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Contents

Foreword

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

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1 Scope

The present document provides an overview and overall description of the minimization of drive tests functionality.

The document describes functions and procedures to support collection of UE-specific measurements for MDT using Control Plane architecture, for UTRAN, E-UTRAN and NR.

Details of the signalling procedures for single-RAT operation are specified in the appropriate radio interface protocol specification. Network operation and overall control of MDT is described in OAM specifications.

NOTE: The focus is on conventional macro cellular network deployments. In the current release no specific support is provided for H(e)NB deployments.

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 25.133: "Requirements for support of radio resource management (FDD)".

[3] 3GPP TS 36.133: "Requirements for support of radio resource management (FDD)".

[4] 3GPP TS 25.331: "Radio Resource Control (RRC); Protocol specification".

[5] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[6] 3GPP TS 32.422: "Subscriber and equipment trace; Trace control and configuration management".

[7] 3GPP TS 25.215: "Physical Layer; Measurements (FDD)".

[8] 3GPP TS 25.225: "Physical Layer; Measurements (TDD)".

[9] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer; Measurements".

[10] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC); Protocol Specification".

[11] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures".

[12] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access (E-UTRAN); Overall description; Stage 2".

[13] 3GPP TS 36.314: "Evolved Universal Terrestrial Radio Access (E-UTRA); Layer 2 – Measurements".

[14] 3GPP TS 25.321: "Medium Access Control (MAC) Protocol Specification".

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

[16] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".

[17] 3GPP TS 28.552: "Technical Specification Group Services and System Aspects; Management and orchestration; 5G performance measurements".

[18] 3GPP TS 38.314: "NR; Layer 2 Measurements".

[19] 3GPP TS 38.215: " NR; Physical layer measurements".

[20] 3GPP TS 38.213: " NR; Physical layer procedures for control".

[21] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification".

[22] 3GPP TS 38.300: "NR; NR and NG-RAN Overall description; Stage-2".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] apply.

Immediate MDT: MDT functionality involving measurements performed by the UE in CONNECTED state and reporting of the measurements to RAN available at the time of reporting condition as well as measurements by the network for MDT purposes.

Logged MDT: MDT functionality involving measurement logging by UE in IDLE mode, INACTIVE state, CELL_PCH, URA_PCH states and CELL_FACH state when second DRX cycle is used (when UE is in UTRA) for reporting to eNB/RNC/gNB at a later point in time, and logging of MBSFN measurements by E-UTRA UE in IDLE and CONNECTED modes.

Management Based MDT PLMN List: MDT PLMN List applicable to management based MDT.

MDT measurements: Measurements determined for MDT.

MDT PLMN List: A list of PLMNs where MDT is allowed for a user. It is a subset of the EPLMN list and RPLMN at the time when MDT is initiated.

Signalling Based MDT PLMN List: MDT PLMN List applicable to signalling based MDT.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

3.3 Abbreviations

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

ACK	Acknowledgement
AICH	Acquisition Indicator CHannel
BLER	Block Error Rate
BSSID	Basic Service Set Identifier
CA	Carrier Aggregation
CDMA	Code Division Multiple Access
CN	Core Network
CPICH	Common Pilot CHannel
DCH	Dedicated CHannel
DL	Downlink

DRX	Discontinuous Reception
ECGI	E-UTRAN Cell Global Identifier
E-CID	Enhanced Cell-ID (positioning method)
E-DCH	Enhanced Uplink DCH
EDGE	Enhanced Data rates for GSM Evolution
E-RUCCH	E-DCH Random Access Uplink Control CHannel
eNB	Evolved NodeB
EPLMN	Equivalent PLMN
E-UTRA	Evolved UTRA
E-UTRAN	Evolved UTRAN
FACH	Forward Access CHannel
FDD	Frequency Division Duplex
FIFO	First Input First Output
FPACH	Fast Physical Access CHannel
GERAN	GSM EDGE Radio Access Network
gNB	Next Generation Node B
GNSS	Global Navigation Satellite System
HESSID	Homogenous Extended Service Set Identifier
HOF	Handover Failure
IMEI-SV	International Mobile Equipment Identity Software Version
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
ISCP	Interference on Signal Code Power
LA	Location Area
LTE	Long Term Evolution
MAC	Medium Access Control
MBMS	Multimedia Broadcast Multicast Service
MBSFN	MBMS Single Frequency Network
MDT	Minimization of Drive-Tests
NG-RAN	Next Generation RAN
NR	New Radio
OAM	Operation and Maintenance
P-CCPCH	Primary Physical Common Control CHannel
PCH	Paging CHannel
PCI	Physical Cell Id
PDCP	Packet Data Convergence Protocol
PH	Power Headroom
PLMN	Public Land Mobile Network
PS	Packet Switched
QCI	QoS Class Identifier
QoS	Quality of Service
RA	Routing Area
RAB	Radio Access Bearer
RAT	Radio Access Technology
RB	Radio Bearer
RF	Radio Frequency
RLC	Radio Link Control
RLF	Radio Link Failure
RNC	Radio Network Controller
RPLMN	Registered PLMN
RRC	Radio Resource Control
RRM	Radio Resource Management
RSCP	Received Signal Code Power
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
RSSI	Received Signal Strength Indicator
RTT	Round Trip Time
RTWP	Received Total Wideband Power
SCell	Secondary Cell
SIR	Signal to Interference Ratio
SINR	Signal to Noise plus Interference Ratio
SNR	Signal to Noise Ratio

