NSSAI (if indicated in determined mapping rule) and a DNN (if indicated in determined mapping rule) indicated in the determined mapping rule, if such PDU session does not exist yet. The UE shall use the transport layer protocol, if indicated in the determined mapping rule, to receive the A2X message;

3) if the PDU session is of "IPv4", "IPv6" or "IPv4v6" PDU session type:

    i) if the A2X service identifier is included in the list of A2X service identifier to A2X application server address mapping rules as specified in clause 5.2.7, then:

        A) the UE shall discover the A2X application server address for downlink transport as described in clause 6.2.6. If the A2X application server address cannot be discovered, the UE shall determine that the transmission of A2X communication over Uu from A2X application server to UE is not possible and shall not continue with the rest of the steps. If the A2X service identifier is not included in the list of A2X service identifier to A2X application server address mapping rules as specified in clause 5.2.7, the UE shall continue with the rest of the steps; and

        B) if UDP is to be used for the determined A2X application server address:

            1) the UE shall select the UDP port for downlink transport based on configuration parameters for A2X communication as defined in clause 5.2.7; and

            2) the UE shall listen for UDP packets over the determined UDP port, and provide the UDP packets to the upper layers if received; and

        C) if TCP is to be used for the determined A2X application server address:

            1) if a TCP connection with the determined A2X application server address is not established yet, the UE shall establish a TCP connection with the determined A2X application server address; and

            2) the UE shall listen for TCP packets over the established TCP connection, and provide the TCP packets to the upper layers if received; and

4) if the PDU session is of "Unstructured" PDU session type and the type of data in the A2X message is non-IP, the UE shall proceed as UDP is to be used for the determined A2X application server address with the exception that the A2X message is encapsulated as IP type data packets.

Upon a request from upper layers to receive a A2X message of a A2X service identified by a A2X service identifier using A2X communication over Uu, in order to receive the A2X message of the A2X service identified by the A2X service identifier via MBS:

a) if the registered PLMN of the UE is not in the list of PLMNs in which the UE is configured to use A2X communication over Uu as specified in clause 5.2.7, the UE shall determine that the transmission of A2X communication over Uu from A2X application server to the UE is not configured and shall not continue with the rest of the steps; and

b) if the A2X service is identified by a A2X service identifier:

1) the UE shall discover one or more A2X MBS configuration(s) for receiving A2X communication over Uu via MBS as described in subclause 6.2.8;

2) if the A2X MBS configuration for receiving A2X communication over Uu via MBS is discovered:

A) if the type of data in the A2X message is IP, the UE shall listen for a UDP packet:

   i) with the destination IP address set to the IP address indicated in the "c=" line applicable for the "m=" line with the application/vnd.3gpp.5gsa2x media type with the type parameter indicating IP in the SDP body of the A2X MBS configuration for receiving A2X communication over Uu using MBS; and

   ii) with the destination UDP port set to the port indicated in the "m=" line with the application/vnd.3gpp.5gsa2x media type with the type parameter indicating IP in the SDP body of the A2X MBS configuration for receiving A2X communication over Uu using MBS;

   received via an MBS radio bearer corresponding to the MBS session announcement of the A2X MBS configuration for receiving A2X communication over Uu using MBS. If several A2X MBS configurations for receiving A2X communication over Uu using MBS were discovered, the UE shall perform this action once per each discovered A2X MBS configurations for receiving A2X communication over Uu using MBS;

B) if the type of data in the A2X message is non-IP, the UE shall listen for a UDP packet:

   i) with the destination IP address set to the IP address indicated in the "c=" line applicable for the "m=" line with the application/vnd.3gpp.5gsa2x media type with:

      - the type parameter indicating non-IP; and

      - the a2x-message-family parameter indicating the A2X message family;

      in the SDP body of the A2X MBS configuration for receiving A2X communication over Uu using MBS; and

   ii) with the destination UDP port set to the port indicated in the "m=" line with the application/vnd.3gpp.5gsa2x media type with:

      - the type parameter indicating non-IP; and

      - the a2x-message-family parameter indicating the A2X message family;

      in the SDP body of the A2X MBS configuration for receiving A2X communication over Uu using MBS;

   received via an MBS radio bearer corresponding to the MBS session announcement of the A2X MBS configuration for receiving A2X communication over Uu using MBS. If several A2X MBS configurations for receiving A2X communication over Uu using MBS were discovered, the UE shall perform this action once per each discovered A2X MBS configurations for receiving A2X communication over Uu using MBS; and

C) the UE shall extract the A2X message from the data octets field of the received UDP message as described in IETF RFC 768 [23] and pass the A2X message to upper layers; and

3) if the A2X MBS configuration for receiving A2X communication over Uu using MBS is not discovered, the UE shall determine that the transport of a A2X message of a A2X service identified by a A2X service identifier via MBS is not possible and shall attempt to receive the A2X message of the A2X service identified by the A2X service identifier via unicast.

6.2.6 A2X application server discovery

Before initiating A2X communication over Uu, the UE needs to discover the A2X application server to which the A2X messages shall be sent or received.

To discover the A2X application server address for uplink transport, the UE shall proceed as follows, in priority order:

a) if the A2X service of the A2X message is identified by a A2X service identifier and this A2X service identifier is associated with a A2X application server IP address and a UDP port for uplink transport or a TCP port for bidirectional transport in the list of A2X service identifier to A2X application server address mapping rules for the serving PLMN and the geographical area in which the UE is located as specified in clause 5.2.7, the UE shall use this IP address and the UDP or TCP port for A2X communication over Uu;

b) else if the A2X service of the A2X message is identified by a A2X service identifier and this A2X service identifier is associated with a A2X application server FQDN and a UDP port for uplink transport or a TCP port for bidirectional transport in the list of A2X service identifier to A2X application server address mapping rules for the serving PLMN and the geographical area in which the UE is located as specified in clause 5.2.7, the UE shall perform DNS lookup as specified in IETF RFC 1035 [25], then use the resulting IP address and the UDP or TCP port for A2X communication over Uu;

c) else if the A2X service of the A2X message is identified by a A2X service identifier and this A2X service identifier is associated with a A2X application server IP address and a UDP port for uplink transport or a TCP port for bidirectional transport in the list of A2X service identifier to A2X application server address mapping rules for the serving PLMN as specified in clause 5.2.7, the UE shall use this IP address and the UDP or TCP port for A2X communication over Uu;

d) else if the A2X service of the A2X message is identified by a A2X service identifier and this A2X service identifier is associated with a A2X application server FQDN and a UDP port for uplink transport or a TCP port for bidirectional transport in the list of A2X service identifier to A2X application server address mapping rules for the serving PLMN as specified in clause 5.2.7, the UE shall perform DNS lookup as specified in IETF RFC 1035 [25], then use the resulting IP address and the UDP or TCP port for A2X communication over Uu;

e) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains IP data, and the default A2X application server address applicable for the serving PLMN, the geographical area in which the UE is located and the IP type of data as specified in clause 5.2.7 is configured and contains an IP address and a UDP port for uplink transport or a TCP port for bidirectional transport, then the UE shall use the IP address and the UDP or TCP port for A2X communication over Uu;

f) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains IP data, and the default A2X application server address applicable for the serving PLMN, the geographical area in which the UE is located and the IP type of data as specified in clause 5.2.7 is configured and contains an FQDN and a UDP port for uplink transport or a TCP port for bidirectional transport, then the UE shall perform DNS lookup of the FQDN as specified in IETF RFC 1035 [25], and shall use the resulting IP address and the UDP or TCP port for A2X communication over Uu;

g) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains IP data, and the default A2X application server address applicable for the serving PLMN and the IP type of data as specified in clause 5.2.7 is configured and contains an IP address and a UDP port for uplink transport or a TCP port for bidirectional transport, then the UE shall use the IP address and the UDP or TCP port for A2X communication over Uu;

h) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains IP data, and the default A2X application server address applicable for the serving PLMN and the IP type of data as specified in clause 5.2.7 is configured and contains an FQDN and a UDP port for uplink transport or a TCP port for bidirectional transport, then the UE shall perform DNS lookup of the FQDN as specified in IETF RFC 1035 [25], and shall use the resulting IP address and the UDP or TCP port for A2X communication over Uu;

i) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains non-IP data, and the default A2X application server address applicable for the serving PLMN, the geographical area in which the UE is located and the A2X message family of the non-IP data as specified in clause 5.2.7 is configured and contains an IP address and a UDP port for uplink transport or a TCP port for bidirectional transport, then the UE shall use the IP address and the UDP or TCP port for A2X communication over Uu;

j) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains non-IP data, and the default A2X application server address applicable for the serving PLMN, the geographical area in which the UE is located and the A2X message family of the non-IP data as specified in clause 5.2.7 is configured and contains an FQDN and a UDP port for uplink transport or a TCP port for bidirectional transport, then the UE shall perform DNS lookup of the FQDN as specified in IETF RFC 1035 [25], and shall use the resulting IP address and the UDP or TCP port for A2X communication over Uu;

k) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains non-IP data, and the default A2X application server address applicable for the serving PLMN and the A2X message family of the non-IP data as specified in clause 5.2.7 is configured and contains an IP address and a UDP port for uplink transport or a TCP port for bidirectional transport, then the UE shall use the IP address and the UDP or TCP port for A2X communication over Uu;

l) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains non-IP data, and the default A2X application server address applicable for the serving PLMN and the A2X message family of the non-IP data as specified in clause 5.2.7 is configured and contains an FQDN and a UDP port for uplink transport or a TCP port for bidirectional transport, then the UE shall perform DNS lookup of the FQDN as specified in IETF RFC 1035 [25], and shall use the resulting IP address and the UDP or TCP port for A2X communication over Uu;

m) else if the A2X service of the A2X message is not identified by a A2X service identifier and the UE is configured with a A2X application server IP address for the serving PLMN and the geographical area in which the UE is located as specified in clause 5.2.7, the UE shall use this IP address for A2X communication over Uu;

n) else if the A2X service of the A2X message is not identified by a A2X service identifier and the UE is configured with a A2X application server FQDN for the serving PLMN and the geographical area in which the UE is located as specified in clause 5.2.7, the UE shall perform DNS lookup as specified in IETF RFC 1035 [25], then use the resulting IP address for A2X communication over Uu;

o) else if the A2X service of the A2X message is not identified by a A2X service identifier and the UE is configured with a A2X application server IP address for the serving PLMN as specified in clause 5.2.7, the UE shall use this IP address for A2X communication over Uu; and

p) else if the A2X service of the A2X message is not identified by a A2X service identifier and the UE is configured with a A2X application server FQDN for the serving PLMN as specified in clause 5.2.7, the UE shall perform DNS lookup as specified in IETF RFC 1035 [25], then use the resulting IP address for A2X communication over Uu.

NOTE: It is out of scope of the present specification to define how the UE can locate itself in a specific geographical area. When the UE is in coverage of a 3GPP RAT it can for example use information derived from the serving PLMN. When the UE is not in coverage of a 3GPP RAT it can use other techniques.

To discover the A2X application server address for downlink transport, the UE shall proceed as follows, in priority order:

a) if the A2X service of the A2X message is identified by a A2X service identifier and this A2X service identifier is associated with a A2X application server IP address and a UDP port for downlink transport or a TCP port for bidirectional transport in the list of A2X service identifier to A2X application server address mapping rules for the serving PLMN and the geographical area in which the UE is located as specified in clause 5.2.7, the UE shall use this IP address and the UDP or TCP port for A2X communication over Uu;

b) else if the A2X service of the A2X message is identified by a A2X service identifier and this A2X service identifier is associated with a A2X application server FQDN and a UDP port for downlink transport or a TCP port for bidirectional transport in the list of A2X service identifier to A2X application server address mapping rules for the serving PLMN and the geographical area in which the UE is located as specified in clause 5.2.7, the UE shall perform DNS lookup as specified in IETF RFC 1035 [25], then use the resulting IP address and the UDP or TCP port for A2X communication over Uu;

c) else if the A2X service of the A2X message is identified by a A2X service identifier and this A2X service identifier is associated with a A2X application server IP address and a UDP port for downlink transport or a TCP port for bidirectional transport in the list of A2X service identifier to A2X application server address mapping rules for the serving PLMN as specified in clause 5.2.7, the UE shall use this IP address and the UDP or TCP port for A2X communication over Uu;

d) else if the A2X service of the A2X message is identified by a A2X service identifier and this A2X service identifier is associated with a A2X application server FQDN and a UDP port for downlink transport or a TCP port for bidirectional transport in the list of A2X service identifier to A2X application server address mapping rules for the serving PLMN as specified in clause 5.2.7, the UE shall perform DNS lookup as specified in IETF RFC 1035 [25], then use the resulting IP address and the UDP or TCP port for A2X communication over Uu;

e) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains IP data, and the default A2X application server address applicable for the serving PLMN, the geographical area in which the UE is located and the IP type of data as specified in clause 5.2.7 is configured and contains an IP address and a UDP port for downlink transport or a TCP port for bidirectional transport, then the UE shall use the IP address and the UDP or TCP port for A2X communication over Uu;

f) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains IP data, and the default A2X application server address applicable for the serving PLMN, the geographical area in which the UE is located and the IP type of data as specified in clause 5.2.7 is configured and contains an FQDN and a UDP port for downlink transport or a TCP port for bidirectional transport, then the UE shall perform DNS lookup of the FQDN as specified in IETF RFC 1035 [25], and shall use the resulting IP address and the UDP or TCP port for A2X communication over Uu;

g) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains IP data, and the default A2X application server address applicable for the serving PLMN and the IP type of data as specified in clause 5.2.7 is configured and contains an IP address and a UDP port for downlink transport or a TCP port for bidirectional transport, then the UE shall use the IP address and the UDP or TCP port for A2X communication over Uu;

h) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains IP data, and the default A2X application server address applicable for the serving PLMN and the IP type of data as specified in clause 5.2.7 is configured and contains an FQDN and a UDP port for downlink transport or a TCP port for bidirectional transport, then the UE shall perform DNS lookup of the FQDN as specified in IETF RFC 1035 [25], and shall use the resulting IP address and the UDP or TCP port for A2X communication over Uu;

i) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains non-IP data, and the default A2X application server address applicable for the serving PLMN, the geographical area in which the UE is located and the A2X message family of the non-IP data as specified in clause 5.2.7 is configured and contains an IP address and a UDP port for downlink transport or a TCP port for bidirectional transport, then the UE shall use the IP address and the UDP or TCP port for A2X communication over Uu;

j) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains non-IP data, and the default A2X application server address applicable for the serving PLMN, the geographical area in which the UE is located and the A2X message family of the non-IP data as specified in clause 5.2.7 is configured and contains an FQDN and a UDP port for downlink transport or a TCP port for bidirectional transport, then the UE shall perform DNS lookup of the FQDN as specified in IETF RFC 1035 [25], and shall use the resulting IP address and the UDP or TCP port for A2X communication over Uu;

k) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains non-IP data, and the default A2X application server address applicable for the serving PLMN and the A2X message family of the non-IP data as specified in clause 5.2.7 is configured and contains an IP address and a UDP port for downlink transport or a TCP port for bidirectional transport, then the UE shall use the IP address and the UDP or TCP port for A2X communication over Uu; and

l) else if the A2X service of the A2X message is identified by a A2X service identifier, the A2X message contains non-IP data, and the default A2X application server address applicable for the serving PLMN and the A2X message family of the non-IP data as specified in clause 5.2.7 is configured and contains an FQDN and a UDP port for downlink transport or a TCP port for bidirectional transport, then the UE shall perform DNS lookup of the FQDN as specified in IETF RFC 1035 [25], and shall use the resulting IP address and the UDP or TCP port for A2X communication over Uu.

If multiple A2X application servers are discovered, the A2X application server to be used is selected by the A2X application layer.

The UE shall perform A2X application server discovery again when the UE changes its registered PLMN.

If the A2X application server used by the UE is associated with a particular geographical area, the UE shall perform A2X application server discovery again when the UE moves out of that geographical area.

6.2.6.1 A2X application server discovery using MBS

6.2.6.1.1 General

The purpose of the A2X application server discovery using MBS procedure is to allow the UE to receive the A2X application server information via MBS.

The UE shall only initiate the A2X application server discovery using MBS procedure if:

   a) the UE is configured to use A2X communication over Uu in the serving PLMN as specified in clause 5.2.7; and

   b) the serving PLMN is associated with a A2X AS MBS configuration for receiving A2X application server information using MBS in the configuration parameters for A2X communication over Uu provisioned to the UE as specified in subclause 5.2.7.

The UE should use the A2X application server information received via MBS for transmission of A2X communication over Uu via unicast only when the UE is registered in the PLMN from which this A2X application server information was received.

6.2.6.1.2 Procedure for A2X application server discovery using MBS

The UE shall proceed as follows:

   a) the UE shall start listening to the MBS radio bearer corresponding to the MBS session announcement for receiving A2X application server information via MBS of the A2X AS MBS configuration for receiving A2X application server information using MBS associated with the serving PLMN in the configuration parameters for A2X communication over Uu provisioned to the UE as specified in subclause 5.2.7

   b) the UE shall use the IP multicast address and port included in the A2X AS MBS configuration SDP body of the A2X AS MBS configuration for receiving A2X application server information using MBS associated with the serving PLMN in the configuration parameters for A2X communication over Uu provisioned to the UE as specified in subclause 5.2.7 to receive the A2X local service information; and

   Editor's note: The details of the encoding of the A2X AS MBS configuration for receiving A2X local service information are FFS.

   c) If the A2X service identifier of the A2X service requesting A2X communication over Uu maps to a A2X application server FQDN in the A2X application server information obtained at step 2, the UE shall perform DNS lookup as specified in IETF RFC 1035 [25] to resolve the IP address(es) of the A2X application server.

6.2.7 A2X application server configuration

For transport of A2X message(s) of A2X service(s) identified by A2X service identifier(s) using A2X communication over Uu, the A2X application server shall be configured:

   a) with one or more UDP ports for uplink transport;

   b) with one or more UDP ports for downlink transport;

   c) with one or more TCP ports for bidirectional transport;

   d) to handle data of "Unstructured" PDU Session type; or

   e) any combination of the above.

