



Utility IoT Device Test Plan

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Section 1 Introduction

1.1 Purpose

This document defines the CTIA Certification Program test requirements specific to utility IoT devices. It is part of CTIA's Smart Connected Infrastructure certification program in which utility IoT devices are recommended to obtain [IoT Network Certified™ certification](#), [IoT cybersecurity certification](#), and undergo the tests defined in this test plan.

Applicable devices include those operating on LTE, LTE-M or NB-IoT networks in mission critical utility environments such as power grids, oil and gas networks, and water systems.

Testing is intended to be performed on an end-to-end real (non-simulated) network in an infrastructure vendor test lab authorized by CTIA Certification.

1.2 Scope

This document includes cabled interoperability testing for utility IoT devices and networks supporting LTE, LTE-M or NB-IoT as defined by 3GPP standards. Relevant protocol related testing as well as functional testing required for interoperability requirements are defined.

Test cases may be adapted and customized based on the DUT and any special test requirements.

Note that:

1. NAS Integrity protections are activated and ciphering are deactivated, unless explicitly indicated
2. AS Integrity protection and ciphering are activated, unless explicitly indicated
3. USIM is the Home PLMN user, unless explicitly indicated
4. DUT is configured as PLMN selection automatic mode or enabled for PLMN change
5. The test cases are valid on a single requested frequency bands
6. Each test case must be executed 1~3 times
7. DUT subscription has one APN in HSS, unless explicitly indicated
8. DUT is attached with default EPS bearer only, unless explicitly indicated
9. Values used for RSRP, RSRQ, timers, and thresholds are subject to change depending on lab environment and configuration

1.3 Test Preconditions

Test pre-conditions on the DUT include:

- RF/ antenna port detail
- USB drivers and capability for enabling serial port for device tracing
- Capability to insert SIM of test lab network
- Capability to set APN
- Bands under test are available or capability to change band
- Capability to enable features like eDRX, and PSM

- Capability for device SW upgrade
- Device specific cables and connectors for RF
- Application Server for Devices Application

After any changes to the test environment, such as hardware or software updates, the test lab shall use a reference device to ensure consistency in the test results.

1.4 Acronyms and Definitions

Table 1.2-1 Glossary

Acronym/Term	Definition
3GPP	3 rd Generation Partnership Project
APN	Access Point Name
AS	Access Stratum
BR	Bandwidth Reduced
C-RNTI	Cell-Radio Network Temporary Identifier
CE	Coverage Enhancement
Cell	A portion of an eNodeB
CBRA	Contention-Based Random Access
CIoT	Cellular Internet of Things
CMC	Connection Mobility Control
CN	Common Name
CP	Control Plane
CQI	Channel Quality Information
CSR	Channel Status Report
DL	Downlink
DUT	Device Under Test
DoNAS	Data over NAS
eDRX	Extended Discontinuous Reception
eNodeB	Evolved Node B. An eNodeB can consist of multiple cells.
ECM	EPS Connection Management

Acronym/Term	Definition
EMM	EPS Mobility Management
EEA2	EPS Encryption Algorithm
EIA2	EPS Integrity Algorithms
EPC	Evolved Packet Core
EPS	Evolved Packet System
EUTRA	Evolved Universal Terrestrial Radio Access
GUTI	Globally Unique Temporary ID
HARQ	Hybrid Automatic Repeat reQuest
HSS	Home Subscriber Server
IMS	Internet Protocol Multimedia Subsystem
ICMP	Internet Control Message Protocol
IE	Information Element
IoT	Internet of Things
IP	Internet Protocol
IPv4	Internet Protocol version 4
Ipv6	Internet Protocol version 6
IUA	Instant Uplink Access
KPI	Key Performance indicator
LTE	Long Term Evolution
LTE-M	Long Term Evolution for Machines
MAC	Message Authentication Code
MAC-I	Message Authentication Code - Integrity
MCS	Modulation Code Scheme
MIB	Master Information Block
MME	Mobility Management Entity
MO	Mobile Originated
MT	Mobile Terminated

Acronym/Term	Definition
NAS	Non Access Stratum
NB-IoT	Narrowband IoT
NPRACH	Narrowband Physical Random Access Channel
OLSM	Open Loop Spatial Multiplexing
PDCP	Packet Data Convergence Protocol
PDN	Packet Data Network
PLMN	Public Land Mobile Network
PRACH	Physical Random Access Channel
PRB	Physical Resource Blocks
PSM	Power Saving Mode
PTW	Paging Time Window
PUSCH	Physical Uplink Shared Channel
QAM	Quadrature Amplitude Modulation
RA	Random Access
RLF	Radio Link Failure
RRC	Radio Resource Control
RF	Radio Frequency
RI	Rank Indication
RNTI	Radio Network Temporary Identifier
RSRP	Reference Signal Received Power
RTT	Round Trip Time
RoHC	Robust Header Compression
S-TMSI	Serving-Temporary Mobile Subscriber Identity
SIB	System Information Block
SIM	Subscriber Identity Module
SINR	Signal to interference plus noise ratio
SOAK	Performance related testing

Acronym/Term	Definition
SRB1	Signaling Radio Bearer type 1
SPS	Semi-Persistent Scheduling
SW	Software
TAU	Tracking Area Update
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UL	Uplink
UP	User Plane
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module
X-MAC-I	Computed Message Authentication Code - Integrity

1.5 Document References

The following documents are referenced in this test plan:

Document Number, Document Name	
[1]	3GPP TS 36.523-1, Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Packet Core (EPC); User Equipment (UE) conformance specification; Part 1: Protocol conformance specification
[2]	3GPP TS 36.304, Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode
[3]	3GPP TS 36.508, Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Packet Core (EPC); Common test environments for User Equipment (UE) conformance testing
[4]	3GPP TS 36.521-1, Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) conformance specification; Radio transmission and reception; Part 1: Conformance testing
[5]	3GPP TS 36.321, Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification
[6]	3GPP TS 36.306, Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities
[7]	3GPP TS 38.331, NR; Radio Resource Control (RRC); Protocol specification
[8]	3GPP TS 36.323, Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) specification
[9]	3GPP TS 36.211, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation
[10]	3GPP TS 36.213, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures
[11]	3GPP TS 36.101, Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception
[12]	3GPP TS 36.331, Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification
[13]	3GPP TS 24.301, Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3
[14]	3GPP TS 23.401, General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access
[15]	3GPP TS 24.008, Mobile radio interface Layer 3 specification; Core network protocols; Stage 3
[16]	3GPP TS 36.212, Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding
[17]	3GPP TS 36.413, Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP)

Section 2 Utility IoT Devices on LTE

2.1 Idle Mode

2.1.1 Periodic Tracking Area Update

Conformance Specification:

- 36.523-1 [1] subclause 9.2.3.1.5
- 36.304 [2] chapter 5.2

Initial Condition:

1. One cell shall be active in eNodeB
2. The DUT is in EMM_REGISTERED and RRC_IDLE state

Procedure:

DUT will trigger Tracking Area Update Procedure after T3412 timer is expired

Exit Criteria:

1. The Tracking Area Updating procedure is initiated by the DUT
2. TRACKING AREA UPDATE REQUEST message without "Active" flag is sent by DUT
3. If GUTI is included in the TAU Accept, the DUT acknowledges the received message by returning a TAU Complete message to the MME

2.2 Registration and EPS Bearer Setup and Release

2.2.1 Detach Initiated by DUT

Conformance Specification:

- 36.523-1 [1] subclause 8.1.3.1
- 36.523-1 [1] subclause 9.2.2.1.1

Initial Condition:

1. IPv4
 2. One cell shall be active in eNodeB
 3. The DUT is in EMM-REGISTERED and RRC_CONNECTED state
- or
4. The DUT is in EMM-REGISTERED and RRC_IDLE state

Procedure:

Switch off Detach initiated by DUT

Exit Criteria:

1. If DUT is RRC_IDLE, DUT establishes the RRC connection with the RRC establishmentCause set to 'mo-signalling' and sends DETACH REQUEST message, keeps the native security context
2. DUT sends DETACH REQUEST with Detach type IE "switch off" and "EPS detach"
3. DUT enters EMM-DEREGISTERED state. All radio bearers have been released

2.2.2 Paging (Mobile Terminating Connection Set-up)

Conformance Specification:

- 36.508 [3] subclause 4.5.3
- 36.523-1 [1] subclause 8.1.1.1
- 36.523-1 [1] subclause 9.3.2.1

Initial Condition:

1. One cell shall be active in eNodeB
2. DUT is attached with the Default EPS Bearer + at least one Dedicated EPS Bearer
3. The DUT is in EMM-REGISTERED and RRC_IDLE state

Procedure:

Triggered by downlink data.

Exit Criteria:

1. Network initiates a paging procedure using S-TMSI with CN domain indicator set to "PS" for downlink pending user data
2. DUT responds to the paging with a SERVICE REQUEST message providing correct S-TMSI in the RRCConnectionRequest
3. Service Request Procedure is used for the transition from ECM-IDLE to ECM-CONNECTED. The Service Request triggers the establishment of the Radio Bearer and the S1 Bearer
4. The Default EPS Bearer and at least one Dedicated EPS Bearer are established
5. The downlink data has been forwarded to DUT
6. Measure and record the idle-to-connected control plane delay

2.2.3 Detach Initiated by Network

Conformance Specification:

- 36.523-1 [1] subclause 8.1.3.1
- 36.523-1 [1] subclause 9.2.2.1/9.2.2.2

Initial Condition:

1. One cell active (Source Cell)
2. Source Cell is strong (RSRP > - 80)

3. APN Type: IPV4
4. Bearer Type: 1 Default

Procedure:

1. Attach the DUT to the Source Cell
 - Verify the DUT is attached and in RRC Connected Mode
2. Initiate a detach from the network
 - The DUT will receive a Detach Request NAS message with Detach type IE "re-attach required"
 - The DUT will detach from the network and re-attach again
 - Data should be initiated successfully to ensure the DUT can still receive data

Exit Criteria:

1. DUT receives DETACH REQUEST message with the Detach type IE "re-attach required"
2. DUT sends DETACH ACCEPT message, and has entered EMM-DEREGISTERED state. All radio bearers have been released.
3. DUT initiates an attach procedure with the current EPS security context
4. User data is ready to be received in uplink and downlink on each EPS bearer

2.2.4 RRC Connection Re-Establishment (Triggered by DUT Radio Link Failure)

Conformance Specification:

- 36.523-1 [1] subclause 13.3
- 36.523-1 [1] subclause 9.2.3.3.6

Initial Condition:

1. One Cell active (Source Cell)
2. Source Cell is strong (RSRP > - 80)
3. APN Type: IPV4
4. Bearer Type: 1 Default

Procedure:

1. Attach the DUT to the Source Cell
 - Verify the DUT is attached and in RRC Connected Mode with AS security established
 - Verify no UL/DL traffic is ongoing
2. Attenuate the Source Cell completely until: DUT measures Source Cell < -140
3. Between 2 and 10 seconds, bring up the Source Cell until: DUT measures Source Cell > - 80

- Verify the RRC connection re-establishment procedure which involves the resumption of the Signaling Radio Bearer
- Verify the message is triggered by DUT RLF with the reestablishment cause set to “OtherFailure”
- AS security has been re-activated without change of algorithm
- SRB1 will be reconfigured
- Data should be initiated successfully to ensure the DUT can still receive data

Exit Criteria:

1. The RRC message exchange is successful
2. For DUT RLF the Reestablishment cause is set to the value “OtherFailure”
3. AS security has been re-activated without change of algorithm
4. The SRB1 has been reconfigured and data traffic can be resumed
5. KPI: Measure and record the time from when the eNodeB receives the first RRC Connection Reestablishment Request message until the time when the eNodeB receives the RRC Connection Reestablishment Complete message