SON	Self Organizing/Optimizing Network
SRB	Signalling Radio Bearer
SRNC	Serving RNC
SSB	Synchronization Signal Block
SSID	Service Set Identifier
TA	Tracking Area
TCE	Trace Collection Entity
TDD	Time Division Duplex
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunication System
UPH	Uplink PH
URA	UTRAN Registration Area
UTRA	Universal Terrestrial Radio Access
UTRAN	Universal Terrestrial Radio Access Network

4 Main concept and requirements

4.1 General

The general principles and requirements guiding the definition of functions for Minimization of drive tests are the following:

1. **MDT mode**
   There are two modes for the MDT measurements: Logged MDT and Immediate MDT. There are also cases of measurement collection not specified as either immediate or logged MDT, such as Accessibility measurements.

2. **UE measurement configuration**
   It is possible to configure MDT measurements for the UE logging purpose independently from the network configurations for normal RRM purposes. However, in most cases, the availability of measurement results is conditionally dependent on the UE RRM configuration.

3. **UE measurement collection and reporting**
   UE MDT measurement logs consist of multiple events and measurements taken over time. The time interval for measurement collection and reporting is decoupled in order to limit the impact on the UE battery consumption and network signalling load.

4. **Geographical scope of measurement logging**
   It is possible to configure the geographical area where the defined set of measurements shall be collected.

5. **Location information**
   The measurements shall be linked to available location information and/or other information or measurements that can be used to derive location information.

6. **Time information**
   The measurements in measurement logs shall be linked to a time stamp.

7. **Sensor information**
   The measurements can be linked to available sensor information that can be used to derive UE orientation in a global coordinate system, the uncompensated barometric pressure and the UE speed.

8. **UE capability information**
   The network may use UE capabilities to select terminals for MDT measurements.

9. **Dependency on SON**
   The solutions for MDT are able to work independently from SON support in the network. Relation between measurements/solution for MDT and UE side SON functions shall be established in a way that re-use of functions is achieved where possible.

10. **Dependency on TRACE**
    The subscriber/cell trace functionality is reused and extended to support MDT. If the MDT is initiated towards a

specific UE (e.g. based on IMSI, IMEI-SV, etc.), the signalling based trace procedure is used, otherwise the management based trace procedure (or cell traffic trace procedure) is used. Network signalling and overall control of MDT is described in TS 32.422 [6].

The solutions for MDT shall take into account the following constraints:

1. **UE measurements**
   The UE measurement logging mechanism is an optional feature. In order to limit the impact on UE power consumption and processing, the UE measurement logging should as much as possible rely on the measurements that are available in the UE according to radio resource management enforced by the access network.

2. **Location information**
   The availability of location information is subject to UE capability and/or UE implementation. Solutions requiring location information shall take into account power consumption of the UE due to the need to run its positioning components.

5 Functions and procedures

5.1 General procedures

5.1.1 Logged MDT procedures

Support of Logged MDT complies with the principles for IDLE and INACTIVE state measurements in the UE specified in TS 25.133[2], TS 36.133 [3] and TS 38.133 [16] and principles for IDLE and CONNECTED mode MBSFN measurements in the UE specified in TS 36.133 [3].

NOTE: It should be noted the established principles may result in different logged information in different UEs.

Furthermore, measurement logging is differentiated based on UE states in idle mode i.e. camped normally, any cell selection or camped on any cell. The UE shall perform measurement logging in "camped normally" state and "any cell selection" state. In "camped on any cell" state the UE is not required to perform MDT measurement logging (including time and location information).

For Logged MDT, the configuration will always be done in cells of the same RAT type. However, measurements included in the logged MDT report comprises of measurements from the same RAT type (serving cell measurements, intra-frequency and inter-frequency neighbor cell measurements) and different RAT types (inter-RAT neighbor cell measurements).

Logging of MBSFN measurements is only applicable to E-UTRA.

5.1.1.1 Measurement configuration

Logged MDT measurements are configured with a MDT Measurement Configuration procedure, as shown in Figure 5.1.1.1-1.