If the A2X application server is configured with one or more UDP ports for uplink transport of A2X message(s) of a A2X service(s) identified by A2X service identifier(s) using A2X communication over Uu:

   1) if the A2X application server supports A2X messages of IP type of data and of non-IP type of data, then the A2X application server shall be configured with different UDP ports for A2X messages of different types of data; and

   2) if the A2X application server supports A2X messages of several A2X message families, then the A2X application server shall be configured with different UDP ports for A2X messages of different A2X message families.

6.2.8 A2X MBS parameter discovery

Before receiving a A2X communication over Uu using MBS bearer, the UE needs to discover the A2X MBS parameters via which the A2X communication is to be received.

The UE shall proceed as follows, in priority order:

a) if the A2X message to be received is of IP type of data, the A2X service of the A2X message to be received is identified by a A2X service identifier, and this A2X service identifier is associated with a A2X MBS configuration for receiving A2X communication over Uu using MBS in the list of A2X services authorized for A2X communication over Uu for the registered PLMN of the UE and the SDP body of the A2X MBS configuration for receiving A2X communication over Uu using MBS contains a "m=" line of the application/vnd.3gpp.5gsa2x media type with the type parameter indicating IP, the UE shall use the A2X MBS configuration for receiving A2X communication over Uu using MBS. If several such A2X MBS configurations are configured, the UE shall use all such A2X MBS configurations for receiving A2X communication over Uu using MBS;

b) else if the A2X message to be received is of non-IP type of data, the A2X message to be received is of A2X message family, the A2X service of the A2X message to be received is identified by a A2X service identifier, and this A2X service identifier is associated with a A2X MBS configuration for receiving A2X communication over Uu using MBS in the list of A2X services authorized for A2X communication over Uu for the registered PLMN of the UE and the SDP body of the A2X MBS configuration for receiving A2X communication over Uu using MBS contains a "m=" line of the application/vnd.3gpp.5gsa2x media type with:

1) the type parameter indicating non-IP; and

2) the a2x-message-family parameter indicating the A2X message family;

the UE shall use the A2X MBS configuration for receiving A2X communication over Uu using MBS. If several such A2X MBS configurations are configured, the UE shall use all such A2X MBS configurations for receiving A2X communication over Uu using MBS;

c) else if the A2X message to be received is of IP type of data, the A2X service of the A2X message to be received is identified by a A2X service identifier, and the default A2X MBS configuration for receiving A2X communication over Uu using MBS as specified in subclause 5.2.7 is configured and the SDP body of the A2X MBS configuration for receiving A2X communication over Uu using MBS contains a "m=" line of the application/vnd.3gpp.5gsa2x media type with the type parameter indicating IP, the UE shall use the default A2X MBS configuration for receiving A2X communication over Uu using MBS. If several such A2X MBS configurations are configured, the UE shall use all such A2X MBS configurations for receiving A2X communication over Uu using MBS;

d) else if the A2X message to be received is of non-IP type of data, the A2X message to be received is of A2X message family, the A2X service of the A2X message to be received is identified by a A2X service identifier, and the default A2X MBS configuration for receiving A2X communication over Uu using MBS as specified in subclause 5.2.7 is configured and the SDP body of the A2X MBS configuration for receiving A2X communication over Uu using MBS contains a "m=" line of the application/vnd.3gpp.5gsa2x media type with:

1) the type parameter indicating non-IP; and

2) the a2x-message-family parameter indicating the A2X message family;

the UE shall use the default A2X MBS configuration for receiving A2X communication over Uu using MBS. If several such A2X MBS configurations are configured, the UE shall use all such A2X MBS configurations for receiving A2X communication over Uu using MBS; and

e) else if the A2X service of the A2X message to be received is not identified by a A2X service identifier, and the A2X MBS configuration for receiving A2X communication over Uu using MBS as specified in subclause 5.2.7 is configured, the UE shall use the A2X MBS configuration for receiving A2X communication over Uu using MBS. If several such A2X MBS configurations are configured, the UE shall use all such A2X MBS configurations for receiving A2X communication over Uu using MBS.

7 Broadcast remote ID (BRID)

7.1 General

This clause describes the procedures:

- at the UE, and between UEs, for broadcast remote ID (BRID) using A2X communication over PC5 as specified in clause 6.1; and

- between the UE and the A2X AS, for broadcast remote ID (BRID) using A2X communication over Uu as specified in clause 6.2.

The broadcast mode A2X communication is used for BRID over PC5.

BRID over PC5 is supported for both UAV UEs that register to the MNO network(s) and UAVs that operate out of coverage. For UAVs out of coverage or without UICC, the use of A2X communications over PC5 for BRID can be authorized by configuration parameters for A2X communication over PC5 as specified in clause 5.2.3, provided via pre-configuration or A2X1, as specified in clause 5.2.2.

The content of the messages for BRID is defined according to regional regulations for BRID (e.g. message set of ASTM F3411 19 [17] or ASD-STAN prEN 4709-002 P1 [18]) and optionally according to regional mean of compliance documents.

7.2 Procedures

The UE performs broadcast mode A2X communication over PC5 as specified in clause 6.1.3 with following clarifications:

- A2X service identifier of the A2X service is set to the A2X service identifier for BRID; and

- the A2X message includes the message for BRID.

The UE and the A2X AS perform A2X communication over Uu as specified in clause 6.2 with the following clarifications:

- A2X service identifier of the A2X service is set to the A2X service identifier for BRID;

- the A2X message includes the message for BRID; and

- messages for BRID are transported using unicast in uplink, and MBS in downlink.

    NOTE: The A2X service identifier for BRID and the message for BRID are determined by the upper layers.

8 Direct detect and avoid (DDAA) over PC5

8.1 General

This clause describes the procedures at the UE, and between UEs, for direct detect and avoid (DDAA) using A2X communication over PC5 as specified in clause 6.1. Both the unicast mode A2X communication over NR-PC5 and the broadcast mode A2X communication is supported for DDAA.

DDAA over PC5 is supported for both UAV UEs that register to the MNO network(s) and UAVs that operate out of coverage. For UAVs out of coverage or without UICC, the use of A2X communications over PC5 for DDAA can be authorized by configuration parameters for A2X communication over PC5 as specified in clause 5.2.3, provided via pre-configuration or A2X1, as specified in clause 5.2.2.

The content of the messages for DDAA are defined according to the regional regulations for DAA and is out of scope of 3GPP.

8.2   Procedures

The initiating UE shall meet the following pre-conditions before initiating this procedure:

a) a request from upper layers to transmit the packet for DDAA including;

i) A2X service identifier(s) for DDAA;

ii) the communication mode over PC5 for DAA deconfliction whether unicast mode or broadcast mode; and

iii) the application layer packet for DDAA.

NOTE 1: The content of the DAA payload is out of scope of this specification.

The initiating UE identifies the A2X policy for DDAA based on the A2X service identifier(s) requested from the upper layers. The initiating UE selects a communication mode for DAA deconfliction based on the A2X policy for DDAA and the input received from the upper layers. If the communication mode for DAA deconfliction in the A2X policy is different with the one requested by the upper layers, the UE shall follow the A2X policy for DDAA.

NOTE 2: If there is no corresponding communication mode for DAA deconfliction to the A2X service identifier(s) in the A2X policy for DDAA, it is up to UE implementation to select the communication mode for DAA deconfliction e.g., the UE follows the request from the upper layers, or the UE can try both communication modes if no explicit request from the upper layers.

If the unicast communication mode is selected for DAA deconfliction, both the initiating UE and the target UE(s) follow the procedures of unicast mode A2X communication over PC5 defined in clause 6.1.2. The initiating UE may trigger A2X PC5 unicast link release procedure after the successful traffic conflict resolution.

If the broadcast communication mode is selected for DAA deconfliction, both the initiating UE and the target UE(s) UE follow the procedures for broadcast mode A2X communication over PC5 defined in the clause 6.1.3.

8A   Ground based detect and avoid for an area (GBDAAA)

8A.1   General

This clause describes the procedures between area airspace manager (AAM) UE and an UAV UE for ground based detect and avoid for an area (GBDAAA) as specified in 3GPP TS 23.256 [3].

Each discovered UAV UE is identified by a remote ID.

NOTE 1: AAM UE discovery of a UAV UE in the area is out of scope of 3GPP.

The unicast mode A2X communication over NR-PC5 is used for GBDAAA.

GBDAAA is supported for both UAV UEs that register to the MNO network(s) and UAVs that operate out of coverage. For UAVs out of coverage or without UICC, the use of A2X communications over PC5 for GBDAAA can be authorized by configuration parameters for A2X communication over PC5 as specified in clause 5.2.3, provided via pre-configuration or A2X1 as specified in clause 5.2.2.

8A.2   Procedures

The AAM UE performs unicast mode A2X communication over NR-PC5 as specified in clause 6.1.2 with the UAV UE with following clarifications:

a) the A2X service identifier of the A2X service shall be set to the A2X service identifier for GBDAAA;

b) the A2X message shall include the message for GBDAAA;

NOTE 1: The A2X service identifier for GBDAAA and the message for GBDAAA are determined by the upper layers.

c) for A2X PC5 unicast link establishment procedure as specified in clause 6.1.2.2, the Target user info IE of the A2X DIRECT LINK ESTABLISHMENT REQUEST message shall be set to the remote ID of a discovered UAV UE; and

d) for A2X PC5 unicast link establishment procedure as specified in clause 6.1.2.2, after the A2X DIRECT LINK ESTABLISHMENT REQUEST message is generated, the destination layer-2 ID used for unicast initial signalling passed by the UE to the lower layers shall be the default destination layer-2 ID as configured in the UE.

NOTE 2: The content of the messages for GBDAAA is defined according to the regional regulations for GBDAAA and is out of scope of 3GPP.

9 Direct C2 communication over PC5

9.1 General

A UAV can establish direct C2 communication with a UAV-C as specified in 3GPP TS 23.256 [3]. In this release of specification, only NR-PC5 is supported for the direct C2 communication.

This clause describes the procedures for direct C2 communication including:

a) C2 authorization procedure for direct C2 communication (see clause 9.2.1); and

b) direct C2 communication procedures over NR-PC5 (see clause 9.2.2);

9.2 Procedures

9.2.1 C2 authorization procedure for direct C2 communication

For a UAV supporting direct C2 communication, in order to request C2 authorization for direct C2 communication to the USS, the UAV provides the request for authorization of direct C2 communication to the USS.

NOTE 1: In 5GS, the request for authorization of direct C2 communication is included in the C2 authorization payload in the Service-level-AA container IE which is defined in 3GPP TS 24.501 [7].

NOTE 2: In EPS, the request for authorization of direct C2 communication is included in the C2 authorization payload in the service-level-AA payload parameter which is defined in 3GPP TS 24.301 [6].

NOTE 3: Direct C2 communication over NR-PC5 is supported for both UAV UEs that register to the MNO network(s) and UAVs that operate out of coverage. For UAVs out of coverage, or not capable of 3GPP network connection, direct C2 communication can be authorized by configuration parameters for direct C2 communication over PC5 as specified in clause 5.2.6, provided via application level pre-configuration or A2X1, as specified in clause 5.2.2.

9.2.2 Direct C2 communication procedures over NR-PC5

The procedures for unicast mode A2X communication over NR-PC5 as specified in clause 6.1.2 are used for the direct C2 communication procedures with clarifications and differences specified as follows:

a) A2X service identifier received from upper layer is for direct C2 communication;

b) either UAV or UAV-C can initiate procedures for unicast mode A2X communication over NR-PC5, except for A2X PC5 unicast link establishment procedure as specified in clause 6.1.2.2,

1) "initiating UE" refers to UAV only; and

2) "target UE" refers to UAV-C only; and

c) for A2X PC5 unicast link establishment procedure as specified in clause 6.1.2.2, after the A2X DIRECT LINK ESTABLISHMENT REQUEST message is generated, the destination layer-2 ID used for unicast initial signalling passed by the UAV to the lower layers shall be the default destination layer-2 ID as configured in the UAV.

In this release of the specification, only unicast communication mode over NR-PC5 is supported for direct C2 communication.

10 Handling of unknown, unforeseen, and erroneous PC5 signalling protocol data

10.1 General

The procedures specified in clause 6.1 apply to those messages which pass the checks described in clause 10.

Clause 10 also specifies procedures for the handling of unknown, unforeseen, and erroneous PC5 signalling protocol data by the receiving entity. These procedures are called "error handling procedures", but in addition to providing recovery mechanisms for error situations they define a compatibility mechanism for future extensions of the PC5 signalling protocol.

Clauses 10.1 to 10.7 shall be applied in order of precedence.

Detailed error handling procedures in the UE are implementation dependent and may vary. However, when extensions of PC5 signalling protocol are developed, UEs will be assumed to have the error handling which is indicated in this clause as mandatory ("shall") and that is indicated as strongly recommended ("should").

Also, the error handling of the UE is only considered as mandatory or strongly recommended when certain thresholds for errors are not reached during a dedicated connection.

For definition of semantical and syntactical errors see 3GPP TS 24.007 [19], clause 11.4.2.

10.2 Message too short or too long

10.2.1 Message too short

When a message is received that is too short to contain a complete message type information element, that message shall be ignored, cf. 3GPP TS 24.007 [19].

10.2.2 Message too long

The maximum size of a PC5 signalling message is 65535 octets.

10.3 Unknown or unforeseen message type

If the UE receives a PC5 signalling message with message type not defined for the PC5 signalling protocol or not implemented by the receiver, it shall ignore the PC5 signalling message.

NOTE: A message type not defined for the PC5 signalling protocol in the given direction is regarded by the receiver as a message type not defined for the PC5 signalling protocol, see 3GPP TS 24.007 [19].

If the UE receives a message not compatible with the PC5 signalling protocol state, the UE shall ignore the PC5 signalling message.

10.4 Non-semantical mandatory information element errors

When on receipt of a message,

   a) an "imperative message part" error; or

   b) a "missing mandatory IE" error

is diagnosed or when a message containing:

   a) a syntactically incorrect mandatory IE;

   b) an IE unknown in the message, but encoded as "comprehension required" (see 3GPP TS 24.007 [19]); or

   c) an out of sequence IE encoded as "comprehension required" (see 3GPP TS 24.007 [19]) is received,

the UE shall ignore the PC5 signalling message.

10.5 Unknown and unforeseen IEs in the non-imperative message part

10.5.1 IEIs unknown in the message

The UE shall ignore all IEs unknown in a message which are not encoded as "comprehension required" (see 3GPP TS 24.007 [19]).

10.5.2 Out of sequence IEs

The UE shall ignore all out of sequence IEs in a message which are not encoded as "comprehension required" (see 3GPP TS 24.007 [19]).

10.5.3 Repeated IEs

If an information element with format T, TV, TLV, or TLV-E is repeated in a message in which repetition of the information element is not specified in clause 12.3, the UE shall handle only the contents of the information element appearing first and shall ignore all subsequent repetitions of the information element. When repetition of information elements is specified, the UE shall handle only the contents of specified repeated information elements. If the limit on repetition of information elements is exceeded, the UE shall handle the contents of information elements appearing first up to the limit of repetitions and shall ignore all subsequent repetitions of the information element.

10.6 Non-imperative message part errors

10.6.1 General

This category includes:

   a) syntactically incorrect optional IEs; and

   b) conditional IE errors.

10.6.2 Syntactically incorrect optional IEs

The UE shall treat all optional IEs that are syntactically incorrect in a message as not present in the message.

10.6.3 Conditional IE errors

When upon receipt of a PC5 signalling message the UE diagnoses a "missing conditional IE" error or an "unexpected conditional IE" error, or when it receives a PC5 signalling message containing at least one syntactically incorrect conditional IE, the UE shall ignore the message.

10.7 Messages with semantically incorrect contents

When a message with semantically incorrect contents is received, the UE shall perform the foreseen reactions of the procedural part of clause 6.1. If, however no such reactions are specified, the UE shall ignore the message.

11 Message functional definition and contents

11.1 Overview

This clause contains the definition and contents of the messages used in the procedures described in the present document.

11.2 A2X communication over PC5 signalling messages

11.2.1 A2X Direct link establishment request

11.2.1.1 Message definition

This message is sent by a UE to another peer UE to establish a direct link. See table 11.2.1.1.1.

    Message type: A2X DIRECT LINK ESTABLISHMENT REQUEST

    Significance: dual

    Direction: UE to peer UE

Table 11.2.1.1.1: A2X DIRECT LINK ESTABLISHMENT REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK ESTABLISHMENT REQUEST message identity	A2X PC5 signalling message type 12.3.1	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	A2X service identifiers	A2X service identifier 12.3.3	M	LV	5-253
	Source user info	Application layer ID 12.3.4	M	LV	3-253
	UE security capabilities	UE security capabilities 12.3.14	M	LV	3-9
	UE A2X PC5 unicast signalling security policy	UE PC5 unicast signalling security policy 12.3.15	M	V	1
74	Key establishment information container	Key establishment information container 12.3.25	O	TLV-E	4-n
53	Nonce_1	Nonce 12.3.13	O	TV	17
54	MSB of $K_{NRP\text{-}sess}$ ID	MSB of $K_{NRP\text{-}sess}$ ID 12.3.16	O	TV	2
28	Target user info	Application layer ID 12.3.4	O	TLV	4-254
52	K_{NRP} ID	K_{NRP} ID 12.3.17	O	TV	5

11.2.1.2 Target user info

The UE shall include this IE if it has received the target UE's application layer ID from upper layers or if the destination layer-2 ID is the unicast layer-2 ID of target UE.

11.2.1.3 Key establishment information container

The UE shall include this IE if the UE A2X PC5 unicast signalling security policy is set to "signalling integrity protection required" or "signalling integrity protection preferred".

11.2.1.4 Nonce_1

The UE shall include this IE if the UE A2X PC5 unicast signalling security policy is set to "signalling integrity protection required" or "signalling integrity protection preferred".

11.2.1.5 MSB of $K_{NRP\text{-}sess}$ ID

The UE shall include this IE if the UE A2X PC5 unicast signalling security policy is set to "signalling integrity protection required" or "signalling integrity protection preferred".

