

CHANGE REQUEST

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33.103 CR xxx

Current Version: **3.2.0**

GSM (AA.BB) or 3G (AA.BBB) specification number ↑

↑ CR number as allocated by MCC support team

For submission to: **SA #8**
list expected approval meeting # here ↑

for approval
for information

strategic
non-strategic (for SMG use only)

Form: CR cover sheet, version 2 for 3GPP and SMG The latest version of this form is available from: <ftp://ftp.3gpp.org/Information/CR-Form-v2.doc>

Proposed change affects: (U)SIM ME UTRAN / Radio Core Network
(at least one should be marked with an X)

Source: Ericsson **Date:** 2000-05-19

Subject: SQN length

Work item: Security

Category: F Correction **Release:** Phase 2
(only one category shall be marked with an X) A Corresponds to a correction in an earlier release Release 96
B Addition of feature Release 97
C Functional modification of feature Release 98
D Editorial modification Release 99
Release 00

Reason for change: S3 decision to fix the length of SQN to 48 bits must be reflected in TS 33.103. The length of "AUTN", "AUTS" and "UMTS AV" is also aligned accordingly.

Clauses affected: 4.2.2, 4.5.3, 4.6.1

Other specs affected: Other 3G core specifications → List of CRs:
Other GSM core specifications → List of CRs:
MS test specifications → List of CRs:
BSS test specifications → List of CRs:
O&M specifications → List of CRs:

Other comments: This CR considers that EUIC and MAP Security features are not part of R99 and therefore these chapters are not updated and proposed to be removed instead.



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4.2.2 Authentication and key agreement (AKA_{USIM})

The USIM shall support the UMTS mechanism for authentication and key agreement described in 6.3 of 3G TS 33.102.

The following data elements need to be stored on the USIM:

- a) K : a permanent secret key;
- b) SQN_{MS} : a counter that is equal to the highest sequence number SN in an AUTN parameter accepted by the user;
- c) $RAND_{MS}$: the random challenge which was received together with the last AUTN parameter accepted by the user. It is used to calculate the re-synchronisation message together with the highest accepted sequence number (SQN_{MS});
- d) KSI : key set identifier;
- e) $THRESHOLD_C$: a threshold defined by the HE to trigger re-authentication and to control the cipher key lifetime;
- f) CK The access link cipher key established as part of authentication;
- g) IK The access link integrity key established as part of authentication;
- h) HFN_{MS} : Stored Hyper Frame Number provides the Initialisation value for most significant part of COUNT-C and COUNT-I. The least significant part is obtained from the RRC sequence number;
- i) AMF : A 16-bit field used Authentication Management. The use and format are unspecified in the architecture but examples are given in an informative annex;
- j) The GSM authentication parameter and GSM cipher key derived from the UMTS to GSM conversion functions.

Table 3 provides an overview of the data elements stored on the USIM to support authentication and key agreement.

Table 3: USIM – Authentication and key agreement – Data elements

Symbol	Description	Multiplicity	Lifetime	Length	Mandatory / Optional
K	Permanent secret key	1 (note 1)	Permanent	128 bits	Mandatory
SQN _{MS}	Sequence number counter	1	Updated when AKA protocol is executed	32-64 48 bits	Mandatory
WINDOW (option 1)	Accepted sequence number array	1	Updated when AKA protocol is executed	10 to 100 bits	Optional
LIST (option 2)	Ordered list of sequence numbers received	1	Updated when AKA protocol is executed	32-64 bits	Optional
RAND _{MS}	Random challenge received by the user.	1	Updated when AKA protocol is executed	128 bits	Mandatory
KSI	Key set identifier	1	Updated when AKA protocol is executed	3 bits	Mandatory
THRESHOLD _C	Threshold value for ciphering	1	Permanent	32 bits	Optional
CK	Cipher key	1	Updated when AKA protocol is executed	128 bits	Mandatory
IK	Integrity key	1	Updated when AKA protocol is executed	128 bits	Mandatory
HFN _{MS}	Initialisation value for most significant part for COUNT-C and for COUNT-I	1	Updated when connection is released	25 bits	Mandatory
AMF	Authentication Management Field (indicates the algorithm and key in use)	1	Updated when AKA protocol is executed	16 bits	Mandatory
RAND _G	GSM authentication parameter from conversion function	1	Updated when GSM AKA or UMTS AKA protocol is executed	As for GSM	Optional
SRES	GSM authentication parameter from conversion function	1	Updated when GSM AKA or UMTS AKA protocol is executed	As for GSM	Optional
Kc	GSM cipher Key	1	Updated when GSM AKA or UMTS AKA protocol is executed	As for GSM	Optional

NOTE 1: HE policy may dictate more than one, the active key signalled using the AMF function.