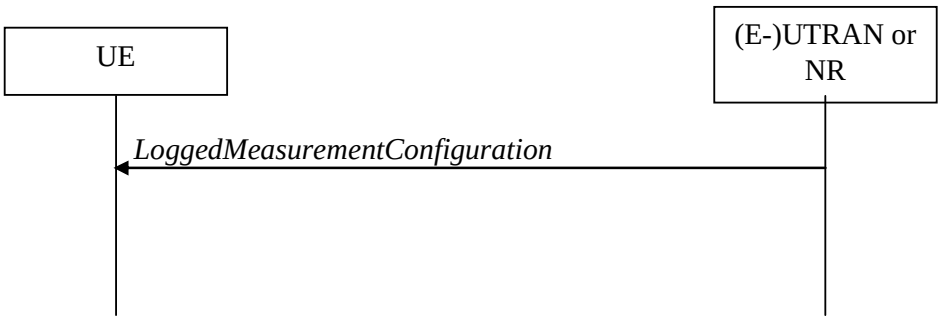

Figure 5.1.1.1-1: MDT measurement configuration for Logged MDT

Network initiates the procedure to UE in RRC Connected by sending *LoggedMeasurementConfiguration* message, which is used to transfer configuration parameters for Logged MDT. This is a unidirectional RRC signalling procedure.

A release operation for logged measurement configuration in the UE is realized only by configuration replacement when the configuration is overwritten or by configuration clearance in case a duration timer stopping or expiration condition is met.

5.1.1.1.1 Configuration parameters

The logged measurement configuration consists of:

- configuration of downlink pilot strength measurements logging for (E-)UTRA and NR.
- configuration of MBSFN measurement logging for E-UTRA.
- configuration of the triggering of logging events:
  - for (E-)UTRAN only periodic measurement trigger is supported, for which the logging interval is configurable. The parameter specifies the periodicity for storing MDT measurement results. It should be configured in seconds in multiples of the applied IDLE mode DRX, i.e. multiples of 1.28s which is either a factor or multiple of the IDLE mode DRX. The UE behaviour is unspecified when the UE is configured with a DRX cycle larger than the logging interval.
  - for NR:
    - periodic measurement trigger is supported, for which the logging interval is configurable. The parameter specifies the periodicity for storing MDT measurement results.
    - event-based trigger is supported, for which the logging interval is configurable, which determines periodical logging of available data (e.g. time stamp, location information), and the following two types of events are supported:
      - measurement quantity-based event L1, for which the event threshold, hysteresis, and time to trigger are configurable. If the configured time to trigger is not a multiple of the DRX cycle, then the UE uses the next multiple of DRX cycle duration that is larger than the time to trigger for evaluating the event L1;
      - out-of-coverage detection trigger.

NOTE: The logging configuration for event-based and periodical DL pilot strength logged measurements can be configured independently. Only one type of event can be configured to the UE.

- configuration of the logging duration. This configuration parameter defines a timer activated at the moment of configuration, that continues independent of state changes, RAT or RPLMN change. When the timer expires the logging is stopped and the configuration is cleared (except for the parameters that are required for further reporting e.g. network absolute time stamp, trace reference, trace recording session reference and TCE Id).

- network absolute time stamp to be used as a time reference to UE.
- Trace Reference parameter as indicated by the OAM configuration as specified in TS 32.422 [6].
- Trace Recording Session Reference as indicated by the OAM configuration as specified in TS 32.422 [6].
- TCE Id as indicated by the OAM configuration as specified in TS 32.422 [6].
- (optionally) MDT PLMN List, indicating the PLMNs where measurement collection and log reporting is allowed. It is either the Management Based MDT PLMN List or the Signalling Based MDT PLMN List, depending on how the Logged MDT task was initiated (see 5.1.3).
- (optionally) configuration of a logging area. A UE will log measurements as long as it is within the configured logging area. The scope of the logging area may consist of one of:
  - a list of up to 32 global cell identities. If this list is configured, the UE will only log measurements when camping in any of these cells
  - a list of up to 8 TAs or 8 LAs or 8 RAs. If this list is configured, the UE will only log measurements when camping in any cell belonging to the preconfigured TA/LA/RAs.
- The configured logging area can span PLMNs in the MDT PLMN List. If no area is configured, the UE will log measurements throughout the PLMNs of the MDT PLMN list.
- (optionally) for NR, configuration of a list of neighbouring frequencies and/or cells, indicating the UE to include neighbouring cell's measurements as indicated in the list in the logged MDT report.
- (optionally) for E-UTRA, configuration of target MBSFN area(s) for MBSFN measurement logging. If target MBSFN area(s) is configured, UE applies it in addition to other restrictions such as the logging area. The UE will log measurements as long as it receives MBMS service from an indicated target MBSFN area and is within the configured logging area. The target MBSFN area(s) is defined by a list of up to 8 entries, where each entry indicates a carrier frequency and optionally indicates a specific MBSFN area on a carrier frequency.
- (optionally) configuration of the WLAN access point names, indicating the UE to attempt to obtain WLAN measurements associated to these access points.
- (optionally) configuration of the Bluetooth beacon names, indicating the UE to attempt to obtain Bluetooth measurements associated to these beacons.
- (optionally) for NR, configuration of the sensor names, indicating the UE to attempt to obtain sensor measurements.