11.2.1.6 K_{NRP} ID

The UE may include this IE if it has an existing K_{NRP} for the target UE.

11.2.2 A2X Direct link establishment accept

11.2.2.1 Message definition

This message is sent by a UE to another peer UE to accept the received A2X DIRECT LINK ESTABLISHMENT REQUEST message. See table 11.2.2.1.1.

Message type: A2X DIRECT LINK ESTABLISHMENT ACCEPT

Significance: dual

Direction: UE to peer UE

Table 11.2.2.1.1: A2X DIRECT LINK ESTABLISHMENT ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK ESTABLISHMENT ACCEPT message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	Source user info	Application layer ID 12.3.4	M	LV	3-253
	QoS flow descriptions	PC5 QoS flow descriptions 12.3.5	M	LV-E	5-65537
	Configuration of UE A2X PC5 unicast user plane security protection	Configuration of UE PC5 unicast user plane security protection 12.3.23	M	V	1
57	IP address configuration	IP address configuration 12.3.6	O	TV	2
58	Link local IPv6 address	Link local IPv6 address 12.3.7	O	TV	17

11.2.2.2   IP address configuration

The UE shall include this IE if IP communication is used.

11.2.2.3   Link local IPv6 address

The UE shall include this IE if IP communication is used and the IP address configuration is set to "IPv6 address allocation not supported".

11.2.3   A2X Direct link establishment reject

11.2.3.1   Message definition

This message is sent by the UE to another peer UE to indicate that the A2X link establishment request is not accepted. See table 11.2.3.1.1.

Message type: A2X DIRECT LINK ESTABLISHMENT REJECT

Significance: dual

Direction: UE to peer UE

Table 11.2.3.1.1: A2X DIRECT LINK ESTABLISHMENT REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK ESTABLISHMENT REJECT message identity	A2X PC5 signalling message type 12.3.1	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	PC5 signalling protocol cause	PC5 signalling protocol cause 12.3.9	M	V	1

11.2.4   A2X Direct link modification request

11.2.4.1   Message definition

This message is sent by the UE to another peer UE to initiate the A2X direct link modification procedure. See table 11.2.4.1.1.

Message type: A2X DIRECT LINK MODIFICATION REQUEST

Significance: dual

Direction: UE to peer UE

Table 11.2.4.1.1: A2X DIRECT LINK MODIFICATION REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK MODIFICATION REQUEST message identity	A2X PC5 signalling message type 12.3.1	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	Link modification operation code	Link modification operation code 12.3.8	M	V	1
	QoS flow descriptions	PC5 QoS flow descriptions 12.3.5	M	LV-E	5-65537

11.2.5   A2X Direct link modification accept

11.2.5.1   Message definition

This message is sent by the UE to another peer UE to indicate that the A2X link modification request is accepted. See table 11.2.5.1.1

Message type: A2X DIRECT LINK MODIFICATION ACCEPT

Significance: dual

Direction: UE to peer UE

Table 11.2.5.1.1: A2X DIRECT LINK MODIFICATION ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK MODIFICATION ACCEPT message identity	A2X PC5 signalling message type 12.3.1	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
79	QoS flow descriptions	PC5 QoS flow descriptions 12.3.5	O	TLV-E	6-65538

11.2.5.2   QoS flow descriptions

The UE shall include this IE if the PC5 unicast link modification procedure is to:

a) add new PC5 QoS flow(s) to the existing PC5 unicast link;

b) modify PC5 QoS parameters of the existing PC5 QoS flow(s);

c) associate new A2X service(s) with existing PC5 QoS flow(s); or

d) remove A2X service(s) from existing PC5 QoS flow(s).

11.2.6   A2X Direct link modification reject

11.2.6.1   Message definition

This message is sent by the UE to another peer UE to indicate that the A2X link modification request is not accepted. See table 11.2.6.1.1.

Message type: A2X DIRECT LINK MODIFICATION REJECT

Significance: dual

Direction: UE to peer UE

Table 11.2.6.1.1: A2X DIRECT LINK MODIFICATION REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK MODIFICATION REJECT message identity	A2X PC5 signalling message type 12.3.1	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	PC5 signalling protocol cause	PC5 signalling protocol cause 12.3.9	M	V	1

11.2.7   A2X Direct link release request

11.2.7.1   Message definition

This message is sent by the UE to another peer UE to initiate the A2X direct link release procedure. See table 11.2.7.1.1.

Message type: A2X DIRECT LINK RELEASE REQUEST

Significance: dual

Direction: UE to peer UE

Table 11.2.7.1.1: A2X DIRECT LINK RELEASE REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK RELEASE REQUEST message identity	A2X PC5 signalling message type 12.3.1	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	PC5 signalling protocol cause	PC5 signalling protocol cause 12.3.9	M	V	1
	MSBs of K_{NRP} ID	MSBs of K_{NRP} ID 12.3.20	M	V	2

11.2.8 A2X Direct link release accept

11.2.8.1 Message definition

This message is sent by the UE to another peer UE to indicate that the A2X link release request is accepted. See table 11.2.8.1.

Message type: A2X DIRECT LINK RELEASE ACCEPT

Significance: dual

Direction: UE to peer UE

Table 11.2.8.1: A2X DIRECT LINK RELEASE ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT_LINK_RELEASE ACCEPT message identity	A2X PC5 signalling message type 12.3.1	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	LSBs of K_{NRP} ID	LSBs of K_{NRP} ID 12.3.21	M	V	2

11.2.9 A2X Direct link identifier update request

11.2.9.1 Message definition

This message is sent by a UE to another peer UE to initiate the A2X direct link identifier procedure. See table 11.2.9.1.1.

Message type: A2X DIRECT LINK IDENTIFIER UPDATE REQUEST

Significance: dual

Direction: UE to peer UE

Table 11.2.9.1.1: A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message identity	A2X PC5 signalling message type 12.3.1	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	MSB of $K_{NRP-sess}$ ID	MSB of $K_{NRP-sess}$ ID 12.3.16	M	V	1
	Source layer-2 ID	Layer-2 ID 12.3.12	M	V	3
57	Source user info	Application layer ID 12.3.4	O	TLV	4-254
58	Source link local IPv6 address	Link local IPv6 address 12.3.7	O	TV	17

11.2.9.2 Source user info

This IE is included when the initiating UE receives a new application layer ID.

11.2.9.3 Source link local IPv6 address

This IE is included when the link local IPv6 address changes at the initiating UE.

11.2.10　A2X Direct link identifier update accept

11.2.10.1　Message definition

This message is sent by the UE to another peer UE to indicate that the A2X link identifier update request is accepted. See table 11.2.10.1.1.

Message type:　A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT

Significance: dual

Direction: UE to peer UE

Table 11.2.10.1.1: A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message identity	A2X PC5 signalling message type 12.3.1	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	LSB of $K_{NRP-sess}$ ID	LSB of $K_{NRP-sess}$ ID 12.3.19	M	V	1
	MSB of $K_{NRP-sess}$ ID	MSB of $K_{NRP-sess}$ ID 12.3.16	M	V	1
	Source layer-2 ID	Layer-2 ID 12.3.12	M	V	3
	Target layer-2 ID	Layer-2 ID 12.3.12	M	V	3
28	Target user info	Application layer ID 12.3.4	O	TLV	4-254
59	Target link local IPv6 address	Link local IPv6 address 12.3.7	O	TV	17
57	Source user info	Application layer ID 12.3.4	O	TLV	4-254
58	Source link local IPv6 address	Link local IPv6 address 12.3.7	O	TV	17

11.2.10.2　Target user info

This IE is included if the target UE receives the Source user info IE in the A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message.

11.2.10.3　Target link local IPv6 address

This IE is included if the target UE receives the Source link local IPv6 address IE in the A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message.

11.2.10.4　Source user info

This IE is included when the application layer ID changes at the target UE and the target UE receives a new application layer ID from the upper layers.

11.2.10.5　Source link local IPv6 address

This IE is included when the link local IPv6 address changes at the target UE and the target UE receives a new Link local IPv6 address from the upper layers.

11.2.11 A2X Direct link identifier update ack

11.2.11.1 Message definition

This message is sent by the initiating UE to target UE to indicate that the initiating UE has received target UE's accept message. See table 11.2.11.1.1.

Message type: A2X DIRECT LINK IDENTIFIER UPDATE ACK

Significance: dual

Direction: UE to peer UE

Table 11.2.11.1.1: A2X DIRECT LINK IDENTIFIER UPDATE ACK message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK IDENTIFIER UPDATE ACK message identity	A2X PC5 signalling message type 12.3.1	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	LSB of $K_{NRP\text{-}sess}$ ID	LSB of $K_{NRP\text{-}sess}$ ID 12.3.19	M	V	1
	Target layer-2 ID	Layer-2 ID 12.3.12	M	V	3
28	Target user info	Application layer ID 12.3.4	O	TLV	4-254
59	Target link local IPv6 address	Link local IPv6 address 12.3.7	O	TV	17

11.2.11.2 Target user info

This IE is included when the initiating UE receives the Source user info IE in the A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message.

11.2.11.3 Target link local IPv6 address

This IE is included when the initiating UE receives the Source link local IPv6 address IE in the A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message.

11.2.12 A2X Direct link identifier update reject

11.2.12.1 Message definition

This message is sent by the target UE to the initiating UE to indicate that the A2X link identifier update request is not accepted. See table 11.2.12.1.1.

Message type: A2X DIRECT LINK IDENTIFIER UPDATE REJECT

Significance: dual

Direction: UE to peer UE

Table 11.2.12.1.1: A2X DIRECT LINK IDENTIFIER UPDATE REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK IDENTIFIER UPDATE REJECT message identity	A2X PC5 signalling message type 12.3.1	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	PC5 signalling protocol cause	PC5 signalling protocol cause 12.3.9	M	V	1

11.2.13   A2X Direct link keepalive request

11.2.13.1   Message definition

This message is sent by a UE to another peer UE when an A2X PC5 unicast link keep-alive procedure is initiated. See table 11.2.13.1.1.

   Message type: A2X DIRECT LINK KEEPALIVE REQUEST

   Significance: dual

   Direction: UE to peer UE

Table 11.2.13.1.1: A2X DIRECT LINK KEEPALIVE REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK KEEPALIVE REQUEST message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	Keep-alive counter	Keep-alive counter 12.3.10	M	V	4
55	Maximum inactivity period	Maximum inactivity period 12.3.11	O	TV	5

11.2.13.2   Maximum inactivity period

The UE may include this IE to indicate its maximum inactivity period to the peer UE.

11.2.14   A2X Direct link keepalive response

11.2.14.1   Message definition

This message is sent by a UE to another peer UE to respond to an A2X DIRECT LINK KEEPALIVE REQUEST message. See table 11.2.14.1.1.

   Message type: A2X DIRECT LINK KEEPALIVE RESPONSE

   Significance: dual

   Direction: UE to peer UE

Table 11.2.14.1.1: DIRECT LINK KEEPALIVE RESPONSE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK KEEPALIVE RESPONSE message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	Keep-alive counter	Keep-alive counter 12.3.10	M	V	4

11.2.15 A2X Direct link authentication request

11.2.15.1　　Message definition

This message is sent by a UE to another peer UE when an A2X PC5 unicast link authentication procedure is initiated. See table 11.2.15.1.1.

Message type:　　A2X DIRECT LINK AUTHENTICATION REQUEST

Significance:　dual

Direction: UE to peer UE

Table 11.2.15.1.1: A2X DIRECT LINK AUTHENTICATION REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK AUTHENTICATION REQUEST message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	Key establishment information container	Key establishment information container 12.3.25	M	LV-E	3-n

11.2.16 A2X Direct link authentication response

11.2.16.1　　Message definition

This message is sent by a UE to another peer UE to respond to an A2X DIRECT LINK AUTHENTICATION REQUEST message. See table 11.2.16.1.1.

Message type:　　A2X DIRECT LINK AUTHENTICATION RESPONSE

Significance:　dual

Direction: UE to peer UE

Table 11.2.16.1.1: A2X DIRECT LINK AUTHENTICATION RESPONSE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK AUTHENTICATION RESPONSE message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	Key establishment information container	Key establishment information container 12.3.25	M	LV-E	3-n

11.2.17 A2X Direct link authentication reject

11.2.17.1 Message definition

This message is sent by a UE to another peer UE to reject an A2X DIRECT LINK AUTHENTICATION REQUEST message. See table 11.2.17.1.1.

Message type: A2X DIRECT LINK AUTHENTICATION REJECT

Significance: dual

Direction: UE to peer UE

Table 11.2.17.1.1: A2X DIRECT LINK AUTHENTICATION REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK AUTHENTICATION REJECT message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	PC5 signalling protocol cause value	PC5 signalling protocol cause value 12.3.9	M	V	1

11.2.18 A2X Direct link authentication failure

11.2.18.1 Message definition

This message is sent by a UE to another peer UE to reject an A2X DIRECT LINK AUTHENTICATION RESPONSE message. See table 11.2.18.1.1.

Message type: A2X DIRECT LINK AUTHENTICATION FAILURE

Significance: dual

Direction: UE to peer UE

Table 11.2.18.1.1: A2X DIRECT LINK AUTHENTICATION FAILURE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK AUTHENTICATION FAILURE message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
74	Key establishment information container	Key establishment information container 12.3.25	O	TLV-E	4-n

11.2.18.2 Key establishment information container

The UE shall include this IE if it is provided by upper layers.

11.2.19 A2X Direct link security mode command

11.2.19.1 Message definition

This message is sent by a UE to another peer UE when an A2X PC5 unicast link security mode control procedure is initiated. See table 11.2.19.1.1.

Message type: A2X DIRECT LINK SECURITY MODE COMMAND

Significance: dual

Direction: UE to peer UE

Table 11.2.19.1.1: A2X DIRECT LINK SECURITY MODE COMMAND message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK SECURITY MODE COMMAND message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	Selected security algorithms	Selected security algorithms 12.3.18	M	V	1
	UE security capabilities	UE security capabilities 12.3.14	M	LV	3-9
59	UE PC5 unicast signalling security policy	UE PC5 unicast signalling security policy 12.3.15	O	TV	2
55	Nonce_2	Nonce 12.3.13	O	TV	17
52	LSB of $K_{NRP-sess}$ ID	LSB of $K_{NRP-sess}$ ID 12.3.19	O	TV	2
74	Key establishment information container	Key establishment information container 12.3.25	O	TLV-E	4-n
62	MSBs of K_{NRP} ID	MSBs of K_{NRP} ID 12.3.20	O	TV	3

11.2.19.2   Nonce_2

The UE shall include this IE if the selected integrity protection algorithms is not the null integrity protection algorithm.

11.2.19.3   LSB of KNRP-sess ID

The UE shall include this IE if the selected integrity protection algorithms is not the null integrity protection algorithm.

11.2.19.4   Key establishment information container

The UE shall include this IE if the UE has derived a new K_{NRP} and the authentication method used to generate K_{NRP} requires sending information to complete the authentication procedure.

11.2.19.5   MSBs of KNRP ID

The UE shall include this IE if the UE has derived a new K_{NRP}.

11.2.19.6   UE PC5 unicast signalling security policy

The UE shall include this IE if the A2X DIRECT LINK SECURITY MODE COMMAND message is triggered by the A2X DIRECT LINK ESTABLISHMENT REQUEST message. The content of the IE is the same as the content of UE PC5 unicast signalling security policy IE in the received A2X DIRECT LINK ESTABLISHMENT REQUEST message in order to provide protection against bidding down attacks.

11.2.20 A2X Direct link security mode complete

11.2.20.1   Message definition

This message is sent by a UE to another peer UE to respond to an A2X DIRECT LINK SECURITY MODE COMMAND message. See table 11.2.20.1.1.

Message type: A2X DIRECT LINK SECURITY MODE COMPLETE

Significance: dual

Direction: UE to peer UE

Table 11.2.20.1.1: A2X DIRECT LINK SECURITY MODE COMPLETE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK SECURITY MODE COMPLETE message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	QoS flow descriptions	PC5 QoS flow descriptions 12.3.5	M	LV-E	6-n
	UE PC5 unicast user plane security policy	UE PC5 unicast user plane security policy 12.3.22	M	V	1
57	IP address configuration	IP address configuration 12.3.6	O	TV	2
58	Link local IPv6 address	Link local IPv6 address 12.3.7	O	TV	17
52	LSBs of K$_{NRP}$ ID	LSBs of K$_{NRP}$ ID 12.3.21	O	TV	3

11.2.20.2   IP address configuration

The UE shall include this IE if IP communication is used and the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link establishment procedure.

11.2.20.3   Link local IPv6 address

The UE shall include this IE if IP communication is used, the IP address configuration is set to "IPv6 address allocation not supported" and the A2X PC5 unicast link security mode control procedure was triggered during an A2X PC5 unicast link establishment procedure.

11.2.20.4   LSBs of K$_{NRP}$ ID

The UE shall include this IE if a new K$_{NRP}$ was derived.

11.2.21 A2X Direct link security mode reject

11.2.21.1   Message definition

This message is sent by a UE to another peer UE to reject an A2X DIRECT LINK SECURITY MODE COMMAND message. See table 11.2.21.1.1.

Message type: A2X DIRECT LINK SECURITY MODE REJECT

Significance: dual

Direction: UE to peer UE

Table 11.2.21.1.1: A2X DIRECT LINK SECURITY MODE REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK SECURITY MODE REJECT message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	PC5 signalling protocol cause	PC5 signalling protocol cause 12.3.9	M	V	1

11.2.22 A2X Direct link rekeying request

11.2.22.1 Message definition

This message is sent by a UE to another peer UE when an A2X PC5 unicast link re-keying procedure is initiated. See table 11.2.22.1.1.

Message type: A2X DIRECT LINK REKEYING REQUEST

Significance: dual

Direction: UE to peer UE

Table 11.2.22.1.1: A2X DIRECT LINK REKEYING REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK REKEYING REQUEST message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1
	UE security capabilities	UE security capabilities 12.3.14	M	LV	3-9
74	Key establishment information container	Key establishment information container 12.3.25	O	TLV-E	4-n
53	Nonce_1	Nonce 12.3.13	O	TV	17
54	MSB of $K_{NRP\text{-}sess}$ ID	MSB of $K_{NRP\text{-}sess}$ ID 12.3.16	O	TV	2
56	Re-authentication indication	Re-authentication indication 12.3.24	O	TV	2

11.2.22.2 Key establishment information container

The UE shall include this IE if the null integrity protection algorithm is not in use.