2.3 EPS Session Management

2.3.1 Multiple PDN Connections

Conformance Specification:

- 36.523-1 [1] subclause 10.9.1/13.1.1
- 36.523-1 [1] subclause 10.5.1
- 36.523-1 [1] subclause 10.9.1/13.1.1
- 36.523-1 [1] subclause 8.2.3.1
- 36.523-1 [1] subclause 10.6.1

Initial Condition:

1. APN Type: IPv4
2. One cell shall be active in eNodeB
3. DUT subscription has 2 APNs in HSS
4. DUT is attached to PDN1 with the Default EPS Bearer + at least one Dedicated EPS Bearer
5. DUT is in EMM_REGISTERED and RRC_IDLE state

Procedure:

1. DUT initiates a secondary PDN connectivity (PDN2) with the Default EPS Bearer

Exit Criteria:

1. DUT successfully activates a secondary PDN connection and the Default EPS Bearer has been activated to the requested PDN2
2. DUT is able to receive two unique IP's one from the PDN1 and another from the PDN2
3. Verify that both default EPS bearers and Dedicated EPS bearer have been activated towards the respective PDNs by initiating a bi-directional user data session on each bearer

2.4 Performance**2.4.1 Round Trip Time****Conformance Specification:**

- 36.523-1 [1] subclause 8.2.1.5

Initial Condition:

1. One cell active (Source Cell)
2. Source Cell is strong (RSRP > - 80)
3. APN Type: IPV4
4. Bearer Type: 1 Default

Procedure:

1. Attach the DUT to the Source Cell
 - Verify the DUT is attached and in RRC Connected Mode
2. Allow the DUT to go into Idle Mode by preventing all UL and DL data
3. Ping the network from the DUT once to transition the DUT from RRC Idle Mode to RRC Connected Mode state
 - Record the time required for the transition from Idle to Connected state
4. Perform 100 Pings to the network from the DUT while in RRC Connected Mode
 - Record the average round trip time of the 100 pings
5. Repeat steps 2 to 4 above for the following ICMP packet sizes:
 - 64 bytes
 - 512 bytes
 - 1500 bytes

Exit Criteria:

1. Measure and record The RTT for the first ping transiting from RRC_IDLE to RRC_CONNECTED states
2. The average value of the RTT in the RRC_CONNECTED should be less than 50 ms

2.4.2 Maximum Uplink/Downlink Data Throughput - SOAK

Conformance Specification:

- 36.523-1 [1] subclause 13.1.1
- 36.523-1 [1] subclause 7.1.7

Initial Condition:

1. One Cell active (Source Cell)
2. Source Cell is strong (RSRP > - 80)
3. APN Type: IPV4 and IPV6 or IPV4V6
4. Bearer Type: Default
5. UL up to 256QAM Maximum MCS/ DL up to 256QAM Maximum MCS
6. UDP
7. Modulation Scheme:
 - DUT: Max Modulation supported
 - eNodeB: Configured to support up to 256QAM UL and up to 256QAM DL

Procedure:

1. Attach the DUT to the Source Cell with allocated IPV4 address
 - Verify the DUT is attached and in RRC Connected mode
2. Initiate UL/DL UDP traffic to the DUT on default bearer
 - The transmitters (DUT and network) should run with max traffic based on the total bandwidth
 - Record the average throughput for 5 minutes
3. Repeat the procedure with allocated IPV6 address
 - Record the average throughput for 5 minutes

Exit Criteria:

1. Record the average DL throughput value along with the Modulation, MCS, CQI and PRB
2. Record the average UL throughput value along with the Modulation, MCS, and PRB
3. Verify the Data rate according to the throughput expectations based on both Modulation scheme used, MCS, and Total bandwidth

2.5 Link Adaptation and HARQ

2.5.1 Aperiodic CSR Reporting on PUSCH

Conformance Specification:

- 36.521-1 [4] subclause 9.3.1.1.1

- 36.521-1 [4] subclause 9.3.3.1.1

Initial Condition:

1. Reporting mode 3-0
2. One Cell active (Source Cell)
3. Source Cell is strong (RSRP > - 80)
4. APN Type: IPV4
5. Bearer Type: 1 Default

Procedure:

1. Attach the DUT to the Source Cell
 - Verify the DUT is attached and in RRC Connected mode
 - Verify that the DUT is sending aperiodic CQI reports on PUSCH
 - Verify CQI reports are received with the correct reporting mode
2. Initiate DownLink UDP traffic to the DUT on the Default bearer
 - The transmitter on the network should run with maximum traffic (full buffers) for the duration of the test
3. Reduce the SINR by attenuating the Source Cell until: DUT measures Source Cell < -130
 - Verify that the CQI values and Rank Indicator follow the changes in attenuation
 - The CQI values will gradually go down to CQI 1 or 2 with RI 1
4. Increase the SINR by attenuating the Source Cell until: DUT measures Source Cell > -80
 - Verify that the CQI values and Rank Indicator follow the changes in attenuation
 - The CQI values will gradually go up to CQI 15 with RI 2

Exit Criteria:

1. Verify that the DUT is sending Aperiodic CQI reports on PUSCH
2. Verify CQI reports are received with the correct reporting mode 3-0
3. When the radio conditions are excellent, the highest CQI value of 15 is expected to be reported
4. The DUT reports the range of CQI values from 15 to 2 when radio conditions are varied
5. For OLSM mode, verify that RI reports changes from 2 to 1 depending on the radio condition
6. Ensure that the DUT degrades CQI on RI 2 before switching to RI 1 avoiding a sudden drop in throughput

2.6 AS and NAS Security

2.6.1 AS Security Procedure for RRC Messages and UP Data

Conformance Specification:

- 36.523-1 [1] subclause 7.3.3
- 36.523-1 [1] subclause 7.3.4

Initial Condition:

1. EIA2 and EEA2
2. One cell shall be active in eNodeB
3. DUT is powered off and in EMM-DEREGISTERED state

Procedure:

1. Power on the DUT
2. After successfully attach, Initiate UL/DL Data transfer

Exit Criteria:

1. eNodeB initiates AS Security Mode Command Procedure to the DUT and start RRC integrity protection, when only SRB1 is established, i.e., prior to establishment of SRB2 and /or DRBs
2. eNodeB sends the AS Security Mode Command message to DUT, which shall contain the selected AS algorithms and MAC-I
 - EIA2 for RRC signalling
 - EEA2 for RRC signalling and UP data

This message shall be integrity protected.