5.1.1.1.2 Configuration effectiveness

The logged measurement configuration is provided in a cell by dedicated control while UE is in CONNECTED and implies:

- logged measurement configuration for downlink pilot strength measurements (or events) logging is active
  - in IDLE UE state in E-UTRAN, or
  - in IDLE mode, CELL_PCH and URA_PCH states in UTRAN, or
  - in CELL_FACH state when second DRX cycle is used in UTRAN, or
  - in IDLE and INACTIVE states in NR
  - until logging duration timer expires or stops
- logged measurement configuration for MBSFN measurement logging is active
  - in IDLE and CONNECTED UE states in E-UTRAN
  - until logging duration timer expires or stops

- logged measurement configuration and logs are maintained when the UE is in any state as described above, despite multiple periods interrupted by UE state transitions, e.g. for downlink pilot strength measurements when the UE is in CONNECTED state for E-UTRAN and NR and CELL_DCH, CELL_FACH state when second DRX cycle is not used in UTRAN

- logged measurement configuration and logs are maintained when the UE is in any state as described above in that RAT, despite multiple periods interrupted by UE presence in another RAT

There is only one RAT-specific logged measurement configuration for Logged MDT in the UE. When the network provides a configuration, any previously configured logged measurement configuration will be entirely replaced by the new one. Moreover, logged measurements corresponding to the previous configuration will be cleared at the same time. It is left up to the network to retrieve any relevant data before providing a new configuration.

NOTE: The network may have to do inter-RAT coordination.

When a logging area is configured, logged MDT measurements are performed as long as the UE is within this logging area. For NR, when determining whether a cell is part of the logging area, only the first entry of the *plmn-IdentityList* in the first entry of the *PLMN-IdentityInfoList* (in SIB1), and cellIdentity and TAC corresponding to the first entry of the *PLMN-IdentityInfoList* are considered. If no logging area is configured, logged MDT measurements are performed as long as the RPLMN is part of the MDT PLMN list. When the UE is not in the logging area or RPLMN is not part of the MDT PLMN list, the logging is suspended, i.e. the logged measurement configuration and the log are kept but measurement results are not logged. In addition, for MBSFN logged measurements, logged MDT measurements are performed in logging intervals when the UE receives MBMS service from a MBSFN area according to the target MBSFN area(s) configuration When the UE is not in the logging area or does not receive MBMS service from a MBSFN area that matches the target MBSFN area(s) configuration in the logging interval the logged measurement configuration and the log are kept but measurement results are not logged.

NOTE: The logging duration timer continues.

In case the new PLMN that does not belong to the MDT PLMN list provides a logged measurement configuration any previously configured logged measurement configuration and corresponding log are cleared and overwritten without being retrieved.

5.1.1.2 Measurement collection

In "camped normally" state, a UE shall perform logging as per the logged measurement configuration. This state includes a period between cell selection criteria not being met and UE entering "any cell selection" state, i.e. 10 s for E-UTRA (See TS 36.133 [3]) or 12 s for UTRA (See TS 25.133 [2]) or 10s for NR (See TS 38.133 [16]).

In "any cell selection" state, a UE shall perform logging of available information (i.e. at least indicator 'anyCellSelectionDetected', time stamp, and the available location information). In "camped on any cell" state, the periodic logging stops. However, it should be noted that the duration timer is kept running. When the UE re-enters "camped normally" state and the duration timer has not expired, the periodic logging is restarted based on new DRX and logging resumes automatically (with a leap in time stamp).

When an E-UTRA UE detects an in-device coexistence problem that may affect the logged measurement results, the UE shall stop measurement logging, indicate in the log that an in-device coexistence problem has occurred, and keep the duration timer running. When the in-device coexistence problem is no longer present, and the duration timer has not expired, the logging resumes, with a leap in time stamp.

For E-UTRA MBSFN measurement logging, the UE shall perform MBSFN measurements only when receiving MBMS service, and measurement logging is performed only for logging intervals for which MBSFN measurements are available. The UE shall perform MBSFN measurements and MBSFN measurement logging in both IDLE and CONNECTED modes.

NOTE: the UE is only required to perform MBSFN measurements when receiving MBMS service of the MBSFN area(s) targeted for logging.

For WLAN measurement logging and Bluetooth measurement logging, the UE shall perform WLAN and Bluetooth measurements, respectively, only when indicated in the corresponding configuration. The measurement logging is performed only for logging intervals for which WLAN and Bluetooth measurements are available, respectively.

The measurement quantities for downlink pilot strength measurement logging are fixed and consist of both RSRP and RSRQ for EUTRA, both RSCP and Ec/No for UTRA FDD, P-CCPCH RSCP for UTRA 1.28 Mcps TDD, Rxlev for

GERAN, and Pilot Pn Phase and Pilot Strength for CDMA2000 if the serving cell is EUTRAN cell, and both RSRP and RSRQ for NR.

For NR, in addition to the logged measurement quantities of the camped cell, the best beam index (SSB Index) as along with the best beam RSRP/RSRQ are logged as well as the 'number of good beams' (the number of SSBs that are above the configured threshold i.e., *absThreshSS-BlocksConsolidation,* if configured by the network) associated to the cells within the R value range (which is configured by network for cell reselection) of the highest ranked cell as part of the beam level measurements. Sensor measurements are logged if available.