11.2.22.3 Nonce_1

The UE shall include this IE if the null integrity protection algorithm is not in use.

11.2.22.4 MSB of KNRP-sess ID

The UE shall include this IE if the null integrity protection algorithm is not in use.

11.2.22.5 Re-authentication indication

The UE shall include this IE if the UE wants to derive a new K_{NRP}.

11.2.23 A2X Direct link rekeying response

11.2.23.1 Message definition

This message is sent by a UE to another peer UE to respond to an A2X DIRECT LINK REKEYING REQUEST message. See table 11.2.23.1.1.

Message type: A2X DIRECT LINK REKEYING RESPONSE

Significance: dual

Direction: UE to peer UE

Table 11.2.23.1.1: A2X DIRECT LINK REKEYING RESPONSE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	A2X DIRECT LINK REKEYING RESPONSE message identity	A2X PC5 signalling message type 12.3.1.	M	V	1
	Sequence number	Sequence number 12.3.2	M	V	1

12 Information elements coding

12.1 Overview

This clause contains the information elements coding for the messages used in the procedures described in the present document.

12.2 General

12.3 A2X communication over PC5 signalling information elements

12.3.1 A2X PC5 signalling message type

The purpose of the A2X PC5 signalling message type information element is to indicate the type of messages used in A2X PC5 signalling protocol.

The value part of the A2X PC5 signalling message type information element used in the A2X PC5 signalling messages is coded as shown in table 12.3.1.1.

The A2X PC5 signalling message type is a type 3 information element, with the length of 1 octet.

Table 12.3.1.1: A2X PC5 signalling message type

				Bits				
8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	1	A2X DIRECT LINK ESTABLISHMENT REQUEST
0	0	0	0	0	0	1	0	A2X DIRECT LINK ESTABLISHMENT ACCEPT
0	0	0	0	0	0	1	1	A2X DIRECT LINK ESTABLISHMENT REJECT
0	0	0	0	0	1	0	0	A2X DIRECT LINK MODIFICATION REQUEST
0	0	0	0	0	1	0	1	A2X DIRECT LINK MODIFICATION ACCEPT
0	0	0	0	0	1	1	0	A2X DIRECT LINK MODIFICATION REJECT
0	0	0	0	0	1	1	1	A2X DIRECT LINK RELEASE REQUEST
0	0	0	0	1	0	0	0	A2X DIRECT LINK RELEASE ACCEPT
0	0	0	0	1	0	0	1	A2X DIRECT LINK KEEPALIVE REQUEST
0	0	0	0	1	0	1	0	A2X DIRECT LINK KEEPALIVE RESPONSE
0	0	0	0	1	0	1	1	A2X DIRECT LINK AUTHENTICATION REQUEST
0	0	0	0	1	1	0	0	A2X DIRECT LINK AUTHENTICATION RESPONSE
0	0	0	0	1	1	0	1	A2X DIRECT LINK AUTHENTICATION REJECT
0	0	0	0	1	1	1	0	A2X DIRECT LINK SECURITY MODE COMMAND
0	0	0	0	1	1	1	1	A2X DIRECT LINK SECURITY MODE COMPLETE
0	0	0	1	0	0	0	0	A2X DIRECT LINK SECURITY MODE REJECT
0	0	0	1	0	0	0	1	A2X DIRECT LINK REKEYING REQUEST
0	0	0	1	0	0	1	0	A2X DIRECT LINK REKEYING RESPONSE
0	0	0	1	0	0	1	1	A2X DIRECT LINK IDENTIFIER UPDATE REQUEST
0	0	0	1	0	1	0	0	A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT
0	0	0	1	0	1	0	1	A2X DIRECT LINK IDENTIFIER UPDATE ACK
0	0	0	1	0	1	1	0	A2X DIRECT LINK IDENTIFIER UPDATE REJECT
0	0	0	1	0	1	1	1	A2X DIRECT LINK AUTHENTICATION FAILURE

12.3.2　Sequence number

The purpose of the Sequence number information element is to uniquely identify an A2X PC5 signalling message being sent or received. The sending UE will increment the sequence number for each outgoing new A2X PC5 signalling message.

The Sequence number information element is an integer in the 0-255 range.

The Sequence number is a type 3 information element, with a length of 1 octet.

12.3.3　A2X service identifier

The purpose of the A2X service identifier parameter is to carry the identifier of an A2X service.

The A2X service identifier information element is coded as shown in figure 12.3.3.1 and table 12.3.3.1.

The A2X service identifier is a type 4 information element with a minimum length of 6 octets.

8	7	6	5	4	3	2	1	
A2X service identifier IEI								octet 1
Length of A2X service identifier contents								octet 2
A2X service identifier 1								octet 3 – octet 6
A2X service identifier 2								octet 7* – octet 10*
…								octet 11* – octet 4n-2*
A2X service identifier n								octet 4n-1* – octet 4n+2*
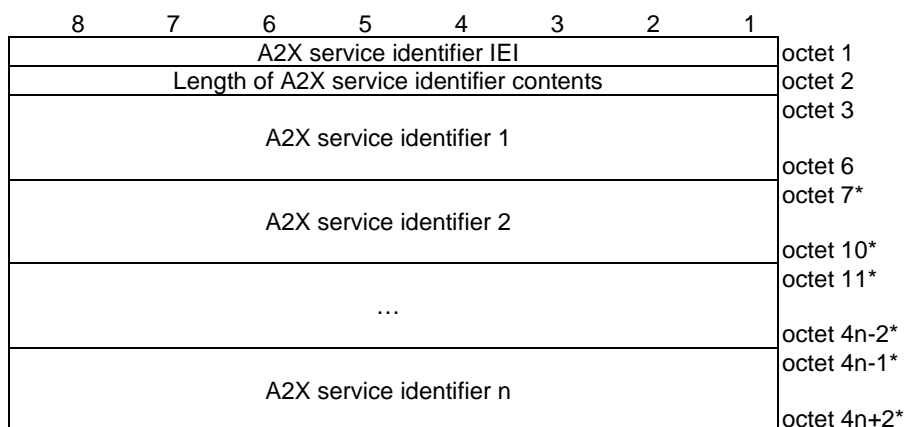
Figure 12.3.3.1: A2X service identifier information element

Table 12.3.3.1: A2X service identifier information element

A2X service identifier: The A2X service identifier field contains a binary coded A2X service identifier as identified by one of ITS-AID specified in ISO TS 17419 ITS-AID AssignedNumbers [21], PSID (Provider Service Identifier) or AID (Application Identifier) according to values defined specifically for aviation applications.

12.3.4   Application layer ID

The purpose of the Application layer ID parameter information element carries an application layer ID as specified in 3GPP TS 23.256 [3].

The Application layer ID information element is coded as shown in figure 12.3.4.1 and table 12.3.4.1.

The Application layer ID is a type 4 information element.

8	7	6	5	4	3	2	1	
Application layer ID IEI								octet 1
Length of Application layer ID contents								octet 2
Application layer ID contents								octet 3 octet m
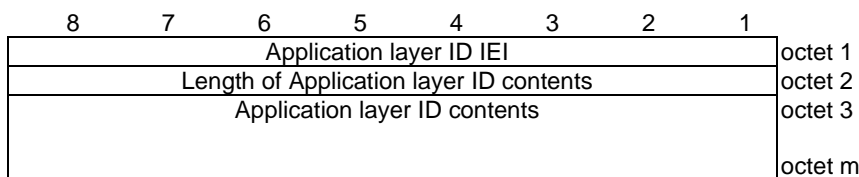
Figure 12.3.4.1: Application layer ID information element

Table 12.3.4.1: Application layer ID information element

The length of Application layer ID contents field contains the binary coded representation of the length of the Application layer ID contents field. The Application layer ID contents field contains the octets indicating the Application layer ID. The format of the Application layer ID parameter is out of scope of this specification.

12.3.5   PC5 QoS flow descriptions

The purpose of the PC5 QoS flow descriptions information element is to indicate a set of PC5 QoS flow descriptions to be used by the UE over the direct link, where each PC5 QoS flow description is a set of parameters as described in clause 6.2.4.1 of 3GPP TS 23.256 [3].

The PC5 QoS flow descriptions is a type 6 information element with a minimum length of 6 octets. The maximum length for the information element is 65538 octets.

The PC5 QoS flow descriptions information element is coded as shown in figure 12.3.5.1, figure 12.3.5.2, figure 12.3.5.3, figure 12.3.5.4, and table 12.3.5.1.

8	7	6	5	4	3	2	1	
PC5 QoS flow descriptions IEI								octet 1
Length of PC5 QoS flow descriptions contents								octet 2 octet 3
PC5 QoS flow description 1								octet 4 octet u
PC5 QoS flow description 2								octet u+1 octet v
...								octet v+1 octet w
PC5 QoS flow description n								octet w+1 octet x
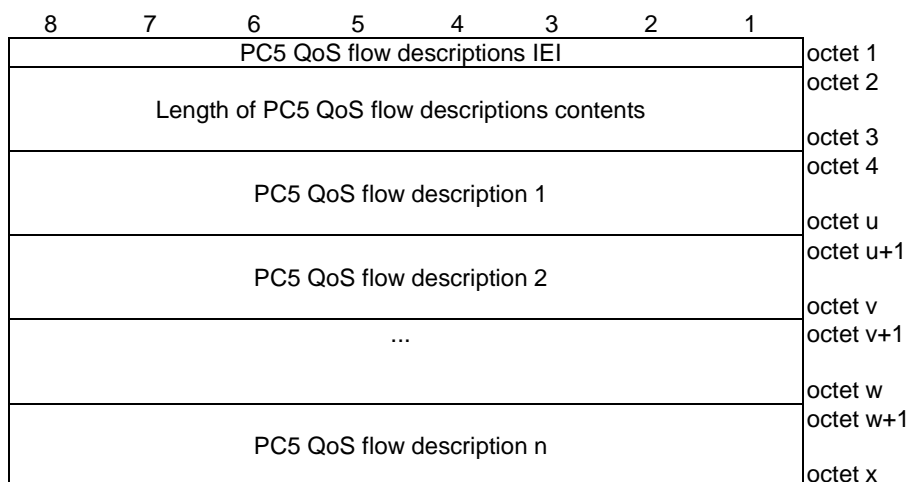
Figure 12.3.5.1: PC5 QoS flow descriptions information element

8	7	6	5	4	3	2	1	
0 Spare	0 Spare		PQFI					octet 4
Operation code			0 Spare	0 Spare	0 Spare	0 Spare	0 Spare	octet 5
0 Spare	E		Number of parameters					octet 6
Associated A2X service identifiers								octet 7* octet k*
Parameters list								octet k+1* octet u*
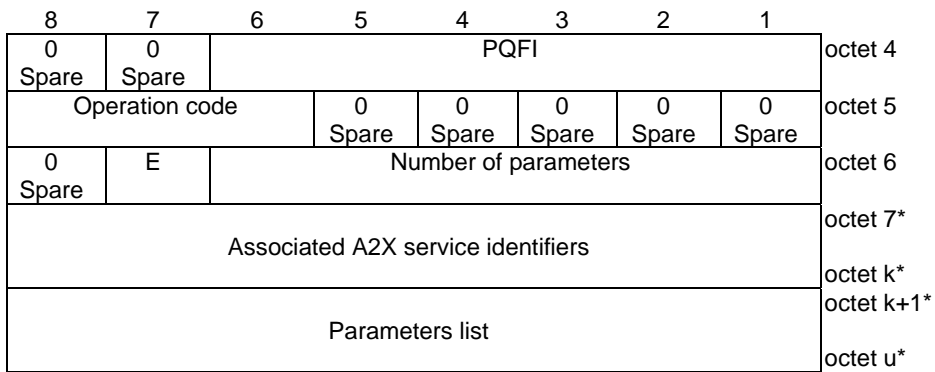
Figure 12.3.5.2: PC5 QoS flow description

8	7	6	5	4	3	2	1	
Parameter 1								octet k+1 octet m
Parameter 2								octet m+1 octet n
…								octet n+1 octet o
Parameter n								octet o+1 octet u
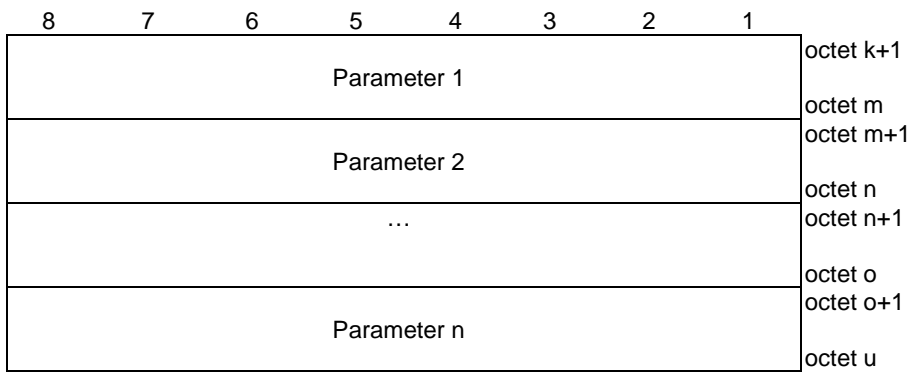
Figure 12.3.5.3: Parameters list

8	7	6	5	4	3	2	1	
Parameter identifier								octet k+1
Length of parameter contents								octet k+2
Parameter contents								octet k+3 octet m
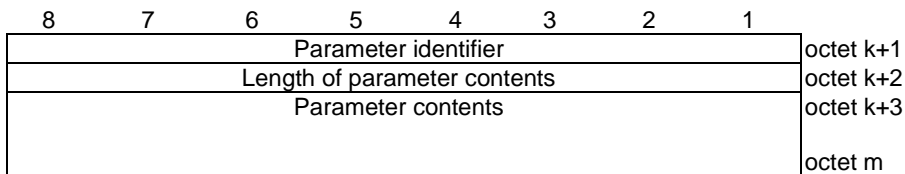
Figure 12.3.5.4: Parameter

Table 12.3.4.1: PC5 QoS flow descriptions information element

PC5 QoS flow identifier (PQFI) (bits 6 to 1 of octet 4)
PQFI field contains the PC5 QoS flow identifier.
Bits
6 5 4 3 2 1
0 0 0 0 0 1 PQFI 1
    to
1 1 1 1 1 1 PQFI 63
The UE shall not set the PQFI value to 0.

Operation code (bits 8 to 6 of octet 5)
Bits
8 7 6
0 0 1   Create new PC5 QoS flow description
0 1 0   Delete existing PC5 QoS flow description
0 1 1   Modify existing PC5 QoS flow description
All other values are reserved.

E bit (bit 7 of octet 6)
For the "create new PC5 QoS flow description" operation, the E bit is encoded as
follows:
Bit
7
0   reserved
1   parameters list is included

For the "Delete existing PC5 QoS flow description" operation, the E bit is encoded as
follows:
Bit
7
0   parameters list is not included
1   reserved

For the "modify existing PC5 QoS flow description" operation, the E bit is encoded as
follows:
Bit
7
0   extension of previously provided parameters
1   replacement of all previously provided parameters

If the E bit is set to "parameters list is not included", the number of parameters field has
zero value. If the E bit is set to "parameters list is included", the number of parameters
field has non-zero value. If the E bit is set to "extension of previously provided
parameters" or "replacement of all previously provided parameters", the number of
parameters field has non-zero value. If the E bit is set to "extension of previously
provided parameters" and one of the parameters in the new parameters list already
exists in the previously provided parameters, the parameter shall be set to the new
value.

Number of parameters (bits 6 to 1 of octet 6)
The number of parameters field contains the binary coding for the number of
parameters in the parameters list field. The number of parameters field is encoded in
bits 6 through 1 of octet 6 where bit 6 is the most significant and bit 1 is the least
significant bit.

Associated A2X service identifiers (octet 7 to k)
The associated A2X service identifiers field contains a variable number of A2X service
identifiers associated with the PC5 QoS flow. Associated A2X service identifiers field is
coded as the length and value part of A2X service identifier information element as
specified in clause 12.3.3 starting with the second octet.

Parameters list (octets k+1 to u)
The parameters list contains a variable number of parameters.

Each parameter included in the parameters list is of variable length and consists of:
-    a parameter identifier (1 octet);
-    the length of the parameter contents (1 octet); and
-    the parameter contents itself (variable amount of octets).

The parameter identifier field is used to identify each parameter included in the
parameters list and it contains the hexadecimal coding of the parameter identifier. Bit 8
of the parameter identifier field contains the most significant bit and bit 1 contains the
least significant bit. In this version of the protocol, the following parameter identifiers are
specified:
-    01H (PQI);
-    02H (GFBR); (see NOTE)
-    03H (MFBR); (see NOTE)
-    04H (Averaging window);
-    05H (Resource type);
-    06H (Default priority level);
-    07H (Packet delay budget);
-    08H (Packet error rate);

If the parameters list contains a parameter identifier that is not supported by the
receiving entity the corresponding parameter shall be discarded.

The length of parameter contents field contains the binary coded representation of the length of the parameter contents field. The first bit in transmission order is the most significant bit.

When the parameter identifier indicates PQI, the parameter contents field contains the binary representation of PQI that is one octet in length.

```
PQI:
Bits
8 7 6 5 4 3 2 1
0 0 0 0 0 0 0 0    Reserved
0 0 0 0 0 0 0 1
   to      Spare
0 0 1 0 0 1 1 1
0 0 1 0 1 0 0 0    PQI 40
0 0 1 0 1 0 0 1    PQI 41
0 0 1 0 1 0 1 0    PQI 42
0 0 1 0 1 0 1 1    PQI 43
0 0 1 0 1 1 0 0    PQI 44
0 0 1 0 1 1 0 1
   to      Spare
0 0 1 1 1 1 0 1
0 0 1 1 1 1 1 0    PQI 62
0 0 1 1 1 1 1 1    PQI 63
0 1 0 0 0 0 0 0    PQI 64
0 1 0 0 0 0 0 1    PQI 65
0 1 0 0 0 0 1 0
   to      Spare
0 1 1 1 1 1 1 1
1 0 0 0 0 0 0 0
   to      Operator-specific PQIs
1 1 1 1 1 1 1 0
1 1 1 1 1 1 1 1    Reserved
```

The UE shall consider all other values not explicitly defined in this version of the protocol as unsupported.