3. RRC and UP downlink ciphering (encryption) at the eNodeB shall start after sending the AS security mode command message
4. If the PDCP entity correctly calculates X-MAC-I and match the received MAC-I, DUT starts RRC integrity protection, RRC/UP downlink deciphering, and sends AS Security Mode Complete
5. RRC and UP uplink ciphering (encryption) at the DUT shall start after sending the AS security mode complete message.
6. RRC and UP uplink deciphering (decryption) at the eNodeB shall start after receiving and successful verification of the AS security mode complete message
7. The DUT is successfully attached, a Default EPS Bearer and at least one Dedicated EPS Bearer are established
8. DUT shall correctly receive DL data
9. eNodeB shall correctly receive UL data

2.7 IUA (Instant Uplink Access)

2.7.1 RRC Connection Re-Establishment (Triggered by DUT Radio Link Failure)

Conformance Specification:

- 36.321 [5]
- 36.306 [6]

Initial Condition:

1. IUA is configured and enabled
2. One cell active in eNodeB
3. The DUT is in RRC_CONNECTED state
4. APN Type: IPV4
5. Bearer Type: 1 Default

Procedure:

1. Continuously run DL ping (interval of 200ms) and UL data (500 kB/s UDP). Ensure that InstantUplinkAccess is activated.
2. Using the attenuator, degrade the downlink signal to the DUT to a very low level for at least 2 sec. Between 2 sec and 30 sec, return the downlink signal to the original good signal strength.
3. Verify that the RRC Connection Reestablishment message exchange is successful
4. Radio Bearers have been re-established and data traffic can be initiated
5. Perform this scenario 3 to 4 times

Exit Criteria:

1. Verify that DUT advertises the support for below IEs in DUT capability information message:
 - shortSPS-IntervalFDD-r14 supported,
 - shortSPS-IntervalTDD-r14 supported,
 - skipUplinkDynamic-r14 supported,
 - skipUplinkSPS-r14 supported
2. Verify that IUA configured and enabled
3. The RRC Connection Reestablishment message is successful which involves the resumption of the Signaling Radio Bearer
4. For DUT RLF the Reestablishment cause is set to the value "OtherFailure"
5. Confirm that IUA is reconfigured and reactivated once UL traffic is resumed

2.8 UL RoHC for Data (Robust Header Compression)

2.8.1 Feature interaction - UL RoHC for data and RRC Connection Re-Establishment

Conformance Specification:

- 38.331 [7]
- 36.323 [8]

Initial Condition:

1. LTE Cell
2. Source Cell is strong (RSRP > - 80)
3. APN Type: IPv6
4. Bearer Type: Default
5. TCP

Procedure:

1. Attach the DUT to the Source Cell
2. Initiate DL TCP data transfer
3. Attenuate the Source Cell completely until: DUT measures Source Cell < -140
4. Between 2 and 10 seconds, bring up the Source Cell back to good RF condition
 - Verify the RRC connection re-establishment procedure which involves the resumption of the Signaling Radio Bearer
 - Verify the message is triggered by DUT RLF with the reestablishment cause set to "OtherFailure"
 - Data should be resumed successfully after reestablishment

Exit Criteria:

1. Verify that the DUT indicates support of ROHC profile 0x0006 in IE DUT-EUTRA-CAPABILITY and the DUT indicates the maximum number of context sessions supported
2. Verify that data has been mapped to appropriate ROHC profiles (profile0x0006) from the IE PDCP-Config in RRC Connection Reconfiguration message
3. Verify that the RRC Connection Reestablishment procedure is completed successful and the Reestablishment cause is set the value "OtherFaiure"
4. Verify data traffic is resumed after reestablishment is completed, and throughput not degraded

Section 3 Utility IoT Devices on LTE-M

3.1 Registration and EPS Bearer Setup and Release

3.1.1 Attach and EPS Bearer Setup

Conformance Specification:

- Physical Layer Synchronization
 - 36.211 [9] chapter 6.10 & 6.11
 - 36.213 [10] chapter 4.1
 - 36.101 [11]
- Reception of MIB
 - 36.331 [12] chapter 5.2 & 6.2.2
 - 36.211 [9] chapter 6.6.4
 - 36.213 [10] chapter 7.1.6 & 7.1.7.2.7
- SIB1
 - 36.331 [12] chapter 5.2 & 6.2.2
 - 36.211 [9] chapter 6.4.1
 - 36.213 [10] chapter 7.1.6
- SIB2
 - 36.331 [12] chapter 5.2 & 6.2.2
- Cell Selection
 - 36.304 [2], chapter 5.2
- CBRA
 - 36.321 [5] chapter 5.1 & 6.1.5
- RRC Connection Establishment
 - 36.331 [12], 5.3.3 and chapter 6.2.2
- RRC Connection Reconfiguration
 - 36.331 [12] chapter 5.3.5
- IMSI/GUTI Attach
 - 24.301 [13], chapter 5.5.1

- 24.301 [13], chapter 6.4.1
- 23.401 [14], chapter 4.3.22
- 24.301 [13], chapter 5.3.11
- 24.008 [15], chapter 10.5.5.32

Initial Condition:

1. CE Mode A level 0, CDRX,eDRX enabled

Procedure:

1. Power up DUT
2. Attach the DUT to the source cell

Exit Criteria:

1. Verify that the CAT-M1 DUT successfully attached to the cell and received a valid IP address
2. Verify eNodeB sends SIB1-BR with EDRX configuration
3. For EDRX capable DUTs, verify that the IE Extended DRX parameters is included both in Attach ReqSmart Deviceest and Attach Accept
4. Verify that the RRC Reconfiguration Msg with CDRX profile is sent to the DUT

3.2 Idle Mode

3.2.1 Periodic Tracking Area Update

Conformance Specification:

- 36.304 [2], chapter 5.2
- 23.401 [14], chapter 4.3.22
- 24.301 [13], chapter 5.3.11
- 24.008 [15], chapter 10.5.5.32

Initial Condition:

1. CE Mode A level 0, CDRX enabled, eDRX enabled

Procedure:

1. Power up DUT
2. Attach the DUT to the source cell
3. Allow DUT to go into idle mode

Exit Criteria:

1. Verify that the Periodic Tracking Area Update was performed successfully at expiry of T3412

3.2.2 Paging**Conformance Specification:**

- 36.211 [9], chapter 6.8B.5
- 36.212 [16], chapter 5.3.3.1.14
- 36.304 [2], chapter 7
- 36.331 [12], chapter 5.3.2

Initial Condition:

1. CE Mode A level 0, CDRX enabled
2. eDRX disabled (preferentially on DUT)

Procedure:

1. Power up DUT
2. Trigger Downlink data

Exit Criteria:

1. Verify that, on reception of the paging message the DUT performs the service reqSmart Deviceest procedure and enters RRC_CONNECTED state

3.3 Performance**3.3.1 Round Trip Time****Conformance Specification:**

- Service reqSmart Deviceest (Idle to Connected)
 - 24.301 [13] rev. 8.1.0 chapter 5.6.1
- Connection release (Connected to Idle)
 - 23.401 [14] chapter 5.3.5
 - 36.331 [12] chapter 5.3.8
 - 36.331 [12] chapter 6.2.2
 - 36.413 [17] chapter 8.3.2
 - 36.413 [17] chapter 9.1.4

Initial Condition:

1. CE Mode A level 0, CDRX enabled, eDRX enabled

Procedure:

1. Attach the DUT to the Source Cell
2. Allow the DUT to go into Idle Mode by preventing all UL and DL data
3. Ping the network from the DUT once to transition the DUT from RRC Idle Mode to RRC Connected Mode state
4. Perform 100 Pings to the network from the DUT while in RRC Connected Mode

Exit Criteria:

1. Record the RTT Delay for the First ping, the Minimum, Maximum and Average RTT
2. For DUT initiated ping, the average valSmart Device of the RTT should be less than 68msec for 64 bytes and less than 260msec for 1500 bytes

3.3.2 Uplink Data Transfer with Maximum Traffic

Conformance Specification:

- 36.306 [6] chapter 4.1

Initial Condition:

1. Default Bearer
2. UDP
3. CE Mode A level 0, CDRX enabled, EDRX enabled

Procedure:

1. Attach the DUT to the Source Cell
2. Initiate UL UDP traffic
 - The transmitter should run with maximum traffic (full buffers) for 120 seconds (i.e., 2 minutes)
 - Record the average throughput for 120 seconds

Exit Criteria:

1. Record the average UL throughput valSmart Device
2. Verify the Data rate according to the throughput expectations

3.3.3 Downlink Data Transfer with Maximum Traffic

Conformance Specification:

- 36.306 [6] chapter 4.1

Initial Condition:

1. Default Bearer
2. UDP
3. Connected mode
4. CE Mode A level 0, CDRX enabled, eDRX enabled

Procedure:

1. Attach the DUT to the Source Cell
2. Initiate DL UDP traffic
 - The transmitter should run with maximum traffic (full buffers) for 120 seconds (i.e., 2 minutes)
 - Record the average throughput for 120 seconds

Exit Criteria:

1. Record the average DL throughput valSmart Device
2. Verify the Data rate according to the throughput expectations

3.3.4 Downlink/Uplink UDP (IPv4) Data Transfer with Maximum Traffic (SOAK)**Conformance Specification:**

- 36.306 [6] chapter 4.1

Initial Condition:

1. Default Bearer
2. IPv4
3. Connected mode
4. CE Mode A level 0, CDRX enabled, EDRX enabled

Procedure:

1. Attach the DUT to the Source Cell
2. Initiate UL/DL UDP traffic to the DUT on the Dedicated bearer
 - The transmitters (both DUT and network) should run with maximum traffic (full buffers) based on the total bandwidth for 5 minutes
 - Record the average throughput for 5 minutes

Exit Criteria:

1. Record the average DL throughput valSmart Device
2. Record the average UL throughput valSmart Device

3.3.5 Downlink/Uplink UDP (IPv6) Data Transfer with Maximum Traffic (SOAK)

Conformance Specification:

- 36.306 [6] chapter 4.1

Initial Condition:

1. Dedicated Bearer
2. IPv6
3. Connected mode
4. CE Mode A level 0, CDRX enabled, eDRX enabled

Procedure:

1. Attach the DUT to the Source Cell
2. Initiate UL/DL UDP traffic to the DUT on the Dedicated bearer
 - The transmitters (both DUT and network) should run with maximum traffic (full buffers) based on the total bandwidth for 5 minutes
 - Record the average throughput for 5 minutes

Exit Criteria:

1. Record the average DL throughput valSmart Device
2. Record the average UL throughput valSmart Device

3.4 RRC Connection Reestablishment

3.4.1 RRC Connection Re-Establishment Triggered by DUT Radio Link Failure (RLF)

Conformance Specification:

- 36.331 [12] chapter 5.3.7, 5.3.11, 6.3.2
- 36.213 [10] chapter 4.2.1

Initial Condition:

1. Re-establishment to the same cell
2. CE Mode A level 0, CDRX enabled, EDRX enabled

Procedure:

1. Attach the DUT to the Source Cell
 - Verify no UL/DL traffic is ongoing
2. Attenuate the Source Cell completely until: DUT measures Source Cell < -140
3. Between 2 and 10 seconds, bring up the Source Cell until: DUT measures Source Cell > -80

Exit Criteria:

1. Verify that the RRC message exchange is successful and that the Reestablishment cause is set the valSmart Device "OtherFailure"
2. SRB1 has been reconfigured, data traffic is resumed and the re-activation of security

3.5 Network Initiated Detach

3.5.1 Network Initiated Detach ReqSmart Device

Conformance Specification:

- 36.523-1 [1] subclause 8.1.3.1
- 36.523-1 [1] subclause 9.2.2.1/9.2.2.2
- 23.401 [14] chapter 5.3.8.3
- 24.301 [13] chapter 5.5.2.3

Initial Condition:

1. Detach Type : reattach required
2. CE Mode A level 0, CDRX enabled, eDRX disabled

Procedure:

1. Attach the DUT to the Source Cell
2. Initiate a detach from the Network

Exit Criteria:

1. DUT receives DETACH REQSmart DeviceST message with the Detach type IE "re-attach required"
2. DUT sends DETACH ACCEPT message, and has entered EMM-DEREGISTERED state. All radio bearers have been released.
3. DUT initiates an attach procedure with the current EPS security context
4. User data is ready to be received in uplink and downlink on each EPS bearer

3.6 Idle Mode Extended DRX

3.6.1 Paging During the PTW in Idle Mode

Conformance Specification:

- Physical Layer Synchronization
 - 36.211 [9] chapter 6.10 & 6.11
 - 36.213 [10] chapter 4.1
 - 36.101 [11]

- Reception of MIB
 - 36.331 [12] chapter 5.2 & 6.2.2
 - 36.211 [9] chapter 6.6.4
 - 36.213 [10] chapter 7.1.6 & 7.1.7.2.7
- SIB1
 - 36.331 [12] chapter 5.2 & 6.2.2
 - 36.211 [9] chapter 6.4.1
 - 36.213 [10] chapter 7.1.6
- SIB2
 - 36.331 [12] chapter 5.2 & 6.2.2
- Cell Selection
 - 36.304 [2], chapter 5.2
- CBRA
 - 36.321 [5] chapter 5.1 & 6.1.5
- RRC connection establishment
 - 36.331 [12], 5.3.3 and chapter 6.2.2
- RRC connection reconfiguration
 - 36.331 [12] chapter 5.3.5
- IMSI/GUTI Attach
 - 24.301 [13], chapter 5.5.1
 - 24.301 [13], chapter 6.4.1
 - 23.401 [14], chapter 4.3.22
 - 24.301 [13], chapter 5.3.11
 - 24.008 [15], chapter 10.5.5.32

Initial Condition:

1. CE Mode A level 0, CDRX enabled, eDRX enabled

Procedure:

1. Power up DUT

2. Allow DUT to go into idle mode
3. Page DUT during PTW

Exit Criteria:

1. Verify eNodeB sends SIB1-BR with EDRX configuration
2. Verify that the IE Extended DRX parameters is included both in Attach ReqSmart Deviceest and Attach Accept
3. Verify that DUT receives Paging during Paging Time Window, on reception of the paging message the DUT performs the service reqSmart Deviceest procedure and enters RRC_CONNECTED state

3.7 Power Saving Mode

3.7.1 Activation of Power Saving Mode

Conformance Specification:

- 23.401 [14], chapter 4.3.5.2
- 24.301 [13], chapter 5.3.11

Initial Condition:

1. CE Mode A level 0, CDRX enabled, eDRX disabled, PSM enabled
2. Uplinkdata before T3324 is expired
3. Downlink data before T3324 is expired

Procedure:

1. Power up DUT
2. Activate Power Saving Mode on DUT
3. DUT sends UL data before T3324 timer expiry
4. Repeat step 2
5. DUT receives DL data before T3324 timer expiry
6. Verify DUT activation of Power Saving Mode
7. Verify that the timers T3324 and T3412 extended are included both in Attach ReqSmart Deviceest and Attach Accept.
8. Verify timer T3324 is reset and started with its initial valSmart Device when the DUT moves into ECM-IDLE mode
9. Verify DUT can send UL data before T3324 timer expiry
10. Verify DL data transfer from the network before timer T3324 has elapsed. The MME shall initiate Paging towards the DUT

Exit Criteria:

1. The DUT performs Attach procedure, the timers T3324 and T3412 extended are included in Attach ReqSmart Deviceest indicating PSM
2. The MME shall send the Attach Accept message together with the Activate Default EPS Bearer Context ReqSmart Deviceest message to activate the default bearer. The timers T3324 and T3412 extended are included in the Attach Accept.
3. The DUT is successfully attached, and a default bearer is established

4. Downlink data transmission is successfully received by the DUT before entering PSM
5. Uplink data transmission is successfully sent by the DUT before entering PSM

Section 4 Utility IoT Devices on NB-IoT

4.1 System Information

4.1.1 MIB, SIB Acquisition

Conformance Specification:

- 36.211 [9] chapter 10.2.7
- 36.211 [9] chapter 10.2.4
- 36.211 [9] chapter 10.2.3
- 36.213 [10] chapter 16.4.1
- 36.213 [10] chapter 16.1
- 36.331 [12] chapter 6.7.2
- 36.331 [12] chapter 6.7.3

Initial Condition:

1. One LTE host cell shall be active in eNodeB
2. One NB-IoT cell shall be active
3. DUT switched off and has no system information stored from previous iterations

Procedure:

1. Power on the DUT and start cell search
2. DUT obtains time and Frequency synchronization and acquires MIB-NB and SIBx-NB information (SIB1, SIB2, SIB3 and SIB5)