The measurement quantities for E-UTRA MBSFN measurement logging are fixed and consist of MBSFN RSRP, MBSFN RSRQ, BLER for signalling and BLER for data per MCH, in addition to the measurement quantities for downlink pilot strength measurements.

The measurement quantities for WLAN measurement logging are fixed and consist of BSSID, SSID, HESSID of WLAN APs. If configured by the network, optionally available RSSI and RTT can be included.

The measurement quantity for Bluetooth measurement logging is fixed and consists of MAC address of Bluetooth beacons. If configured by the network, optionally available RSSI can be included.

UE collects MDT measurements and continues logging according to the logged measurement configuration until UE memory reserved for MDT is full. In this case the UE stops logging, stops the log duration timer and starts the 48 hour timer.

5.1.1.3 Measurement reporting

5.1.1.3.1 Availability Indicator

A UE configured to perform Logged MDT downlink pilot strength measurements indicates the availability of Logged MDT measurements, by means of a one bit, in RRCConnectionSetupComplete or RRCSetupComplete or RRCConnectionResumeComplete or RRCResumeComplete message during connection establishment. Furthermore, the indicator (possibly updated) shall be provided within:

- E-UTRAN handover and re-establishment;
- UTRAN procedures involving the change of SRNC (SRNC relocation), CELL UPDATE, URA UPDATE messages as well as MEASUREMENT REPORT message in case of state transition to CELL_FACH without CELL UPDATE;
- NR re-establishment, reconfiguration.

The UE includes the indication in one of these messages at every transition to RRC Connected mode even though the logging period has not ended, upon connection to RAT which configured the UE to perform Logged MDT measurements and RPLMN which is equal to a PLMN in the MDT PLMN list.

A E-UTRA UE configured to perform Logged MDT MBSFN measurements indicates the availability of Logged MDT MBSFN measurements, by means of an indicator, in RRCConnectionSetupComplete message during connection establishment. The indicator (possibly updated) shall be provided within E-UTRAN also at handover and re-establishment, except when the logged measurement configuration is active in CONNECTED mode, i.e. except when the logging campaign is still ongoing.

A E-UTRA UE configured to perform Logged MDT WLAN measurements indicates the availability of Logged MDT WLAN measurements, by means of an indicator, in RRCConnectionSetupComplete message or RRCConnectionResumeComplete message during connection establishment. Furthermore, the indicator can be included in some uplink RRC messages, i.e., RRCConnectionReconfigurationComplete message, RRCConnectionReestablishmentComplete message, or UEInformationResponse message, at every transition to RRC Connected mode even though the logging period has not ended.

A E-UTRA UE configured to perform Logged MDT Bluetooth measurements indicates the availability of Logged MDT Bluetooth measurements, by means of an indicator, in RRCConnectionSetupComplete message or RRCConnectionResumeComplete message during connection establishment. Furthermore, the indicator can be included in some uplink RRC messages, i.e., RRCConnectionReconfigurationComplete message, RRCConnectionReestablishmentComplete message, or UEInformationResponse message, at every transition to RRC Connected mode even though the logging period has not ended.

A NR UE configured to perform Logged MDT WLAN measurements indicates the availability of Logged MDT WLAN measurements, by means of an indicator, in RRCSetupComplete message or RRCResumeComplete message during connection establishment. Furthermore, the indicator can be included in some uplink RRC messages, i.e., RRCReconfigurationComplete message, RRCReestablishmentComplete message, or UEInformationResponse message, at every transition to RRC Connected mode even though the logging period has not ended.

A NR UE configured to perform Logged MDT Bluetooth measurements indicates the availability of Logged MDT Bluetooth measurements, by means of an indicator, in RRCSetupComplete message or RRCResumeComplete message during connection establishment. Furthermore, the indicator can be included in some uplink RRC messages, i.e., RRCReconfigurationComplete message, RRCReestablishmentComplete message, or UEInformationResponse message, at every transition to RRC Connected mode even though the logging period has not ended.

An indicator shall be also provided in UEInformationResponse message during MDT report retrieval in case the UE has not transferred the total log in one RRC message in order to indicate the remaining data availability.

The UE will not indicate the availability of MDT measurements in another RAT or in a PLMN that is not in the MDT PLMN list.

The network may decide to retrieve the logged measurements based on this indication. In case Logged MDT measurements are retrieved before the completion of the pre-defined logging duration, the reported measurement results are deleted, but MDT measurement logging will continue according to ongoing logged measurement configuration.

In case the network does not retrieve Logged MDT measurements, UE should store non-retrieved measurements for 48 hours from the moment the duration timer for logging expired. There is no requirement to store non-retrieved data beyond 48 hours. In addition, all logged measurement configuration and the log shall be removed by the UE at switch off or detach.

5.1.1.3.2 Report retrieval

For Logged MDT the measurement reporting is triggered by an on-demand mechanism, i.e. the UE is asked by the network to send the collected measurement logs via RRC signalling. UE Information procedure defined in TS 25.331 [4] and TS 36.331 [5] and TS 38.331 [15] is used to request UE to send the collected measurement logs. The reporting may occur in different cells than which the logged measurement configuration is signalled.