When the parameter identifier indicates "GFBR", the parameter contents field contains one octet indicating the unit of the guaranteed flow bit rate followed by two octets containing the value of the guaranteed flow bit rate.
Unit of the guaranteed flow bit rate (octet 1)

```
Bits
8 7 6 5 4 3 2 1
0 0 0 0 0 0 0 0    value is not used
0 0 0 0 0 0 0 1    value is incremented in multiples of 1 Kbps
0 0 0 0 0 0 1 0    value is incremented in multiples of 4 Kbps
0 0 0 0 0 0 1 1    value is incremented in multiples of 16 Kbps
0 0 0 0 0 1 0 0    value is incremented in multiples of 64 Kbps
0 0 0 0 0 1 0 1    value is incremented in multiples of 256 Kbps
0 0 0 0 0 1 1 0    value is incremented in multiples of 1 Mbps
0 0 0 0 0 1 1 1    value is incremented in multiples of 4 Mbps
0 0 0 0 1 0 0 0    value is incremented in multiples of 16 Mbps
0 0 0 0 1 0 0 1    value is incremented in multiples of 64 Mbps
0 0 0 0 1 0 1 0    value is incremented in multiples of 256 Mbps
0 0 0 0 1 0 1 1    value is incremented in multiples of 1 Gbps
0 0 0 0 1 1 0 0    value is incremented in multiples of 4 Gbps
0 0 0 0 1 1 0 1    value is incremented in multiples of 16 Gbps
0 0 0 0 1 1 1 0    value is incremented in multiples of 64 Gbps
0 0 0 0 1 1 1 1    value is incremented in multiples of 256 Gbps
0 0 0 1 0 0 0 0    value is incremented in multiples of 1 Tbps
0 0 0 1 0 0 0 1    value is incremented in multiples of 4 Tbps
0 0 0 1 0 0 1 0    value is incremented in multiples of 16 Tbps
0 0 0 1 0 0 1 1    value is incremented in multiples of 64 Tbps
0 0 0 1 0 1 0 0    value is incremented in multiples of 256 Tbps
0 0 0 1 0 1 0 1    value is incremented in multiples of 1 Pbps
0 0 0 1 0 1 1 0    value is incremented in multiples of 4 Pbps
0 0 0 1 0 1 1 1    value is incremented in multiples of 16 Pbps
0 0 0 1 1 0 0 0    value is incremented in multiples of 64 Pbps
```

0 0 0 1 1 0 0 1   value is incremented in multiples of 256 Pbps
Other values shall be interpreted as multiples of 256 Pbps in this version of the protocol.

Value of the guaranteed flow bit rate (octets 2 and 3)
Octets 2 and 3 represent the binary coded value of the guaranteed flow bit rate in units defined by the unit of the guaranteed flow bit rate.

When the parameter identifier indicates "GFBR downlink", the parameter contents field contains one octet indicating the unit of the guaranteed flow bit rate for downlink followed by two octets containing the value of the guaranteed flow bit rate for downlink.

When the parameter identifier indicates "MFBR ", the parameter contents field contains the one octet indicating the unit of the maximum flow bit rate followed by two octets containing the value of maximum flow bit rate.

Unit of the maximum flow bit rate (octet 1)
The coding is identical to that of the unit of the guaranteed flow bit rate.

Value of the maximum flow bit rate (octets 2 and 3)
Octets 2 and 3 represent the binary coded value of the maximum flow bit rate in units defined by the unit of the maximum flow bit rate.

When the parameter identifier indicates "averaging window", the parameter contents field contains the binary representation of the averaging window for both uplink and downlink in milliseconds and the parameter contents field is two octets in length.

When the parameter identifier indicates "resource type", the parameter contents field contains the binary representation of the resource type that is one octet in length.

Resource type:
Bits
8 7 6 5 4 3 2 1
0 0 0 0 0 0 0 0   Reserved
0 0 0 0 0 0 0 1   Non-GBR
0 0 0 0 0 0 1 0   GBR
0 0 0 0 0 0 1 1
   to   Spare
1 1 1 1 1 1 1 1

When the parameter identifier indicates "default priority level", the parameter contents field contains the binary representation of the default priority level that is one octet in length.

Default priority level:
Bits
8 7 6 5 4 3 2 1
0 0 0 0 0 0 0 0   Reserved
0 0 0 0 0 0 0 1   1
0 0 0 0 0 0 1 0   2
0 0 0 0 0 0 1 1   3
0 0 0 0 0 1 0 0   4
0 0 0 0 0 1 0 1   5
0 0 0 0 0 1 1 0   6
0 0 0 0 0 1 1 1   7
0 0 0 0 1 0 0 0   8
0 0 0 0 1 0 0 1
   to   Spare
1 1 1 1 1 1 1 1

When the parameter identifier indicates "packet delay budget", the parameter contents field contains the binary representation of the packet delay budget for both uplink and downlink in milliseconds and the parameter contents field is two octets in length.

When the parameter identifier indicates "packet error rate", the parameter contents field contains the binary representation of the power of 10^{-1} for both uplink and downlink and the parameter contents field is one octet in length.

NOTE: The GFBR and MFBR apply to both directions of the A2X PC5 unicast link.

12.3.6 IP address configuration

The purpose of the IP address configuration information element is to indicate the configuration options for IP address used by the UE over this direct link.

The IP address configuration is a type 3 information element with the length of 2 octets.

The IP address configuration information element is coded as shown in figure 12.3.6.1 and table 12.3.6.1.

8	7	6	5	4	3	2	1	
IP address configuration IEI								octet 1
IP address configuration content								octet 2
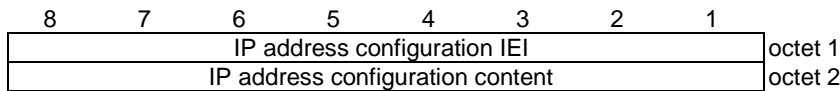
Figure 12.3.6.1: IP address configuration information element

Table 12.3.6.1: IP address configuration information element

IP address configuration content (octet 2)
Bits
4 3 2 1
0 0 0 1   IPv6 Router
0 0 1 0   address allocation not supported
All other values are reserved.
Bit 5 to 8 of octet 2 are spare and shall be coded as zero.

12.3.7 Link local IPv6 address

The purpose of the Link local IPv6 address information element is to indicate the link local IPv6 address.

The Link local IPv6 address is a type 3 information element with the length of 17 octets.

The Link local IPv6 address information element is coded as shown in figure 12.3.7.1 and table 12.3.7.1.

8	7	6	5	4	3	2	1	
Link local IPv6 address IEI								octet 1
Link local IPv6 address content								octet 2
								octet 17
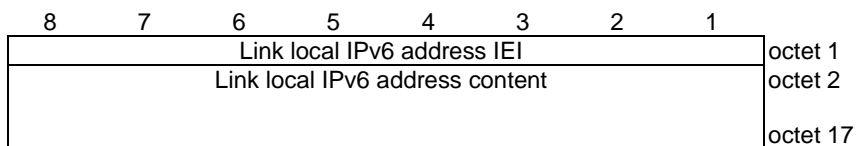
Figure 12.3.7.1: Link local IPv6 address information element

Table 12.3.7.1: Link local IPv6 address information element

Link local IPv6 address content (octet 2 to 17)
This contains the 128-bit IPv6 address. This IPv6 address is encoded as a 128-bit address according to IETF RFC 4291 [20].

12.3.8 Link modification operation code

The purpose of the Link modification operation code information element is to indicate what the operation of the A2X PC5 unicast link modification procedure triggered by initiating UE is.

The Link modification operation code is a type 3 information element, with a length of 2 octets.

The Link modification operation code information element is coded as shown in figure 12.3.8.1 and table 12.3.8.1.

8	7	6	5	4	3	2	1	
Link modification operation code IEI								octet 1
Link modification operation code								octet 2
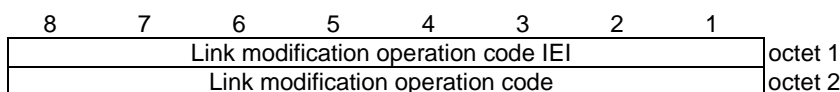
Figure 12.3.8.1: Link modification operation code information element

Table 12.3.8.1: Link modification operation code information element

```
Link modification operation code (octet 2)
Bits
4  3  2  1
0  0  0  1      Add new PC5 QoS flow(s) to the existing PC5 unicast link
0  0  1  0      Modify PC5 QoS parameters of the existing PC5 QoS flow(s)
0  0  1  1      Remove existing PC5 QoS flow(s) from the existing PC5 unicast link
0  1  0  0      Associate new A2X service(s) with existing PC5 QoS flow(s)
0  1  0  1      Remove A2X service(s) from existing PC5 QoS flow(s)
0  1  1  0
to              Spare
1  1  1  0
1  1  1  1      Reserved

Bit 5 to 8 of octet 2 are spare and shall be coded as zero.
```

12.3.9   PC5 signalling protocol cause

The purpose of the PC5 signalling protocol cause information element is to indicate the cause used in the PC5 signalling protocol procedures.

The PC5 signalling protocol cause is a type 3 information element with a length of 2 octets.

The PC5 signalling protocol cause information element is coded as shown in figure 12.3.9.1 and table 12.3.9.1.

8	7	6	5	4	3	2	1	
PC5 signalling protocol cause IEI								octet 1
PC5 signalling cause value								octet 2
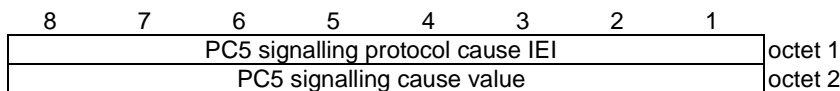
Figure 12.3.9.1: PC5 signalling protocol cause information element

Table 12.3.9.1: PC5 signalling protocol cause information element

```
PC5 signalling cause value (octet 2)

Bits
8  7  6  5  4  3  2  1
0  0  0  0  0  0  0  1      Direct communication to the target UE not
                           allowed
0  0  0  0  0  0  1  0      Direct communication to the target UE no longer
                           needed
0  0  0  0  0  0  1  1      Conflict of layer-2 ID for unicast communication is
                           detected
0  0  0  0  0  1  0  0      Direct connection is not available anymore
0  0  0  0  0  1  0  1      Lack of resources for 5G ProSe direct link
0  0  0  0  0  1  1  0      Authentication failure
0  0  0  0  0  1  1  1      Integrity failure
0  0  0  0  1  0  0  0      UE security capabilities mismatch
0  0  0  0  1  0  0  1      LSB of K_NRP-sess ID conflict
0  0  0  0  1  0  1  0      UE A2X PC5 unicast signalling security policy
                           mismatch
0  0  0  0  1  0  1  1      Required service not allowed
0  0  0  0  1  1  0  0      Security policy not aligned
0  0  0  0  1  1  0  1      Congestion situation
0  0  0  0  1  1  1  0      Authentication synchronisation error
0  0  0  0  1  1  1  1      Security procedure failure of 5G ProSe UE-to-
                           network relay
0  1  1  0  1  1  1  1      Protocol error, unspecified
Any other value received by the UE shall be treated as 0110 1111, "protocol error,
unspecified".
```

12.3.10 Keep-alive counter

The purpose of the Keep-alive counter information element is to indicate the keep-alive counter which is a 32-bit counter used for the A2X PC5 unicast link keep-alive procedure.

The Keep-alive counter is a type 3 information element with a length of 5 octets.

The Keep-alive counter information element is coded as shown in figure 12.3.10.1 and table 12.3.10.1.

8	7	6	5	4	3	2	1	
Keep-alive counter IEI								octet 1
Keep-alive counter contents								octet 2
								octet 5
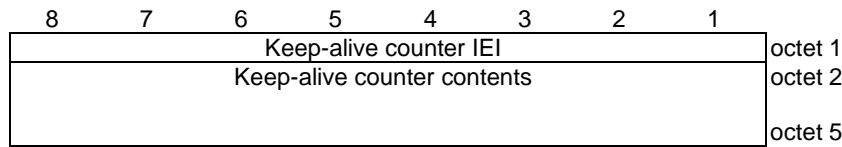
Figure 12.3.10.1: Keep-alive counter information element

Table 12.3.10.1: Keep-alive counter information element

Keep-alive counter contents (octet 2 to 5)
This field contains the 32-bit keep-alive counter.

12.3.11 Maximum inactivity period

The purpose of the Maximum inactivity period information element is to indicate the maximum inactivity period of the initiating UE during an A2X PC5 unicast link keep-alive procedure.

The Maximum inactivity period is a type 3 information element, with a length of 5 octets.

The Maximum inactivity period information element is coded as shown in figure 12.3.11.1 and table 12.3.11.1.

8	7	6	5	4	3	2	1	
Maximum inactivity period IEI								octet 1
Maximum inactivity period contents								octet 2
								octet 5
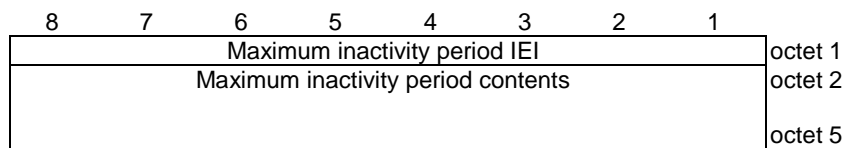
Figure 8.4.11.1: Maximum inactivity period information element

Table 8.4.11.1: Maximum inactivity period information element

Maximum inactivity period contents (octet 2 to 5)
This field contains the binary encoding of the maximum inactivity period expressed in units of seconds.

12.3.12 Layer-2 ID

The purpose of the layer-2 ID information element is to indicate the layer-2 ID that is used by UE.

The layer-2 ID is a type 3 information element with a length of 4 octets.

The layer-2 ID information element is coded as shown in figure 12.3.12.1 and table 12.3.12.1.

| 8	7	6	5	4	3	2	1	
Layer-2 ID IEI								octet 1
Layer-2 ID								octet 2
								octet 4
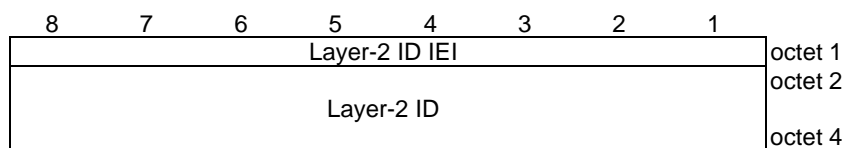
Figure 12.3.12.1: Layer-2 ID information element

Table 12.3.12.1: Layer-2 ID information element

Layer-2 ID (octet 2 to 4)
This field contains the 24-bit layer-2 ID.

12.3.13   Nonce

The Nonce information element contains a 128-bit nonce used during A2X PC5 unicast link security establishment.

The Nonce information element is a type 3 information element, with a length of 17 octets.

The Nonce information element is coded as shown in figure 12.3.13.1 and table 12.3.13.1.

| 8	7	6	5	4	3	2	1	
Nonce IEI								octet 1
Nonce contents								octet 2
								octet 17
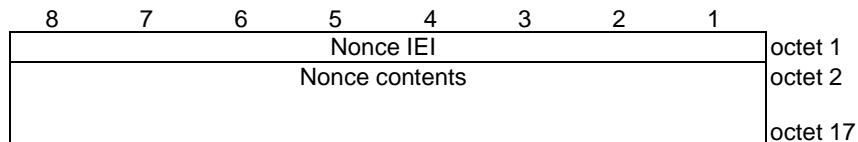
Figure 12.3.13.1: Nonce information element

Table 12.3.13.1: Nonce information element

Nonce contents (octet 2 to 17)
This field contains the 128-bit nonce value.

12.3.14   UE security capabilities

The UE security capabilities information element is used to indicate which security algorithms are supported by the UE.

The UE security capabilities is a type 4 information element with a minimum length of 4 octets and a maximum length of 10 octets.

The UE security capabilities information element is coded as shown in figure 12.3.14.1 and table 12.3.14.1.