The following cryptographic functions need to be implemented on the USIM:

- f1: a message authentication function for network authentication;
- f1*: a message authentication function for support to re-synchronisation;
- f2: a message authentication function for user authentication;
- f3: a key generating function to derive the cipher key;
- f4: a key generating function to derive the integrity key;

- f5: a key generating function to derive the anonymity key;
- c2: Conversion function for interoperation with GSM from XRES (UMTS) to SRES (GSM);
- c3: Conversion function for interoperation with GSM from Ck and IK (UMTS) to Kc (GSM).

Figure 2 provides an overview of the data integrity, data origin authentication and verification of the freshness by the USIM of the RAND and AUTN parameters received from the VLR/SGSN, and the derivation of the response RES, the cipher key CK and the integrity key IK. Note that the anonymity Key (AK) is optional.

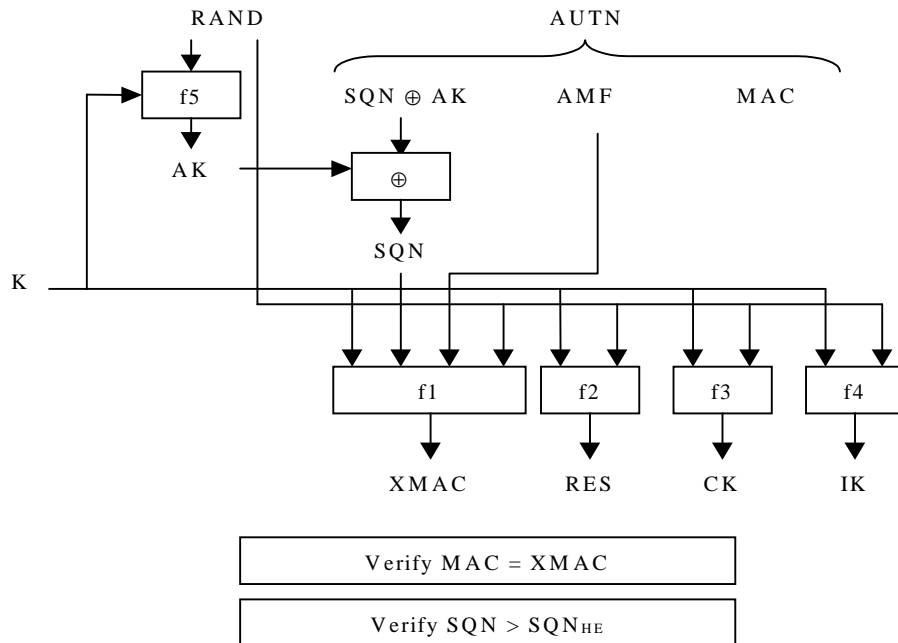


Figure 1: User authentication function in the USIM

Figure 3 provides an overview of the generation in the USIM of a token for re-synchronisation AUTS.

- a) The USIM computes $MAC-S = f1*_K(SQN_{MS} || RAND || AMF^*)$, whereby AMF^* is a default value for AMF used in re-synchronisation.
- b) If SQN_{MS} is to be concealed with an anonymity key AK, the USIM computes $AK = f5_K(MAC-S || 0...0)$, whereby MAC-S forms the 12 most significant octets and 32 zeros form the 4 least significant octets of the required 16 octet input parameter, and the concealed counter value is then computed as $SQN_{MS} \oplus AK$.
- c) The re-synchronisation token is constructed as $AUTS = SQN_{MS} [\oplus AK] || MAC-S$.

Upon receipt of an indication of synchronisation failure and a (AUTS, RAND) pair, the HLR/AuC may perform the following cryptographic functions:

- a) If SQN_{MS} is concealed with an anonymity key AK, the HLR/AuC computes $AK = f5_K(MAC-S || 0...0)$, whereby MAC-S forms the 12 most significant octets and 32 zeros form the 4 least significant octets of the required 16 octet input parameter and retrieves the unconcealed counter value as $SQN_{MS} = (SQN_{MS} \oplus AK) \text{ xor } AK$.
- b) If SQN generated from SQN_{HE} would not be acceptable, then the HLR/AuC computes $XMAC-S = f1*_K(SQN_{MS} || RAND || AMF^*)$, whereby AMF^* is a default value for AMF used in re-synchronisation.