Transport of Logged MDT reports in multiple RRC messages is supported. With every request, the network may receive a part of the total UE log. To indicate the reported data is a segment, the UE shall include data availability indicator in UEInformatonResponse message to convey the information that further measurement information is available, as specified in 5.1.1.3.1. In multiple RRC transmissions for segmented Logged MDT reporting, FIFO order is followed, i.e. the UE should provide oldest available measurement entries in earliest message. There is no requirement specified on the size of particular reporting parts. However, each reported part should be "self-decodable", i.e. interpretable even in case all the other parts are not available.

The UE shall send an empty report when retrieval is attempted and the RPLMN is not in the MDT PLMN list.

5.1.1.3.3 Reporting parameters

For downlink pilot strength measurements, the logged measurement report consists of measurement results for the serving cell (the measurement quantity), available UE measurements performed in idle or inactive for intra-frequency/inter-frequency/inter-RAT, time stamp and location information.

For E-UTRA MBSFN measurements logging, the logged measurement report consists of MBSFN measurement results from target MBSFN area(s), if configured, and available downlink pilot strength measurement results. Inter-RAT downlink pilot strength measurements are not required to be logged.

For WLAN and Bluetooth measurement logging, the logged measurement reports consist of WLAN and Bluetooth measurement results, respectively.

The number of neighbouring cells to be logged is limited by a fixed upper limit per frequency for each category below. The UE should log the measurement results for the neighbouring cells, if available, up to:

- 6 for intra-frequency neighbouring cells;
- 3 for inter-frequency neighbouring cells per frequency;

- 3 for GERAN neighbouring cells per frequency;
- 3 for UTRAN (if non-serving) neighbouring cells per frequency;
- 3 for E-UTRAN (if non-serving) neighbouring cells per frequency;
- 3 for NR (if non-serving) neighbouring cells per frequency;
- 3 for CDMA2000 (if serving is E-UTRA) neighbouring cells per frequency;
- 32 for WLAN APs;
- 32 for Bluetooth Beacons.

NOTE: UE in NR IDLE or INACTIVE state will not log measurements from UMTS or GSM.

The measurement reports for neighbour cells consist of:

- Physical cell identity of the logged cell;
- Carrier frequency;
- RSRP and RSRQ for EUTRA and NR;
- RSCP and Ec/No for UTRA FDD,
- P-CCPCH RSCP for UTRA 1.28 Mcps TDD;
- Rxlev for GERAN;
- Pilot Pn Phase and Pilot Strength for CDMA2000;
- RSSI and RTT for WLAN APs;
- RSSI for Bluetooth Beacons.

For any logged cell (serving or neighbour), latest available measurement result made for cell reselection purposes is included in the log only if it has not already been reported.

While logging neighbour cells measurements, the UE shall determine a fixed number of best cells based on the measurement quantity used for ranking during cell reselection per frequency or RAT.

The MBSFN measurement results consist of, per MBSFN area where MBMS service is received:

- MBSFN area identity;
- Carrier frequency;
- MBSFN RSRP;
- MBSFN RSRQ;
- MCH BLER for signalling;
- MCH BLER for data, and related MCH index.

The WLAN measurement results consist of, per wireless network served by the WLAN AP:

- BSSID, SSID and HESSID;
- RSSI for WLAN;
- RTT.

The Bluetooth measurement results consist of, per wireless network served by the Bluetooth beacon:

- MAC address;
- RSSI for Bluetooth.

Measurements are performed in accordance with requirements defined in TS 25.133 [2] and TS 36.133 [3] and TS 38.133 [16].

The measurement report is self contained, i.e. the RAN node is able to interpret the Logged MDT reporting results even if it does not have access to the logged measurement configuration. Each measurement report also contains the necessary parameters for the network to be able to route the reports to the correct TCE and for OAM to identify what is reported. The parameters are sent to the UE in the logged configuration message, see clause 5.1.1.1.1.

For each MDT measurement the UE includes a relative time stamp. The base unit for time information in the Logged MDT reports is the second. In the log associated to periodical logging configuration, the time stamp indicates the point in time when periodic logging timer expires. The time stamp is counted in seconds from the moment the logged measurement configuration is received at the UE, relative to the absolute time stamp received within the configuration. The absolute time stamp is the current network time at the point when Logged MDT is configured to the UE. The UE echoes back this absolute reference time. The time format for Logged MDT report is: *YY-MM-DD HH:MM:SS*.

Location information is based on available location information in the UE. Thus, the Logged MDT measurements are tagged by the UE with location data in the following manner:

- ECGI, Cell-Id or NCGI in TS 38.300 [22] of the serving cell when the measurement was taken is always included in E-UTRAN, UTRAN or NR respectively;

- Detailed location information (e.g. GNSS location information) is included if available in the UE when the measurement was taken. If detailed location information is available, the reporting shall consist of latitude and longitude. Depending on availability, altitude, uncertainty and confidence may be also additionally included. UE tags available detailed location information only once with upcoming measurement sample, and then the detailed location information is discarded, i.e. the validity of detailed location information is implicitly assumed to be one logging interval;

- For NR, sensor information (i.e. uncompensated barometric pressure measurement, UE speed and UE orientation) can be included, if available in the UE when the measurement was taken.