8	7	6	5	4	3	2	1	
UE security capabilities IEI								octet 1
Length of UE security capabilities contents								octet 2
5G-EA0	128-5G-EA1	128-5G-EA2	128-5G-EA3	5G-EA4	5G-EA5	5G-EA6	5G-EA7	octet 3
5G-IA0	128-5G-IA1	128-5G-IA2	128-5G-IA3	5G-IA4	5G-IA5	5G-IA6	5G-IA7	octet 4
0	0	0	0	0	0	0	0	
Spare								octet 5* -10*
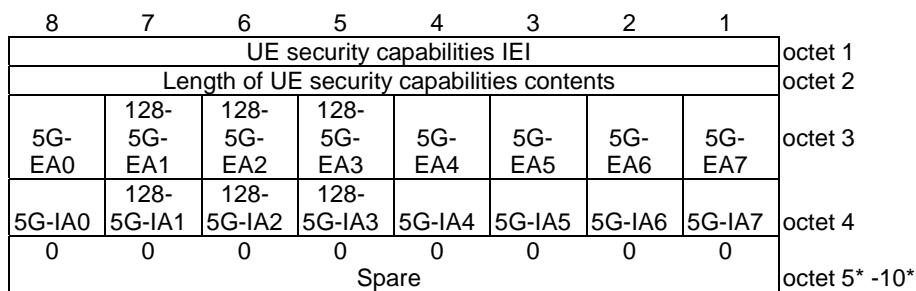
Figure 12.3.14.1: UE security capabilities information element

Table 12.3.14.1: UE security capabilities information element

5GS encryption algorithms supported (octet 3)

5GS encryption algorithm 5G-EA0 supported (octet 3, bit 8)
0   5GS encryption algorithm 5G-EA0 not supported
1   5GS encryption algorithm 5G-EA0 supported

5GS encryption algorithm 128-5G-EA1 supported (octet 3, bit 7)
0   5GS encryption algorithm 128-5G-EA1 not supported
1   5GS encryption algorithm 128-5G-EA1 supported

5GS encryption algorithm 128-5G-EA2 supported (octet 3, bit 6)
0   5GS encryption algorithm 128-5G-EA2 not supported
1   5GS encryption algorithm 128-5G-EA2 supported

5GS encryption algorithm 128-5G-EA3 supported (octet 3, bit 5)
0   5GS encryption algorithm 128-5G-EA3 not supported
1   5GS encryption algorithm 128-5G-EA3 supported

5GS encryption algorithm 5G-EA4 supported (octet 3, bit 4)
0   5GS encryption algorithm 5G-EA4 not supported
1   5GS encryption algorithm 5G-EA4 supported

5GS encryption algorithm 5G-EA5 supported (octet 3, bit 3)
0   5GS encryption algorithm 5G-EA5 not supported
1   5GS encryption algorithm 5G-EA5 supported

5GS encryption algorithm 5G-EA6 supported (octet 3, bit 2)
0   5GS encryption algorithm 5G-EA6 not supported
1   5GS encryption algorithm 5G-EA6 supported

5GS encryption algorithm 5G-EA7 supported (octet 3, bit 1)
0   5GS encryption algorithm 5G-EA7 not supported
1   5GS encryption algorithm 5G-EA7 supported

5GS integrity algorithms supported (octet 4)

5GS integrity algorithm 5G-IA0 supported (octet 4, bit 8)
0   5GS integrity algorithm 5G-IA0 not supported
1   5GS integrity algorithm 5G-IA0 supported

5GS integrity algorithm 128-5G-IA1 supported (octet 4, bit 7)
0   5GS integrity algorithm 128-5G-IA1 not supported
1   5GS integrity algorithm 128-5G-IA1 supported

5GS integrity algorithm 128-5G-IA2 supported (octet 4, bit 6)
0   5GS integrity algorithm 128-5G-IA2 not supported
1   5GS integrity algorithm 128-5G-IA2 supported

5GS integrity algorithm 128-5G-IA3 supported (octet 4, bit 5)
0   5GS integrity algorithm 128-5G-IA3 not supported
1   5GS integrity algorithm 128-5G-IA3 supported

5GS integrity algorithm 5G-IA4 supported (octet 4, bit 4)
0   5GS integrity algorithm 5G-IA4 not supported
1   5GS integrity algorithm 5G-IA4 supported

5GS integrity algorithm 5G-IA5 supported (octet 4, bit 3)
0   5GS integrity algorithm 5G-IA5 not supported
1   5GS integrity algorithm 5G-IA5 supported

5GS integrity algorithm 5G-IA6supported (octet 4, bit 2)
0   5GS integrity algorithm 5G-IA6 not supported
1   5GS integrity algorithm 5G-IA6 supported

5GS integrity algorithm 5G-IA7 supported (octet 4, bit 1)
0   5GS integrity algorithm 5G-IA7 not supported
1   5GS integrity algorithm 5G-IA7 supported

12.3.15 UE PC5 unicast signalling security policy

The purpose of the UE PC5 unicast signalling security policy information element is to indicate the UE's configuration for integrity protection and ciphering of PC5 signalling messages.

The UE PC5 unicast signalling security policy is a type 3 information element with a length of 2 octets.

The UE PC5 unicast signalling security policy information element is coded as shown in figure 12.3.15.1.1 and table 12.3.15.1.

8	7	6	5	4	3	2	1	
UE PC5 unicast signalling security policy IEI								octet 1
0 spare	Signalling ciphering policy			0 spare	Signalling integrity protection policy			octet 2
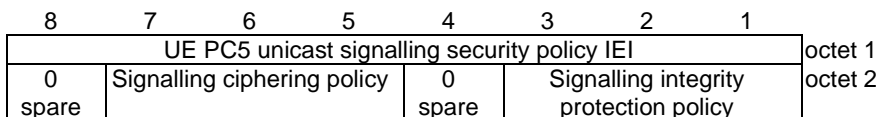
Figure 12.3.15.1: UE PC5 unicast signalling security policy information element

Table 12.3.15.1: UE PC5 unicast signalling security policy information element

```
Signalling integrity protection policy (octet 2, bit 1 to 3)
Bits
3  2  1
0  0  0     Signalling integrity protection not needed
0  0  1     Signalling integrity protection preferred
0  1  0     Signalling integrity protection required
0  1  1
   to  Spare
1  1  0
1  1  1     Reserved

If the UE receives a signalling integrity protection policy value that the UE does not
understand, the UE shall interpret the value as 010 "Signalling integrity protection
required".

Signalling ciphering policy (octet 2, bit 5 to 7)
Bits
7  6  5
0  0  0     Signalling ciphering not needed
0  0  1     Signalling ciphering preferred
0  1  0     Signalling ciphering required
0  1  1
   to  Spare
1  1  0
1  1  1     Reserved

If the UE receives a signalling ciphering policy value that the UE does not understand,
the UE shall interpret the value as 010 "Signalling ciphering required".

Bit 4 and 8 of octet 2 are spare and shall be coded as zero.
```

12.3.16 MSB of $K_{NRP\text{-}sess}$ ID

The purpose of the MSB of $K_{NRP\text{-}sess}$ ID information element is to carry the 8 most significant bits of the $K_{NRP\text{-}sess}$ ID.

The MSB of $K_{NRP\text{-}sess}$ ID information element is a type 3 information element with a length of 2 octets.

The MSB of $K_{NRP\text{-}sess}$ ID information element is coded as shown in figure 12.3.16.1 and table 12.3.16.1.

8	7	6	5	4	3	2	1	
MSB of $K_{NRP\text{-}sess}$ ID IEI								octet 1
MSB of $K_{NRP\text{-}sess}$ ID contents								octet 2
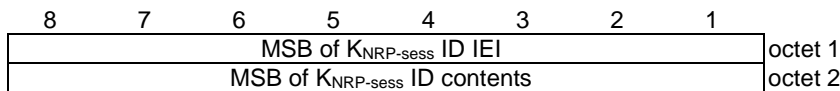
Figure 12.3.16.1: MSB of $K_{NRP\text{-}sess}$ ID information element

Table 12.3.16.1: MSB of $K_{NRP\text{-}sess}$ ID information element

MSB of $K_{NRP\text{-}sess}$ ID contents (octet 2)

This field contains the 8 most significant bits of $K_{NRP\text{-}sess}$ ID.

NOTE: This field is set to all zeros if the $K_{NRP\text{-}sess}$ ID is not generated, i.e., the null integrity algorithm is used.

12.3.17 K_{NRP} ID

The purpose of the K_{NRP} ID information element is to carry the identity of the K_{NRP} held by a UE.

The K_{NRP} ID is a type 3 information element with a length of 5 octets.

The K_{NRP} ID information element is coded as shown in figure 12.3.17.1 and table 12.3.17.1

8	7	6	5	4	3	2	1	
K_{NRP} ID IEI								octet 1
K_{NRP} ID contents								octet 2
								octet 5
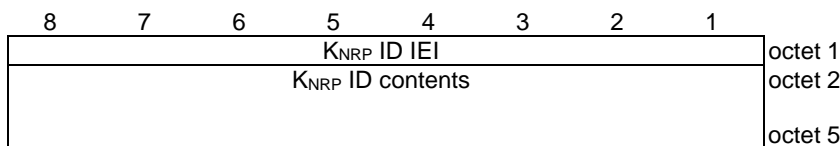
Figure 12.3.17.1: K_{NRP} ID information element

Table 12.3.17.1: K_{NRP} ID information element

K_{NRP} ID contents (octet 2 to 5)

This field contains the 32-bit identifier of a K_{NRP}.

12.3.18 Selected security algorithms

The purpose of the Selected security algorithms information element is to indicate the algorithms to be used for ciphering and integrity protection.

The Selected security algorithms is a type 3 information element with a length of 2 octets.

The Selected security algorithms information element is coded as shown in figure 12.3.18.1 and table 12.3.18.1.

8	7	6	5	4	3	2	1	
Selected security algorithms IEI								octet 1
0 spare	Type of ciphering algorithm			0 spare	Type of integrity protection algorithm			octet 2

Figure 12.3.18.1: Selected security algorithms information element

Table 12.3.18.1: Selected security algorithms information element

```
Type of integrity protection algorithm (octet 2, bit 1 to 3)
Bits
3   2   1
0   0   0        5GS integrity algorithm 5G-IA0 (null integrity protection algorithm)
0   0   1        5GS integrity algorithm 128-5G-IA1
0   1   0        5GS integrity algorithm 128-5G-IA2
0   1   1        5GS integrity algorithm 128-5G-IA3
1   0   0        5GS integrity algorithm 5G-IA4
1   0   1        5GS integrity algorithm 5G-IA5
1   1   0        5GS integrity algorithm 5G-IA6
1   1   1        5GS integrity algorithm 5G-IA7

Type of ciphering algorithm (octet 2, bit 5 to 7)
Bits
7   6   5
0   0   0        5GS encryption algorithm 5G-EA0 (null ciphering algorithm)
0   0   1        5GS encryption algorithm 128-5G-EA1
0   1   0        5GS encryption algorithm 128-5G-EA2
0   1   1        5GS encryption algorithm 128-5G-EA3
1   0   0        5GS encryption algorithm 5G-EA4
1   0   1        5GS encryption algorithm 5G-EA5
1   1   0        5GS encryption algorithm 5G-EA6
1   1   1        5GS encryption algorithm 5G-EA7

Bit 4 and 8 of octet 2 are spare and shall be coded as zero.
```

12.3.19 LSB of $K_{NRP-sess}$ ID

The purpose of the LSB of $K_{NRP-sess}$ ID information element is to carry the 8 least significant bits of the $K_{NRP-sess}$ ID.

The LSB of $K_{NRP-sess}$ ID is a type 3 information element with a length of 2 octets.

The LSB of $K_{NRP-sess}$ ID information element is coded as shown in figure 12.3.19.1 and table 12.3.19.1.

8	7	6	5	4	3	2	1	
			LSB of $K_{NRP-sess}$ ID					octet 1
			LSB of $K_{NRP-sess}$ ID contents					octet 2
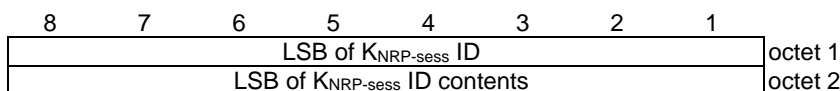
Figure 12.3.19.1: LSB of $K_{NRP-sess}$ ID information element

Table 12.3.19.1: LSB of $K_{NRP-sess}$ ID information element

```
LSB of K_NRP-sess ID contents (octet 2)

This field contains the 8 least significant bits of K_NRP-sess ID.
```

12.3.20 MSBs of K_{NRP} ID

The purpose of the MSBs of K_{NRP} ID information element is to carry the 16 most significant bits of the K_{NRP} ID.

The MSBs of K_{NRP} ID is a type 3 information element with a length of 3 octets.

The MSBs of K_{NRP} ID information element is coded as shown in figure 12.3.20.1 and table 12.3.20.1.

8	7	6	5	4	3	2	1	
			MSBs of K_{NRP} ID IEI					octet 1
			MSBs of K_{NRP} ID contents					octet 2
								octet 3
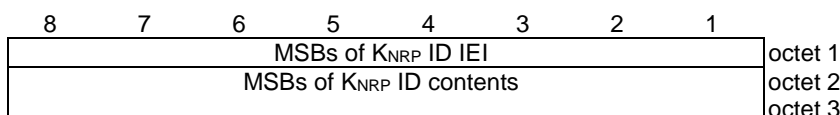
Figure 12.3.20.1: MSBs of K_{NRP} ID information element

Table 12.3.20.1: MSBs of K_{NRP} ID information element

MSBs of K_{NRP} ID contents (octet 2 to 3)
This field contains the 16 most significant bits of K_{NRP} ID.

12.3.21 LSBs of K_{NRP} ID

The purpose of the LSBs of K_{NRP} ID information element is to carry the 16 least significant bits of the K_{NRP} ID.

The LSBs of K_{NRP} ID is a type 3 information element with a length of 3 octets.

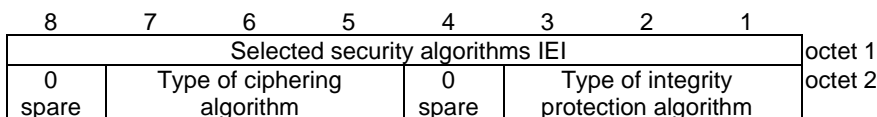The LSBs of K_{NRP} ID information element is coded as shown in figure 12.3.21.1 and table 12.3.21.1.

8	7	6	5	4	3	2	1	
LSBs of K_{NRP} ID IEI								octet 1
LSBs of K_{NRP} ID contents								octet 2
								octet 3
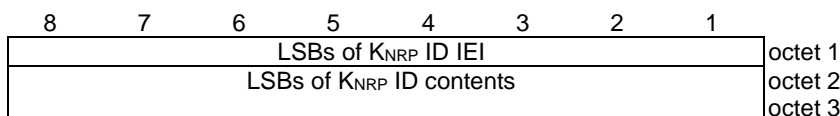
Figure 12.3.21.1: LSBs of K_{NRP} ID information element

Table 12.3.21.1: LSBs of K_{NRP} ID information element

LSBs of K_{NRP} ID contents (octet 2 to 3)
This field contains the 16 least significant bits of K_{NRP} ID.

12.3.22 UE PC5 unicast user plane security policy

The purpose of the UE PC5 unicast user plane security policy information element is to indicate the UE's configuration for integrity protection and ciphering of PC5 user plane data.

The UE PC5 unicast user plane security policy is a type 3 information element with a length of 2 octets.

The UE PC5 unicast user plane security policy information element is coded as shown in figure 12.3.22.1 and table 12.3.22.1.

8	7	6	5	4	3	2	1	
UE PC5 unicast user plane security policy IEI								octet 1
0 spare	User plane ciphering policy			0 spare	User plane integrity protection policy			octet 2
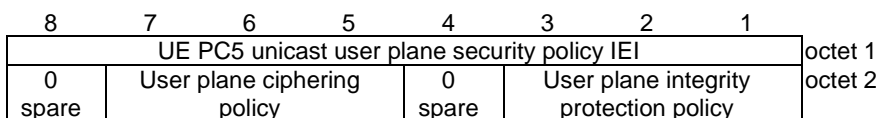
Figure 12.3.22.1: UE PC5 unicast user plane security policy information element

Table 12.3.22.1: UE PC5 unicast user plane security policy information element

```
User plane integrity protection policy (octet 2, bit 1 to 3)
Bits
3  2  1
0  0  0        User plane integrity protection not needed
0  0  1        User plane integrity protection preferred
0  1  0        User plane integrity protection required
0  1  1
   to Spare
1  1  0
1  1  1        Reserved

If the UE receives a user plane integrity protection policy value that the UE does not
understand, the UE shall interpret the value as 010 "user plane integrity protection
required".

User plane ciphering policy (octet 2, bit 5 to 7)
Bits
7  6  5
0  0  0        User plane ciphering not needed
0  0  1        User plane ciphering preferred
0  1  0        User plane ciphering required
0  1  1
   to Spare
1  1  0
1  1  1        Reserved

If the UE receives a user plane ciphering protection policy value that the UE does not
understand, the UE shall interpret the value as 010 "user plane ciphering protection
required".

Bit 4 and 8 of octet 2 are spare and shall be coded as zero.
```

12.3.23 Configuration of UE PC5 unicast user plane security protection

The purpose of the configuration of UE PC5 unicast user plane security protection information element is to indicate the agreed configuration for security protection of PC5 user plane data between UEs over the PC5 unicast link.

The configuration of UE PC5 unicast user plane security protection is a type 3 information element with a length of 2 octets.

The configuration of UE PC5 unicast user plane security protection information element is coded as shown in figure 12.3.23.1 and table 12.3.23.1.

8	7	6	5	4	3	2	1	
configuration of UE PC5 unicast user plane security protection IEI								octet 1
0 spare	User plane ciphering configuration			0 spare	User plane integrity protection configuration			octet 2

Figure 8.4.23.1: Configuration of UE PC5 unicast user plane security protection information element

Table 8.4.23.1: Configuration of UE PC5 unicast user plane security protection information element

```
User plane integrity protection configuration (octet 2, bit 1 to 3)
Bits
3   2   1
0   0   0     Off
0   0   1     Off or On
0   1   0     On
0   1   1
    to  Spare
1   1   0
1   1   1     Reserved

User plane ciphering configuration (octet 2, bit 5 to 7)
Bits
7   6   5
0   0   0     Off
0   0   1     Off or On
0   1   0     On
0   1   1
    to  Spare
1   1   0
1   1   1     Reserved

Bit 4 and 8 of octet 2 are spare and shall be coded as zero.
```

12.3.24   Re-authentication indication

The purpose of the Re-authentication indication information element is to indication that K_{NRP} needs to be refreshed.

The Re-authentication indication information element is a type 3 information element, with a length of 2 octets.

The Re-authentication indication information element is coded as shown in figure 12.3.24.1 and table 12.3.24.1.

8	7	6	5	4	3	2	1	
Re-authentication indication IEI								octet 1
Re-authentication indication contents								octet 2
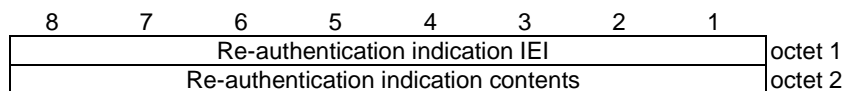
Figure 12.3.24.1: Re-authentication indication information element

Table 12.3.24.1: Re-authentication indication information element

```
Re-authentication indication contents (octet 2)

Bits
1
0  Reserved
1  KNRP is requested to be refreshed

Bits 2 to 8 of octet 2 are spare and shall be coded as zero.
```

12.3.25   Key establishment information container

The Key establishment information container information element contains information for A2X PC5 unicast link key establishment.

The Key establishment information container is a type 6 information element with a minimum length of 4 octets.

The Key establishment information container information element is coded as shown in figure 12.3.25.1 and table 12.3.25.1.