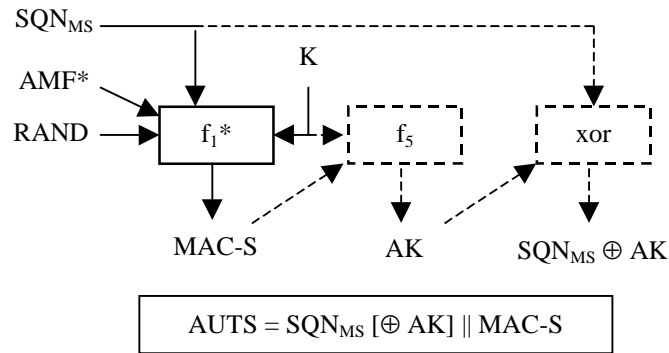


Figure 2: Generation of a token for re-synchronisation AUTS (note 1)

NOTE 1: The lengths of AUTS and MAC-S are specified in table 202.

Table 4 provides a summary of the cryptographic functions implemented on the USIM to support authentication and key agreement.

Table 4: USIM – Authentication and key agreement – Cryptographic functions

Symbol	Description	Multiplicity	Lifetime	Standardised / Proprietary	Mandatory / Optional
f1	Network authentication function	1	Permanent	Proprietary	Mandatory
f1*	Message authentication function for synchronisation	1	Permanent	Proprietary	Mandatory
f2	User authentication function	1	Permanent	Proprietary	Mandatory
f3	Cipher key generating function	1	Permanent	Proprietary	Mandatory
f4	Integrity key generating function	1	Permanent	Proprietary	Mandatory
f5	Anonymity key generating function	1	Permanent	Proprietary	Optional
c2 and c3	Conversion functions for interoperation with GSM	1 of each	Permanent	Standard	Optional

4.5.3 Authentication and key agreement (AKA_{SN})

The VLR (equivalently the SGSN) shall support the UMTS mechanism for authentication and key agreement described in 6.3 of 3G TS 33.102.

The following data elements need to be stored in the VLR (and SGSN):

- a) AV: Authentication vectors;

Table 16 provides an overview of the composition of an authentication vector

Table 16: Composition of an authentication vector

Symbol	Description	Multiplicity	Length
RAND	Network challenge	1	128
XRES	Expected response	1	32-128
CK	Cipher key	1	128
IK	Integrity key	1	128
AUTN	Authentication token	1 that consists of:	128 142 144
SQN or SQN ⊕ AK	Sequence number or Concealed sequence number	1 per AUTN	48 32 64
AMF	Authentication Management Field	1 per AUTN	16
MAC-A	Message authentication code for network authentication	1 per AUTN	64

- b) KSI: Key set identifier;
- c) CK: Cipher key;
- d) IK: Integrity key;
- e) GSM AV: Authentication vectors for GSM.

Table 17 provides an overview of the data elements stored in the VLR/SGSN to support authentication and key agreement.

Table 17: VLR/SGSN – Authentication and key agreement – Data elements

Symbol	Description	Multiplicity	Lifetime	Length	Mandatory / Optional
UMTS AV	UMTS Authentication vectors	several per user, SN dependent	Depends on many things	528- 640 656	Mandatory
KSI	Key set identifier	1 per user	Updated when AKA protocol is executed	3 bits	Mandatory
CK	Cipher key	1 per user	Updated when AKA protocol is executed	128 bits	Mandatory
IK	Integrity key	1 per user	Updated when AKA protocol is executed	128 bits	Mandatory
GSM AV	GSM Authentication vectors	As for GSM	As for GSM	As for GSM	Optional

The following cryptographic functions shall be implemented in the VLR/SGSN:

- c4: Conversion function for interoperation with GSM from Kc (GSM) to CK (UMTS);
- c5: Conversion function for interoperation with GSM from Kc (GSM) to IK (UMTS).

Table 18 provides an overview of the cryptographic functions implemented on the UE to support the mechanism for data confidentiality.

Table 18: VLR/SGSN Authentication and Key Agreement – Cryptographic functions

Symbol	Description	Multiplicity	Lifetime	Standardised / Proprietary	Mandatory / Optional
c4	Conversion function for interoperation with GSM	1	Permanent	Standardised	Optional
c5	Conversion function for interoperation with GSM	1	Permanent	Standardised	Optional

4.6.1 Authentication and key agreement (AKA_{he})

The HLR/AuC shall support the UMTS mechanism for authentication and key agreement described in 6.3 of 3G TS 33.102.

The following data elements need to be stored in the HLR/AuC:

- a) K: a permanent secret key;
- b) SQN_{HE}: a counter used to generate SQN from;
- c) AV: authentication vectors computed in advance;

Table 19 provides an overview of the data elements stored on the HLR/AuC to support authentication and key agreement.