NOTE: The neighbour cell measurement information that is provided by the UE may be used to determine the UE location (RF fingerprint).

Depending on location information availability, measurement log/report consists of:

- time information, RF measurements, RF fingerprints; or

- time information, RF measurements, detailed location information (e.g. GNSS location information);

  time information, RF measurements, detailed location information, sensor information.

5.1.1.4 MDT context handling

For Logged MDT in IDLE, CELL_PCH, URA_PCH states and CELL_FACH state when second DRX cycle is used and INACTIVE, no need is identified to transfer an MDT context (any related configuration information about measurement and reporting) between (e/g)NBs/RNCs if corresponding MDT configuration has already been configured to UE. In addition, MDT context is assumed to be released in the RAN nodes when the UE is in IDLE and INACTIVE if corresponding MDT configuration has already been configured to UE.

For UE in INACTIVE, the MDT context handling during cell reselection as described in 5.4.2 apply.

5.1.2 Immediate MDT procedures

5.1.2.1 Measurement configuration

For Immediate MDT, RAN measurements and UE measurements can be configured. The configuration for UE measurements is based on the existing RRC measurement procedures for configuration and reporting with some extensions for location information.

NOTE: No extensions related to time stamp are expected for Immediate MDT i.e. time stamp is expected to be provided by eNB/RNC/gNB.

If area scope is included in the MDT configuration provided to the RAN, the UE is configured with respective measurement when the UE is connected to a cell that is part of the configured area scope.

5.1.2.2 Measurement reporting

For Immediate MDT, the UE provides detailed location information (e.g. GNSS location information) if available. The UE also provides available neighbour cell measurement information that may be used to determine the UE location (RF fingerprint). ECGI, Cell-Id, or CellIdentity of the serving cell when the measurement was taken is always assumed known in E-UTRAN, UTRAN or NR respectively.

The location information which comes with UE radio measurements for MDT can be correlated with other MDT measurements, e.g. RAN measurements. For MDT measurements where UE location information is provided separately, it is assumed that the correlation of location information and MDT measurements should be done in the TCE based on time-stamps.

5.1.2.3 MDT context handling during handover

The measurements configured in the UE for Immediate MDT should fully comply with the transferring and reconfiguration principles for the current measurements configured in the UE for RRM purpose during handover (including conformance with Rel-8 and Rel-9).

The target node releases the measurements configured in the UE for immediate MDT which are no longer needed based on any MDT trace configuration it receives or does not receive.

In addition, MDT configuration handling during handover depends on MDT initiation from OAM defined in clause 5.1.3:

- The MDT configuration configured by management based trace function will not propagate during handover.
- For LTE, the MDT configuration received by signalling based trace messages for a specific UE will propagate during intra-PLMN handover, and may propagate during inter-PLMN handover if the Signalling Based MDT PLMN List is available and includes the target PLMN. This behaviour applies also for MDT configuration that includes area scope, regardless of whether the source or target cell is part of the configured area scope. This behaviour applies also for Xn inter-RAT handover.
- For UMTS, the MDT configuration received by signalling based trace messages for a specific UE will continue during intra-PLMN handover, and may continue during inter-PLMN handover if the Signalling Based MDT PLMN List is available and includes the target PLMN, except for the case of SRNS relocation.
- For NR, the MDT configuration received by signalling based trace messages for a specific UE will propagate during intra-PLMN handover, and may propagate during inter-PLMN handover if the Signalling Based MDT PLMN List is available and includes the target PLMN. This behaviour applies also for MDT configuration that includes area scope, regardless of whether the source or target cell is part of the configured area scope. This behaviour applies also for Xn inter-RAT handover.

NOTE: In the case of SRNS relocation, MDT may be reactivated by the Core Network following a successful relocation.

5.1.3 MDT Initiation

There are two cases that RAN should initiate a MDT measurements collection task. One is that the MDT task is initiated without targeting a specific UE by the cell traffic trace, i.e. management based trace function from OAM. The other is that the MDT task is initiated towards a specific UE by the signalling trace activation messages from CN nodes, i.e. the Initial Context Setup message, the Trace Start message or the Handover request message in E-UTRAN or NR, the CN Invoke Trace message in UTRAN. The detailed procedures to transfer the MDT configurations to RAN are specified in TS 32.422 [6].

For signalling based MDT, the CN shall not initiate MDT towards a particular user unless it is allowed.

For management based MDT, the CN indicates to the RAN whether MDT is allowed to be configured by the RAN for this user considering e.g. user consent and roaming status (see TS 32.422 [6]), by providing management based MDT allowed information. For E-UTRAN/UTRAN, the MDT allowed information consists of the Management Based MDT Allowed indication and optionally the Management Based MDT PLMN List. For NR, the MDT allowed information

only consists of the Management Based MDT PLMN List. The management based MDT allowed information propagates during inter-PLMN handover if the Management Based MDT PLMN List is available and includes the target PLMN.