8	7	6	5	4	3	2	1	
Key establishment information container IEI								octet 1
Length of key establishment information container contents								octet 2
								octet 3
Key establishment information container contents								octet 4
								octet n
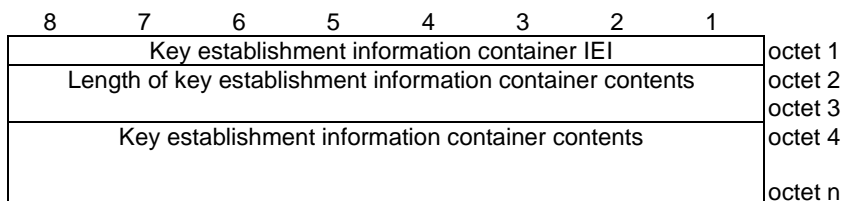
Figure 12.3.25.1: Key establishment information container information element

Table 12.3.25.1: Key establishment information container information element

Key establishment information container contents (octet 4 to n)
This field contains the key establishment information container.

12A Coding other than information element coding

12A.1 Overview

This clause contains the coding of information other than the one provided by the information elements described in clause 12.

12A.2 A2X message family encoding

The values are specified to identify the A2X message family according to table 12A.2.1.

Table 12A.2.1: A2X message family

A2X message family (octet 1)
Bits
8 7 6 5 4 3 2 1
0 0 0 0 0 0 0 0   Reserved
1 1 1 1 1 1 1 1   Operator specific
All other values are spare.

NOTE: In this release of the specification, no specific standard application for A2X message family is available and the A2X message family can be set to "Operator specific".

12A.3 Non-IP PDU format

The non-IP PDU is coded according to figure 12A.3.1 and table 12A.3.1

			Bits					
8	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**Octets**
Non-IP type								1
								2
Non-IP payload								
								n
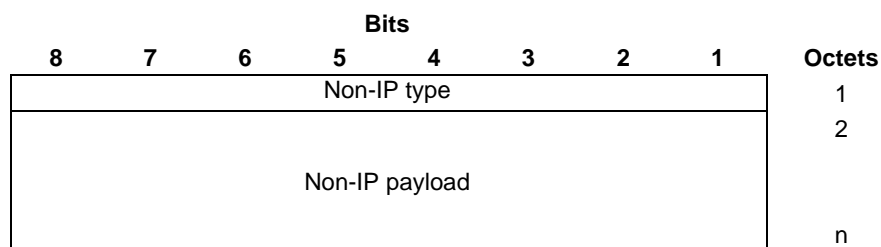
Figure 12A.3.1: Non-IP PDU format

> Octet 1 contains the non-IP type field which indicates the A2X message family (see table 12A.2.1) included in the non-IP payload.
>
> Octets 2 to n contain the non-IP payload field containing the non-IP data.

12A.4 Encoding of A2X MBS configuration SDP

12A.4.1 Minimum components of A2X MBS configuration SDP

The A2X MBS configuration SDP shall contain at least the following parameters:

  a) IP multicast address used for A2X communication over Uu using MBS; and

  b) a list of UDP port numbers used for A2X communication over Uu using MBS, each associated with a A2X message family or IP type of data as defined in clause 12A.2.

These shall be expressed in SDP syntax (see IETF RFC 4566 [22]) according to the following clauses.

In a A2X MBS configuration SDP body, sending entity shall not include any media announcement field ("m=") other than the one specified in clause 12A.4.3.

In a A2X MBS configuration SDP body, receiving entity shall ignore any media announcement field ("m=") other than the one specified in clause 12A.4.3.

12A.4.2 IP multicast address

The IP multicast address shall be defined according to the "connection data" field ("c=") of IETF RFC 4566 [22].

12A.4.3 List of UDP port numbers and associated A2X message family

The association between a UDP port number and a A2X message family is defined according to the media announcement field ("m=") of IETF RFC 4566 [22], with:

  a) the <port> portion set to the UDP port number;

  b) the <media> portion set to "application";

  c) the <transport> portion set to "udp";

  d) the <fmt> portion set to "vnd.3gpp.5gsa2x"; and

  e) an fmtp attribute:

     1) with the <format> portion set to "vnd.3gpp.5gsa2x"; and

     2) with the <format specific parameters> portion containing a semicolon separated list of parameters as specified in clause A.1.2 with:

        A) a type parameter set to IP or non-IP; and

        B) if a UDP port is used for exchange of A2X messages of non-IP type of data, a a2x-message-family parameter set to the value of the associated A2X message family as specified in clause 12A.2.

If multiple parameters are indicated in the <format specific parameters> portion of an fmpt attribute with the <format> portion set to "vnd.3gpp.5gsa2x", the order of parameters is not significant.

Sending entity shall not include any parameter not defined in the present version of the present specification in the <format specific parameters> portion of an fmpt attribute with the <format> portion set to "vnd.3gpp.5gsa2x".

Receiving entity shall ignore any parameter included in the <format specific parameters> portion of an fmpt attribute with the <format> portion set to "vnd.3gpp.5gsa2x", such that the parameter is not specified in the present version of the present specification.

Receiving entity shall ignore the media announcement field ("m=") if the type parameter does not contain a value or contains a value not specified in the present version of the present specification.

12A.4.4 Example of A2X MBS configuration SDP

Here is an example of a A2X MBS configuration SDP:

```
v=0
o=user123 2890844526 2890842807 IN IP6 2201:056D::112E:144A:1E24
s=A2X MBS configuration SDP example
c=IN IP6 FF15::101
m=application 1234 udp vnd.3gpp.5gsa2x
a=fmtp:vnd.3gpp.5gsa2x type=non-IP;a2x-message-family=1
m=application 1235 udp vnd.3gpp.5gsa2x
a=fmtp:vnd.3gpp.5gsa2x a2x-message-family=2;type=non-IP
m=application 1236 udp vnd.3gpp.5gsa2x
a=fmtp:vnd.3gpp.5gsa2x a2x-message-family=3;type=non-IP
m=application 1237 udp vnd.3gpp.5gsa2x
a=fmtp:vnd.3gpp.5gsa2x type=ip
```

12A.4.5 MIME types

The MIME types used by the specification are the following:

a) vnd.3gpp.5gsa2x.

12A.5   Encoding of A2X AS MBS configuration SDP

12A.5.1 Minimum components of A2X AS MBS configuration SDP

The A2X AS MBS configuration SDP shall contain at least the following parameters:

a) IP multicast address used for A2X application server discovery using MBS;

b) transport protocol used for A2X application server discovery using MBS, set to UDP;

c) UDP port number used for A2X application server discovery using MBS;

d) media type set to "application"; and

e) media format set to "vnd.3gpp-5gsa2x-local-service-information".

These parameters shall be expressed in SDP syntax (see IETF RFC 4566 [31]) according to the following clauses.

12A.5.2 IP multicast address

The IP multicast address shall be defined according to the "connection data" field ("c=") of IETF RFC 4566 [31].

12A.5.3 Port number

The UDP port number shall be defined according to the <port> sub-field of the media announcement field ("m=") of IETF RFC 4566 [31].

12A.5.4 Transport protocol

The transport protocol shall be defined according to the <proto> sub-field of the media announcement field ("m=") of IETF RFC 4566 [31] and shall be set to "UDP".

12A.5.5　Media type

The media type shall be defined according to the <media> sub-field of the media announcement field ("m=") of IETF RFC 4566 [31] and shall be set to "application".

12A.5.6　Media format

The media format shall be defined according to the <fmt> sub-field of the media announcement field ("m=") of IETF RFC 4566 [31] and shall be set to "vnd.3gpp-5ga2x-local-service-information".

12A.5.7　Example of A2X AS MBS configuration SDP

Here is an example of a A2X AS MBS configuration SDP:

```
v=0
o=user123 2890844526 2890842807 IN IP6 2201:056D::112E:144A:1E24
s=A2X AS MBS configuration SDP example
c=IN IP6 FF15::101
m=application 1234 UDP vnd.3gpp-5ga2x-local-service-information
```

12A.6　Encoding of A2X local service information

12A.6.1　General

This clause defines the format of the A2X local service information.

This clause also defines the MIME type used to convey the A2X local service information over MBS radio bearers.

12A.6.2　application/vnd.3gpp-5gsa2x-local-service-information

The MIME type is used to carry information related to the local A2X application server, and optionally the A2X MBS configuration. It shall be coded in binary ASN.1 PER as specified below.

```
-- ASN1START

A2X-local-service-information-definitions DEFINITIONS AUTOMATIC TAGS ::= BEGIN

    A2X-local-service-information ::= SEQUENCE {
        a2x-as-info-list            ListOfA2X-as-info,
        a2x-mbs-configuration-list  ListOfA2X-MBS-configuration     OPTIONAL,
        ...
    }

    ListOfA2X-as-info ::= SEQUENCE OF A2X-as-info

    ListOfA2X-MBS-configuration ::= SEQUENCE OF A2X-MBS-configuration


    A2X-as-info ::= SEQUENCE {
        a2x-service-identifier      OCTET STRING (SIZE (4)),
        a2x-as-address              A2X-as-address,
        udp-port                    INTEGER,
        ...
    }

    A2X-MBS-configuration ::= SEQUENCE {
        a2x-service-identifier      OCTET STRING (SIZE (4)),
        tmgi                        OCTET STRING (SIZE (6)),
        mbs-service-type            MBS-service-type,
        mbs-service-area            List-of-MBS-service-area-parameters     OPTIONAL,
        frequency-selection-parameter Frequency-assistance-information      OPTIONAL,
        ip-multicast-address        IP-multicast-address,
        udp-port                    INTEGER,
        ...
    }
```

```
    MBS-service-type ::= ENUMERATED {
        multicast   (0),
        broadcast   (1),
        ...
    }

    Frequency-assistance-information ::= SEQUENCE {
        frequency      INTEGER (0..3279165)   OPTIONAL,
        mbs-fsai-list  MBS-FSAI-List          OPTIONAL
    }

    MBS-FSAI-List ::= SEQUENCE OF MBS-FSAI

    MBS-FSAI ::= OCTET STRING (SIZE (3))

    List-of-MBS-service-area-parameters ::= SEQUENCE OF MBS-service-area-parameter
    MBS-service-area-parameter ::= CHOICE {
        tai    OCTET STRING (SIZE (6)),
        cell-id OCTET STRING (SIZE (8)),
        ...
    }

    IP-multicast-address ::= CHOICE {
        ipv4-address        OCTET STRING (SIZE (4)),
        ipv6-address        OCTET STRING (SIZE (16)),
        ipv4v6-address      IPv4v6-address,
        ...
    }

    A2X-as-address ::= CHOICE {
        ipv4-address        OCTET STRING (SIZE (4)),
        ipv6-address        OCTET STRING (SIZE (16)),
        ipv4v6-address      IPv4v6-address,
        fqdn                VisibleString,
        ...
    }

    IPv4v6-address ::= SEQUENCE {
        ipv4-address        OCTET STRING (SIZE (4)),
        ipv6-address        OCTET STRING (SIZE (16)),
        ...
    }

END

-- ASN1STOP
```

12A.6.3 Semantics

The A2X-local-service-information contains the following elements:

a) a2x-as-info-list element containing one or more A2X-AS-info element(s). Each A2X-AS-info element describes an association between a A2X service identifier and one or more A2X application server address(es) and consists of:

   1) one a2x-service-identifier element containing a 4 octet A2X service identifier;

   2) one a2x-as-address element containing an IPv4 address, an IPv6 address, IPv4 and IPv6 addresses, or an FQDN, of the A2X application server; and

   3) one udp-port element containing a UDP port; and

b) optionally, a a2x-mbs-configuration-list element. The a2x-mbs-configuration-list element contains one or more A2X-MBS-configuration element(s). Each A2X-MBS-configuration element contains information enabling the UE to discover and acquire A2X communication over Uu using MBS and consists of the following:

   1) one a2x-service-identifier element containing a 4 octet A2X service identifier;

   2) one tmgi element containing the TMGI encoded as specified in 3GPP TS 24.008 [26] excluding the temporary mobile group identity IEI field and the length of temporary mobile group identity contents field;

3) an mbs-service-type element, containing an MBS service type, which indicates whether the MBS session is multicast or broadcast;

4) optionally, one mbs-service-area element, containing information on the MBS Service Area as specified in 3GPP TS 23.247 [27]. The mbs-service-area element is a list containing one or more mbs-service-area-parameter element(s), where each mbs-service-area-parameter element is one of:

   A) a tai element containing the tracking area identifier encoded as specified in 3GPP TS 24.501 [6] figure 9.11.3.9.3 not including octet 1; or

   B) a cell-id element containing the NR cell global identity encoded as specified in 3GPP TS 24.501 [6] figure 9.11.4.31.7;

5) optionally, a frequency selection parameter element, containing:

   A) a frequency element containing a frequency encoded as specified in 3GPP TS 38.331 [11];

   B) an mbs-fsai-list element containing a list of MBS FSA IDs. Each MBS FSA ID is a binary encoded 3 octet string; or

   C) both;

6) one ip-multicast-address element containing an IPv4 multicast address, an IPv6 multicast address, or IPv4 and IPv6 multicast addresses; and

7) one udp-port element containing a UDP port.

13 List of system parameters

13.1 General

The description of timers in the following tables should be considered a brief summary. The complete descriptions of the timers are in the procedures defined in clauses 5 and 6.

13.2 Timers of provisioning of parameters for A2X configuration procedures

Timers of provisioning of parameters for A2X configuration are shown in table 13.2.1.

NOTE: Timer T5040 is defined in 3GPP TS 24.587 [9].

Table 13.2.1: Timers of provisioning of parameters for A2X configuration – UE side

TIMER NUM.	TIMER VALUE	CAUSE OF START	NORMAL STOP	ON EXPIRY
T5341	NOTE 1	Start using the new UE policies for A2X communication over PC5 received in MANAGE UE POLICY COMMAND message	Stop using the old UE policies for A2X communication over PC5	Initiate the UE-requested A2X policy provisioning procedure
T5342	NOTE 2	Start using the new UE policies for A2X communication over Uu received in MANAGE UE POLICY COMMAND message	Stop using the old UE policies for A2X communication over Uu	Initiate the UE-requested A2X policy provisioning procedure
NOTE 1: The value of this timer is the validity timer value which is one of the configuration parameters for A2X communication over PC5 (see clause 5.2) and it is specified in 3GPP TS 24.578 [8] clause 5.3.				
NOTE 2: The value of this timer is the validity timer value which is one of the configuration parameters for A2X communication over Uu (see clause 5.2.7) and it is specified in 3GPP TS 24.578 [7] clause 5.4.				

13.3 Timers of A2X PC5 unicast link management procedures

Table 13.3.1: A2X PC5 unicast link management timers

TIMER NUM.	TIMER VALUE	CAUSE OF START	NORMAL STOP	ON EXPIRY
T5300	8s NOTE 1	Upon sending an A2X DIRECT LINK ESTABLISHMENT REQUEST message	Upon receiving an A2X DIRECT LINK ESTABLISHMENT ACCEPT or A2X DIRECT LINK ESTABLISHMENT REJECT message from the target UE if the Target user info is included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message	Retransmission of A2X DIRECT LINK ESTABLISHMENT REQUEST message if the Target user info is included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message; or may abort the ongoing procedure if the Target user info is not included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message
T5301	5s	Upon sending an A2X DIRECT LINK MODIFICATION REQUEST message	Upon receiving an A2X DIRECT LINK MODIFICATION ACCEPT or A2X DIRECT LINK MODIFICATION REJECT or A2X DIRECT LINK RELEASE REQUEST message from the target UE	Retransmission of A2X DIRECT LINK MODIFICATION REQUEST message
T5302	5s	Upon sending an A2X DIRECT LINK RELEASE REQUEST message	Upon receiving an A2X DIRECT LINK RELEASE ACCEPT message from the target UE	Retransmission of A2X DIRECT LINK RELEASE REQUEST message
T5303	Default 10m NOTE 2	Upon receiving a Maximum inactivity period in an A2X DIRECT LINK KEEPALIVE REQUEST message, receiving a PC5 signalling message or receiving PC5 user plane data	Upon receiving a PC5 signalling message or PC5 user plane data	Either initiate the A2X PC5 unicast link keep-alive procedure or the A2X PC5 unicast link release procedure
T5304	2s	Upon sending an A2X DIRECT LINK AUTHENTICATION REQUEST message	Upon receiving an A2X DIRECT LINK AUTHENTICATION RESPONSE or A2X DIRECT LINK AUTHENTICATION REJECT message from the target UE	Retransmission of A2X DIRECT LINK AUTHENTICATION REQUEST message
T5305	NOTE 2	Upon establishing an A2X PC5 unicast link and at least one of A2X service identifier for the A2X PC5 unicast link satisfying the privacy requirements or upon completing an A2X PC5 unicast link identifier update and at least one of A2X service identifiers for the A2X PC5 unicast link satisfying the privacy requirements.	Upon completing an A2X PC5 unicast link identifier update and if available or accepting an A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message or upon an A2X PC5 unicast link release and if available	Transmission of A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message

TIMER NUM.	TIMER VALUE	CAUSE OF START	NORMAL STOP	ON EXPIRY
T5306	2s	Upon sending an A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message	Upon receiving an A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT or A2X DIRECT LINK IDENTIFIER UPDATE REJECT or A2X DIRECT LINK RELEASE REQUEST message from the target UE	Retransmission of the A2X DIRECT LINK IDENTIFIER UPDATE REQUEST message
T5307	2s	Upon sending an A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message	Upon receiving an A2X DIRECT LINK IDENTIFIER UPDATE ACK message or A2X DIRECT LINK RELEASE REQUEST message from the initiating UE	Retransmission of the A2X DIRECT LINK IDENTIFIER UPDATE ACCEPT message
T5308	5s	Upon receiving an A2X PC5 signalling message or A2X PC5 user plane data	Upon A2X PC5 unicast link release or upon initiating the A2X PC5 unicast link keep-alive procedure	Initiate the A2X PC5 unicast link keep-alive procedure
T5309	5s	Upon sending an A2X DIRECT LINK KEEPALIVE REQUEST message	Upon receiving an A2X PC5 signalling message or A2X PC5 user plane data	Retransmission of the A2X DIRECT LINK KEEPALIVE REQUEST message
T5310	2s	Upon sending an A2X DIRECT LINK SECURITY MODE COMMAND message	Upon receiving an A2X DIRECT LINK SECURITY MODE COMPLETE or A2X DIRECT LINK SECURITY MODE REJECT message from the target UE	Retransmission of A2X DIRECT LINK SECURITY MODE COMMAND message
T5311	8s	Upon sending an A2X DIRECT LINK REKEYING REQUEST message	Upon receiving an A2X DIRECT LINK REKEYING RESPONSE message or A2X DIRECT LINK RELEASE REQUEST message from the target UE	Retransmission of A2X DIRECT LINK REKEYING REQUEST message
NOTE 1	If the Target user info is not included in the A2X DIRECT LINK ESTABLISHMENT REQUEST message, then the initiating UE may keep the timer T5300 running upon receiving A2X DIRECT LINK ESTABLISHMENT ACCEPT message.			
NOTE 2	The value of this timer is the privacy timer value which is one of the configuration parameters for A2X communication over PC5 (see clause 5.2) and it is specified in 3GPP TS 24.578 [8] clause 5.3.			