Table 19: HLR/AuC – Authentication and key agreement – Data elements

Symbol	Description	Multiplicity	Lifetime	Length	Mandatory / Optional
K	Permanent secret key	1	Permanent	128 bits	Mandatory
SQN _{HE}	Sequence number counter	1	Updated when AVs are generated	4832-64 bits	Mandatory
UMTS AV	UMTS Authentication vectors	HE option	Updated when AVs are generated	544-640 bits	Optional
GSM AV	GSM Authentication vectors	HE option that consists of:	Updated when AVs are generated	As GSM	Optional
RAND	GSM Random challenge			128 bits	Optional
SRES	GSM Expected response			32 bits	Optional
Kc	GSM cipher key			64 bits	Optional

Table 20 shows how the construction of authentication token for synchronisation failure messages used to support authentication and key agreement.

Table 20: Composition of an authentication token for synchronisation failure messages

Symbol	Description	Multiplicity	Length
AUTS	Synchronisation Failure authentication token	that consists of:	11296-428
SQN	Sequence number	1 per AUTS	4832-64
MAC-S	Message authentication code for Synchronisation Failure messages	1 per AUTS	64

Figure 4 provides an overview of how authentication vectors are generated in the HLR/AuC.

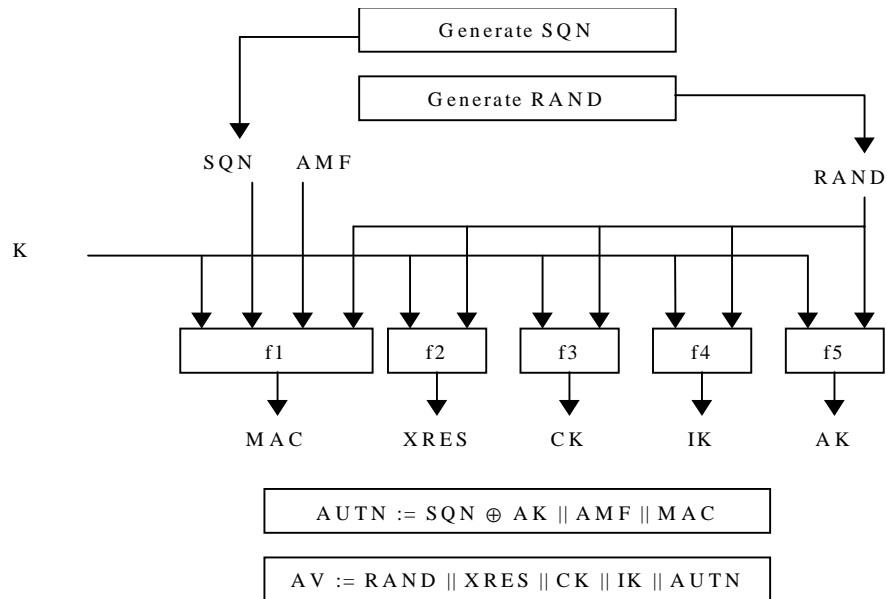


Figure 3: Generation of an authentication vector

The following cryptographic functions need to be implemented in the HLR/AuC:

- f1: a message authentication function for network authentication;
- f1*: a message authentication function for support to re-synchronisation;
- f2: a message authentication function for user authentication;
- f3: a key generating function to derive the cipher key;
- f4: a key generating function to derive the integrity key;
- f5: a key generating function to derive the anonymity key;
- c1: Conversion function for interoperation with GSM from RAND (UMTS) > RAND (GSM);
- c2: Conversion function for interoperation with GSM from XRES (UMTS) to SRES (GSM);
- c3: Conversion function for interoperation with GSM from CK and IK (UMTS) to Kc (GSM).

Table 21 provides a summary of the cryptographic functions implemented on the USIM to support authentication and key agreement.

Table 21: HLR/AuC – Authentication and key agreement – Cryptographic functions

Symbol	Description	Multiplicity	Lifetime	Standardised / Proprietary	Mandatory / Optional
f1	Network authentication function	1	Permanent	Proprietary	Mandatory
f1*	Message authentication function for synchronisation	1	Permanent	Proprietary	Mandatory
f2	User authentication function	1	Permanent	Proprietary	Mandatory
f3	Cipher key generating function	1	Permanent	Proprietary	Mandatory
f4	Integrity key generating function	1	Permanent	Proprietary	Mandatory
f5	Anonymity key generating function	1	Permanent	Proprietary	Optional
A3/A8	GSM user authentication functions	1	Permanent	Proprietary	Optional
c1, c2 and c3	Functions for converting UMTS AV's to GSM AV's	1 for each	Permanent	Standard	Optional