Exit Criteria:

1. DUT has acquired the narrow band cell ID correctly and stays synchronized to the cell
2. NB-MIB is correctly acquired
3. DUT has successfully acquired the SIB1-NB
4. DUT has successfully acquired the SIB2-NB
5. DUT has successfully acquired the SIB3-NB
6. DUT has successfully acquired the SIB5-NB

(Compare the system info acquired by the DUT with info broadcasted by the eNodeB)

4.2 Random Access and RRC Connection

4.2.1 Establish Initial RRC Signalling Connection

Conformance Specification:

- 36.211 [9] chapter 10.1.6 36.321 [5] chapter 5.1 & 6.1.5

- 36.331 [12] chapter 5.3.3 & 6.2.2 & 9.1.2 1a
- 24.301 [13]

Initial Condition:

1. The DUT has successfully detected the cell and acquired all the required System Information in order to perform random access in the cell
2. DUT has no valid Cell RNTI (C-RNTI) and is in good coverage

Procedure:

1. Initiate any high-layer procedure e.g., Attach that would trigger Random Access and RRC Establishment procedure
2. DUT has successfully gone through the RA procedure and has switched to RRC Connected mode

For each of the cell setups, following iterations have to be performed in order to dynamically test different NPRACH levels under various RF conditions

Guard-Band cell setup, run following iterations with CMC x and CE levels y:

- a. CMC 2, CE levels 3; DUT-measured RSRP 5 dB higher than threshold1
- b. CMC 2, CE levels 3; DUT-measured RSRP between the 2 thresholds
- c. CMC 2, CE levels 3; DUT-measured RSRP 5 dB lower than threshold2

Radio-----a----- | ----b----- | ----c-----

th1 th2

Exit Criteria:

1. DUT has successfully read detected the cell and obtained the system information
2. According to the configured CE levels and available RF conditions, DUT should use proper NPRACH resource group
3. Random access contention has been resolved
4. Verify that there were no failed attempts of RA
5. The DUT is connected through MAC and is known in eNodeB by a new uniqSmart Device C-RNTI
6. The DUT is connected to the eNodeB in state RRC_CONNECTED (RRC Connection successfully established)

4.2.2 DUT Radio Link Failure (Recovery on the same cell with data transfer)

Conformance Specification:

- 36.331 [12] chapter 5.3.11
- 36.331 [12] chapter 5.3.12

Initial Condition:

1. Only 1 NB-IoT cell configured

2. DUT in good coverage

Procedure:

1. Attach the DUT supporting CP IoT EPS Optimizations and activate default bearer
2. Start full buffer UL/DL traffic (or alternatively use MO+MT ping)
3. Put the DUT completely out of coverage for 5-10 seconds so that the DUT would declare RLF
4. Return the DUT back to good coverage
5. Wait until the DUT selects the recovered cell and observe that the full buffer UL/DL traffic has resumed
6. Stop the traffic and detach the DUT

Exit Criteria:

1. After attaching, make sure that the DUT can successfully run bidirectional traffic
2. Verify that the DUT declared RLF (DUT internal check) after bringing it out of coverage
3. Verify that the DUT is able to find again the last stored NB-IoT cell and to perform PLMN selection
4. Verify that the DUT can again successfully initiate bidirectional traffic without having to re-attach (by means of CP Service ReqSmart Devicest)

4.3 Attach/Detach & Bearer Handling

4.3.1 IMSI Attach and EPS Bearer Setup

Conformance Specification:

- 24.301 [13] chapter 5.3.1
- 24.301 [13] chapter 5.3.15
- 24.301 [13] chapter 5.5.1
- 24.301 [13] chapter 6.4.1
- 23.401 [14] chapter 4.3.22
- 24.301 [13] chapter 5.3.11
- 24.008 [15] chapter 10.5.5.32

Initial Condition:

1. DUT is powered off and in EMM-DEREGISTERED state
2. For IMSI attach no valid GUTI shall be stored in the DUT
3. DUT is in good coverage

Procedure:

1. Power on the DUT and attach it to the NB-IoT cell

Exit Criteria:

1. Verify that all the procedures before the Attach have been performed successfully (random access, RRC Connection establishment)
2. Check the Attach flow and make sure it is done according to the message flow
3. Make sure IMSI and "Control Plane Clot EPS optimization" have been sent in the Attach message
4. Verify that the Attach procedure was successfully performed and that the Bearer has been established and the DUT assigned with an IP address
5. Verify DUT Capability Information exchange between eNodeB and DUT. DUT should respond to Smart DeviceCapabilityEnquiry with Smart DeviceCapabilityInformation whose content will be successfully decoded by the eNodeB carrying all the needed information
6. Measure KPI
7. "Attach Setup Delay": Measure and record the Attach Setup Delay for 5 consecutive Attaches and report the mean valSmart Device. The Attach setup delay is measured at eNodeB side. [Attach Complete Time Stamp] - [RRC Connection ReqSmart Device Time Stamp] [ms]

4.4 DoNAS Data Transfer**4.4.1 UDP/TCP Uplink/Downlink Data Throughput IPv4****Conformance Specification:**

- 24.301 [13] chapter 6.6.4.2
- 24.301 [13] chapter 6.6.4.3

Initial Condition:

1. DUT is in RRC Connected and in good coverage

Procedure:

1. Initiate full buffer UL/DL UDP traffic to/from the test server for 5 minutes
2. Repeat the TC with TCP data transfer

Exit Criteria:

1. Record and compare UDP layer throughput both in UL and DL with physical layer throughput, UDP throughput should be only slightly lower
2. Record and compare TCP layer throughput with the UDP throughput, TCP throughput should be only slightly lower

4.4.2 UDP/TCP Uplink/Downlink Data Throughput IPv6**Conformance Specification:**

- 24.301 [13] chapter 6.6.4.2
- 24.301 [13] chapter 6.6.4.3

Initial Condition:

1. DUT is in RRC Connected and in good coverage

Procedure:

1. Initiate full buffer UL/DL UDP traffic to/from the test server for 5 minutes
2. Repeat the TC with TCP data transfer

Exit Criteria:

1. Record and compare UDP layer throughput both in UL and DL with physical layer throughput, UDP throughput should be only slightly lower
2. Record and compare TCP layer throughput with the UDP throughput, TCP throughput should be only slightly lower

4.5 Power Saving Mode

4.5.1 Successful MT/MO Data Transfer During Active Time in PSM Mode

Conformance Specification:

- 24.008 [15] section 4.7.2.9
- 24.301 [13] section 5.3.11
- 23.401 [14] section 4.3.23

Initial Condition:

1. One NB-IoT Cell available
2. DUT in good coverage with PSM feature enabled
3. PSM feature enabled in the network
4. DUT Attached to the network with T3324 set to 32s and extended T3412 set to a higher valSmart Device than normal T3412 e.g.,300 minutes

Procedure:

1. Allow the DUT to go to Idle mode
2. Just before the DUT's Active Time expires, initiate MT traffic to the DUT e.g., MT ping
3. Repeat steps 1 and 2
4. Allow DUT to go to Idle
5. Just before the DUT's Active Time expires, initiate MO traffic from the DUT e.g., MO ping
6. Repeat steps 4 and 5
7. Detach the DUT

Exit Criteria:

1. Verify that DUT is reachable for MT traffic during the entire Active Time interval
2. Verify that DUT can initiate MO traffic during the entire Active Time interval

4.5.2 Successful MO Data Transfer from PSM Mode

Conformance Specification:

- 24.008 [15] section 4.7.2.9
- 24.301 [13] section 5.3.11
- 23.401 [14] section 4.3.24

Initial Condition:

1. One NB-IoT Cell available
2. DUT in good coverage with PSM feature enabled
3. PSM feature enabled in the network
4. DUT Attached to the network with T3324 set to 32s and extended T3412 set to a higher valSmart Device than normal T3412 e.g., 300 minutes

Procedure:

1. Allow the DUT to go to Idle mode and then to PSM mode (after Active Time expiry)
2. While the DUT is in PSM, initiate MO traffic e.g., MO ping
3. Stop the traffic and the DUT to go back to Idle
4. Before Active Time expiry, initiate MT traffic to the DUT e.g., MT ping
5. Stop the traffic and the DUT to go back to Idle
6. Before Active Time expiry, initiate MO traffic from the DUT e.g., MO ping
7. Detach the DUT

Exit Criteria:

1. Verify that after Active Time expires, the DUT will enter PSM mode
2. Verify that DUT can successfully initiate MO data towards the network from PSM mode by means of CP Service ReqSmart Devicest
3. Verify that both MT and MO traffic can be successfully initiated during Active Time

4.5.3 Pending MT Data Transfer in PSM Mode

Conformance Specification:

- 24.008 [15] section 4.7.2.9
- 24.301 [13] section 5.3.11
- 23.401 [14] section 4.3.25

Initial Condition:

1. One NB-IoT Cell available
2. DUT in good coverage with PSM feature enabled
3. PSM feature enabled in the network
4. DUT Attached to the network with T3324 set to 32s and extended T3412 set to 10 minutes

Procedure:

1. Allow the DUT to go to Idle mode and then to PSM mode (after Active Time expiry)
2. Initiate a continuous MT ping from the server which should not reach the DUT
3. Wait until extended periodic T3412 has expired and periodic TAU has been triggered
4. Leave the MT ping running for a while
5. Stop the ping and allow the DUT to go to Idle
6. Before Active Time expires, initiate MT traffic to the DUT e.g., MT ping
7. Stop the traffic and allow the DUT to go back to Idle
8. Before Active Time expires, initiate MO traffic from the DUT e.g., MO ping
9. Detach the DUT

Exit Criteria:

1. Verify that the DUT has entered PSM mode from both DUT and network side and that the DUT is not reachable for MT traffic during that time
2. Make sure that the DUT has triggered Periodic TAU after the expiry of Extended T3412 and that MT packets are now being successfully delivered to the DUT
3. Verify that Periodic Tracking Area ReqSmart Device contains same PSM timers used in Attach ReqSmart Device
4. Verify that the DUT is able to run MT and MO traffic during Active Time

4.6 Extended DRX**4.6.1 eDRX Attach Procedure****Conformance Specification:**

- 23.401 [14] section 5.3.2; 24.301 [13] section 5.5.1.2

Initial Condition:

1. One NB-IoT Cell available
2. DUT in good coverage with eDRX feature enabled
3. eDRX feature enabled in the network

Procedure:

1. Attach the DUT to the network with eDRX Cycle set to 2 Hyperframes i.e., 20.48s and PTW set to 5.12s on both DUT and network and allow the DUT to go to Idle
2. Detach the DUT and change valSmart Devices of eDRX Cycle to 256 Hyperframes i.e., 2621.44s and PTW to 12.8s on the DUT. Network should keep the same valSmart Devices as in step 1.
3. Trigger another Attach and allow the DUT to go to Idle
4. Detach the DUT and change valSmart Devices of eDRX Cycle to 1024 Hyperframes i.e., 10485.76 s and PTW to 12.8s on the DUT. Disable eDRX in the network
5. Attach the DUT and allow the DUT to go to Idle
6. Detach the DUT

Exit Criteria:

1. Verify that the DUT sends eDRX Cycle and PTW according to the Setup & Actions

2. Verify that the DUT accepts eDRX Cycle and PTW valSmart Devices returned by the NETWORK when eDRX is enabled in the network
3. Verify that the DUT enters eDRX sleep mode when moving from Connected to Idle mode in steps 1 and 3
4. Make sure that the DUT does not enter eDRX sleep mode when the feature is disabled in the network

Appendix A Revision History

Date	Version	Description
December 2023	1.0	Initial release