13.4 Timers of PC5 broadcast mode A2X communication

Table 13.4.1: PC5 broadcast mode A2X communication timers

TIMER NUM.	TIMER VALUE	CAUSE OF START	NORMAL STOP	ON EXPIRY
T5320	NOTE 1	Upon initiating transmission of broadcast mode A2X communication over PC5, as described in clause 6.1.3.2.4. Upon receiving an indication from upper layers that the application layer identifier has been changed while performing transmission of broadcast mode A2X communication over PC5, as described in clause 6.1.3.2.4. Upon T5320 expiration while performing transmission of broadcast mode A2X communication over PC5, as described in clause 6.1.3.2.4.	Upon stopping transmission of broadcast mode A2X communication over PC5, as described in clause 6.1.3.2.4.	Change the value of the source layer-2 ID self-assigned by the UE for broadcast mode A2X communication over PC5. If the A2X message contains IP data, change the value of the source IP address self-assigned by the UE for broadcast mode A2X communication over PC5.
NOTE 1		The value of this timer is the privacy timer value which is one of the configuration parameters for A2X communication over PC5 (see clause 5.2),		

3GPP

Annex A (informative):
IANA registration template

A.1 vnd.3gpp.5gsa2x MIME type

A.1.1 vnd.3gpp.5gsa2x MIME type registration

Your Name:

<TS rapporteur name>

Your Email Address:

<TS rapporteur email address>

Media Type Name:

Application

Subtype name:

Vendor tree – vnd.3gpp.5gsa2x

Required parameters:

type parameter.

The type parameter can be set to "IP", or "non-IP".

A content of the application/vnd.3gpp.5gsa2x MIME type with the type parameter set to "IP" contains one A2X message such that the A2X message is an IP packet.

A content of the application/vnd.3gpp.5gsa2x MIME type with the type parameter set to "non-IP" and the a2x-message-family parameter indicating a A2X message family contains one A2X message of the A2X message family.

Optional parameters:

a2x-message-family parameter.

The a2x-message-family parameter is included when the type parameter is set to "non-IP". Permissible values of the a2x-message-family are specified in 3GPP TS 24.577 clause 12A.2.

Encoding considerations:

binary.

Security considerations:

This media type does not include provisions for directives that institute actions on a recipient's files or other resources.

The information transported in this media type does not include active or executable content.

This media type does not include provisions for directives that institute actions that, while not directly harmful to the recipient, may result in disclosure of information that either facilitates a subsequent attack or else violates a recipient's privacy in any way.

This media type does not employ compression.

This media type is not targeted for applications that require some sort of security assurance but don't provide the necessary security mechanisms themselves. The security assurance is expected to be provided by the environment this media type operates in. When this media type operates in environment described in 3GPP TS 33.185, security mechanisms are described in 3GPP TS 33.185.

Interoperability considerations:

Receiving entity shall ignore any media type parameter not defined in this media type registration.

If a content of the application/vnd.3gpp.5gsa2x MIME type is transported using UDP transport, the UDP message contains one A2X message.

Published specification:

3GPP TS 24.577 (http://www.3gpp.org/ftp/Specs/html-info/24577.htm)

Applications which use this media type:

A2X applications

Fragment identifier considerations:

This media type does not specify how applications interpret fragment identifiers associated with the media type.

Restrictions on usage:

None

Provisional registration? (standards tree only):

n/a

Additional information:

1. Deprecated alias names for this type: n/a

2. Magic number(s): n/a

3. File extension(s): n/a

4. Macintosh File Type Code(s):   n/a

5. Object Identifier(s) or OID(s):   n/a

Intended usage:

Common.

Other information/general comment:

The media type is intended to be used for A2X communication.

Person to contact for further information:

-   Name: <MCC specification manager>

-   Email: <MCC specification manager email address>

-   Author/Change controller:

    i)   Author: 3GPP CT1 Working Group/3GPP_TSG_CT_WG1@LIST.ETSI.ORG

    ii) Change controller: <MCC specification manager name>/<MCC specification manager email address>

A.1.2   Mapping vnd.3gpp.5gsa2x MIME parameters into SDP

The information carried in the MIME application type has a specific mapping to fields in SDP.

A vnd.3gpp.5gsa2x connection shall be described by using an SDP m line. According to IETF RFC 4566 [22], the m-line format is the following:

    m=<media> <port> <transport> <fmt>

For vnd.3gpp.5gsa2x:

- the media type field shall have a value of "application";

- the port field shall include the transport port for A2X;

- the transport field shall have a value of "udp";

- the format field shall have a value of "vnd.3gpp.5gsa2x".

The following is an example of an m line for a vnd.3gpp.5gsa2x connection:

m=application 1234 udp vnd.3gpp.5gsa2x

The vnd.3gpp.5gsa2x media type parameters are indicated in the <format specific parameters> portion of the SDP "a=fmtp" attribute by a semicolon separated list of parameters as shown in table A.1.2-1.

Table A.1.2-1: ABNF syntax of the <format specific parameters> portion of the SDP "a=fmtp" attribute

```
format-specific-parameters = param *( ";" param )
param                      = param-name [ "=" param-value ]
param-name                 = ALPHA *(ALPHA / DIGIT / "-")
param-value                = *( param-char )
param-char                 = *( %x20-3A / %x3C-FF )
```

The following is an example of an attribute line for vnd.3gpp.5gsa2x options:

a=fmtp:vnd.3gpp.5gsa2x type=non-IP;5gsa2x-message-family=1

A.2 vnd.3gpp.5gsa2x-local-service-information MIME type

A.2.1 vnd.3gpp.5gsa2x-local-service-information MIME type registration

Your Name:

<TS rapporteur name>

Your Email Address:

<TS rapporteur email address>

Media Type Name:

Application

Subtype name:

Vendor tree – vnd.3gpp.5gsa2x-local-service-information

Required parameters:

None.

Optional parameters:

None.

Encoding considerations:

binary.

Security considerations:

The information transported in this media type does not include active or executable content. Mechanisms for privacy and integrity protection of protocol parameters exist. Those mechanisms as well as authentication and further security mechanisms are described in 3GPP TS 33.185.

This media type does not include provisions for directives that institute actions on a recipient's files or other resources.

This media type does not include provisions for directives that institute actions that, while not directly harmful to the recipient, may result in disclosure of information that either facilitates a subsequent attack or else violates a recipient's privacy in any way.

This media type does not employ compression.

Interoperability considerations:

The media type allows for interoperability of messages transmitted for A2X over MBS bearers. The messages are sent between user equipment and mobile network.

Published specification:

3GPP TS 24.577 (http://www.3gpp.org/ftp/Specs/html-info/24577.htm)

Applications which use this media type:

n/a

Fragment identifier considerations:

The handling in section 5 of IETF RFC 7303 applies.

Restrictions on usage:

None

Provisional registration? (standards tree only):

n/a

Additional information:

1. Deprecated alias names for this type: n/a

2. Magic number(s): n/a

3. File extension(s):   n/a

4. Macintosh File Type Code(s):   n/a

5. Object Identifier(s) or OID(s):   n/a

Intended usage:

Common.

Other information/general comment:

The media type is intended to be used for A2X communication. The content of this media type is formatted according to 3GPP TS 24.577 subclause 12A.X.

Person to contact for further information:

- Name: <MCC specification manager>

- Email: <MCC specification manager email address>

- Author/Change controller:

    i)   Author: 3GPP CT1 Working Group/3GPP_TSG_CT_WG1@LIST.ETSI.ORG

ii) Change controller: <MCC specification manager name>/<MCC specification manager email address>

Annex B (informative):
Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2023-04	CT1#141e	C1-232773	-	-	-	TS skeleton from Rapporteur	0.0.0
2023-04	C1#141e	C1-232755	-	-	-	Pseudo-CR on general section on direct C2 communication	0.1.0
2023-04	C1#141e	C1-232772	-	-	-	TS 24.577 Scope, reference, and general sections	0.1.0
2023-04	C1#141e	C1-232774	-	-	-	TS 24.577 general section for A2 comm, BRID, DDAA	0.1.0
2023-04	C1#141e	C1-232717	-	-	-	Pseudo-CR on Provisioning of parameters for A2X configuration	0.1.0
2023-04	C1#141e	C1-232718	-	-	-	Pseudo-CR on A2X communication over PC5 and A2X PC5 unicast link establishment procedure	0.1.0
2023-04	C1#141e	C1-232719	-	-	-	Pseudo-CR on A2X PC5 unicast link modification procedure	0.1.0
2023-04	C1#141e	C1-232720	-	-	-	Pseudo-CR on A2X PC5 unicast link release procedure	0.1.0
2023-04	C1#141e	C1-232721	-	-	-	Pseudo-CR on Broadcast mode A2X communication over PC5	0.1.0
2023-04	C1#141e	C1-232846	-	-	-	Pseudo-CR on procedures for direct C2 communication	0.1.0
2023-04	-	-		-	-	Editorial correction by Rapporteur	0.1.1
2023-05	C1#142	C1-233215		-		Pseudo-CR on clarification of only NR PC5 supported for direct C2 communication	0.2.0
2023-05	C1#142	C1-233234		-		Pseudo-CR on Data transmission over A2X PC5 unicast link	0.2.0
2023-05	C1#142	C1-233235		-		Pseudo-CR on PC5 QoS over A2X PC5 unicast link	0.2.0
2023-05	C1#142	C1-233237		-		Pseudo-CR on A2X communication over NR-PC5 in case of different PLMNs	0.2.0
2023-05	C1#142	C1-233385		-		Clarification on direct c2 communication as A2X services	0.2.0
2023-05	C1#142	C1-233386		-		Removing ENs in TS 24.577	0.2.0
2023-05	C1#142	C1-233939		-		Pseudo-CR on configuration parameters for direct C2 communication over PC5	0.2.0
2023-05	C1#142	C1-233943		-		Pseudo-CR on A2X PC5 unicast link identifier update procedure	0.2.0
2023-05	C1#142	C1-233944		-		Pseudo-CR on A2X PC5 unicast link keep-alive procedure	0.2.0
2023-05	C1#142	C1-233945		-		Pseudo-CR on BRID and DDAA authorization for A2X communication over PC5 when UAV is out of network coverage	0.2.0
2023-05	C1#142	C1-233947		-		Pseudo-CR on direct C2 communication authorization in case of no coverage	0.2.0
2023-05	-	-		-		Editorial correction by Rapporteur	0.2.0
2023-08	C1#143	C1-235153				A2X communication over Uu	0.3.0
2023-08	C1#143	C1-235429	-	-	-	Pseudo-CR on A2X PC5 unicast link establishment messages	0.3.0
2023-08	C1#143	C1-235430	-	-	-	Pseudo-CR on A2X PC5 unicast link modification messages	0.3.0
2023-08	C1#143	C1-235431	-	-	-	Pseudo-CR on A2X PC5 unicast link release messages	0.3.0
2023-08	C1#143	C1-235432	-	-	-	Pseudo-CR on A2X PC5 unicast link identifier update messages	0.3.0
2023-08	C1#143	C1-235433	-	-	-	Pseudo-CR on A2X PC5 unicast link keepalive messages	0.3.0
2023-08	C1#143	C1-235435	-	-	-	Pseudo-CR on A2X PC5 Error Handling	0.3.0
2023-08	C1#143	C1-236089	-	-	-	Pseudo-CR on DDAA deconfliction policy and procedure	0.3.0
2023-08	C1#143	C1-236090	-	-	-	Pseudo-CR on BRID procedure	0.3.0
2023-08	C1#143	C1-236091	-	-	-	Pseudo-CR on Non-IP support for A2X communication over PC5	0.3.0
2023-08	C1#143	C1-236092	-	-	-	Pseudo-CR on direct C2 communication procedures	0.3.0
2023-08	C1#143	C1-236093	-	-	Cat	Pseudo-CR on A2X PC5 signalling information elements	0.3.0
2023-08	-	-	-	-	-	Editorial and numbering by Rapporteur	0.3.0
2023-10	C1#144	C1-237323	-	-	-	Pseudo-CR on Security aspects for A2X PC5 unicast link establishment procedure	0.4.0
2023-10	C1#144	C1-237324	-	-	-	Pseudo-CR on Security aspects for A2X PC5 unicast link release procedure	0.4.0
2023-10	C1#144	C1-237325	-	-	-	Pseudo-CR on Seucrity aspects for A2X PC5 unicast link identifier update procedure	0.4.0
2023-10	C1#144	C1-237326	-	-	-	Pseudo-CR on A2X PC5 unicast link authentication procedure	0.4.0
2023-10	C1#144	C1-237328	-	-	-	Pseudo-CR on A2X PC5 unicast link re-keying procedure	0.4.0
2023-10	C1#144	C1-237330	-	-	-	Pseudo-CR on Security aspects for A2X PC5 unicast link establishment messages	0.4.0
2023-10	C1#144	C1-237331	-	-	-	Pseudo-CR on Security aspects for A2X PC5 unicast link release messages	0.4.0
2023-10	C1#144	C1-237332	-	-	-	Pseudo-CR on Security aspects for A2X PC5 unicast link identifier update messages	0.4.0
2023-10	C1#144	C1-238133	-	-	-	Correction to configuration parameters for A2X communication over PC5	0.4.0
2023-10	C1#144	C1-238134	-	-	-	Correction to configuration parameters for A2X communication over Uu	0.4.0
2023-10	C1#144	C1-238135	-	-	-	Pseudo-CR on BRID configuration	0.4.0
2023-10	C1#144	C1-238136	-	-	-	Pseudo-CR on A2X PC5 unicast link security mode control procedure	0.4.0
2023-10	C1#144	C1-238137	-	-	-	Pseudo-CR on A2X PC5 unicast link security	0.4.0
2023-10	C1#144	C1-238138	-	-	-	Pseudo-CR on Security related parameters in A2X PC5 signalling information elements	0.4.0
2023-10	C1#144	C1-238186	-	-	-	Pseudo-CR on A2X related timer name assignment	0.4.0
2023-10	-	-	-	-	-	Editorial correction by Rapporteur	0.4.0
2023-11	C1#145	C1-238558	-	-	-	Pseudo-CR on A2X PC5 unicast link authentication messages	0.5.0

2023-11	C1#145	C1-238559	-		-	-	Pseudo-CR on A2X PC5 unicast link security mode control messages	0.5.0
2023-11	C1#145	C1-238560	-		-	-	Pseudo-CR on A2X PC5 unicast link rekeying messages	0.5.0
2023-11	C1#145	C1-238561	-		-	-	Pseudo-CR on Selected security algorithms for A2X communication over PC5	0.5.0
2023-11	C1#145	C1-238562	-		-	-	Pseudo-CR on UE PC5 unicast user plane security policy for A2X communication over PC5	0.5.0
2023-11	C1#145	C1-238563	-		-	-	Pseudo-CR on Re-authentication indication for A2X communication over PC5	0.5.0
2023-11	C1#145	C1-238565	-		-	-	Pseudo-CR on resolving the EN on requesting radio resources for A2X communication over PC5	0.5.0
2023-11	C1#145	C1-238566	-		-	-	Pseudo-CR on resolving the EN on RAN specifications references for A2X communication over PC5	0.5.0
2023-11	C1#145	C1-238717	-		-	-	Pseudo-CR on resolution of obsolete ENs	0.5.0
2023-11	C1#145	C1-238718	-		-	-	Pseudo-CR on terminology update to specific to A2X	0.5.0
2023-11	C1#145	C1-239013	-		-	-	A2X MBS configuration	0.5.0
2023-11	C1#145	C1-239441	-		-	-	Pseudo-CR on PQI values and PC5 QoS flow descriptions for A2X communication over PC5	0.5.0
2023-11	C1#145	C1-239443	-		-	-	A2X message transport via MBS bearer	0.5.0
2023-11	C1#145	C1-239444	-		-	-	A2X configuration for MBS	0.5.0
2023-11	C1#145	C1-239445	-		-	-	A2X communication over MBS	0.5.0
2023-11	C1#145	-	-		-	-	Editorial correction by Rapporteur	0.5.0
2023-12		-	-		-	-	Version 1.0.0 is created	1.0.0
2024-03	C1#147	C1-241010					Ground based detect and avoid for an area	2.0.0
2024-03	C1#147	C1-241159					Pseudo-CR on Encoding of A2X AS MBS configuration SDP	2.0.0
2024-03	C1#147	C1-241160					Pseudo-CR on BRID over MBS	2.0.0
2024-03	C1#147	C1-241161					Pseudo-CR on A2X MBS in downlink	2.0.0
2024-03	C1#147	C1-241564					Pseudo-CR on A2X message family	2.0.0
2024-03	C1#147	C1-241565					Pseudo-CR on A2XP for out of coverage	2.0.0
2024-03	C1#147	C1-241620					Pseudo-CR on Encoding of A2X local service information	2.0.0
2024-03	C1#147	-					Editorial correction by Rapporteur	2.0.0
2024-03	CT#103	CP-240258					Presentation to TSG CT for approval	2.0.0
2024-03	CT#103						Approved in CT#103	18.0.0

History

Document history		
V18.0.0	May 2024	Publication