A UE is configured with an MDT PLMN List only if user consent is valid for the RPLMN.

5.1.4 UE capabilities

MDT relevant UE capabilities are component of radio access UE capabilities. Thus, the procedures used for handling UE radio capabilities over (E-)UTRAN and NR apply.

For (E-)UTRAN:

- The UE indicates one capability bit for support for Logged MDT, which indicates that the UE supports logging of downlink pilot strength measurements. The UE may also indicate capability for stand-alone GNSS positioning.
- The E-UTRA UE may indicate a capability for RX-TX time difference measurement for E-CID positioning for MDT.
- The E-UTRA UE may indicate a capability for support of logging of MBSFN measurements.
- The E-UTRA UE may indicate a capability for support of UL PDCP delay measurement when the UE is not configured with MR-DC.
- The E-UTRA UE may indicate a capability for support of UL PDCP Packet Average Delay measurement when the UE is configured with EN-DC.
- The E-UTRA UE may indicate a capability for support of Bluetooth measurements in RRC idle mode.
- The E-UTRA UE may indicate a capability for support of WLAN measurements in RRC idle mode.
- The E-UTRA UE may indicate a capability for support of Bluetooth measurements in RRC connected mode.
- The E-UTRA UE may indicate a capability for support of WLAN measurements in RRC connected mode.
- For UMTS support of the Accessibility measurements is an optional UE feature.

For NR:

- The UE indicates one capability bit for support for Logged MDT in RRC idle and inactive mode, to indicate that the UE supports logging of downlink pilot strength measurements, periodical logging and event-triggered logging.
- The UE may indicate capability for stand-alone GNSS positioning.
- The NR UE may indicate a capability for support of UL PDCP packet average delay measurement.
- The NR UE may indicate a capability for support of Bluetooth measurements in RRC idle and inactive mode.
- The NR UE may indicate a capability for support of WLAN measurements in RRC idle and inactive mode.
- The NR UE may indicate a capability for support of Bluetooth measurements in RRC connected state.
- The NR UE may indicate a capability for support of WLAN measurements in RRC connected state.
- The NR UE may indicate a capability for support of barometer measurements.
- The NR UE may indicate a capability for support of orientation measurements.
- The NR UE may indicate a capability for support of speed measurements.

5.1.5 Void

5.1.6 Accessibility measurements

The UE logs failed RRC connection establishments for LTE, UMTS and NR, i.e. a log is created when the RRC connection establishment procedure fails. For NR, UE logs any failed connection establishment attempt, i.e. a log is created when the RRC setup or resume procedure fails. The UE logs failed RRC connection establishments without the need for prior configuration by the network.

The UE stores the Selected PLMN on the RRC connection establishment failure or RRC resume procedure failure. Only if that PLMN is the same as the RPLMN, the UE may report the log.

NOTE: There is no expected performance degradation for networks using EPLMNs.

The trigger for creating a log related to a failed RRC connection establishment is for NR when timer T300 expires, for LTE when timer T300 expires and for UMTS when V300 is greater than N300. The trigger for creating log related to a failed RRC resume procedure is for NR when timer T319 expires.

The UE can store the following information related to the failed RRC connection establishment or failed RRC resume procedure:

- Time stamp, which is the elapsed time between logging and reporting the log.
- The global cell identity of the serving cell when the RRC connection establishment or resume fails, i.e. the cell which the UE attempted to access.
- The latest available radio measurements for any frequency or RAT
- The latest detailed location information, if available.
- For LTE:
  - Number of Random Access Preambles transmitted;
  - Indication whether the maximum transmission power was used;
  - Contention detected;
  - The latest WLAN measurement results, if available;
  - The latest Bluetooth measurement results, if available.
- For UMTS FDD:
  - Number of RRC Connection Request attempts (e.g. T300 expiry after receiving ACK and AICH)
- For UMTS 1.28 Mcps TDD:
  - Number of RRC Connection Request attempts.
  - Whether the FPACH is received or whether the maximum number Mmax of synchronisation attempts is reached.
  - Failure indication of the E-RUCCH transmission. It is only applied when common E-DCH is supported by UE and network.
- For NR:
  - SSB index of the downlink beams of serving cell;
  - The latest number of consecutive connection failures in the last failed cell the UE has experienced independent of RRC state transitions;
  - RACH failure report:

- Tried SSB index and number of Random Access Preambles transmitted for each tried SSB in chronological order of attempts;
- Contention detected as per RACH attempt;
- Indication whether the selected SSB is above or below the rsrp-ThresholdSSB threshold, as per RACH attempt;
- TAC of the cell in which the UE performs the RA procedure;

- The latest WLAN measurement results, if available;
- The latest Bluetooth measurement results, if available;
- The latest sensor information, if available.

In addition, the CEF report may include additional information required for RACH Optimization solutions, as specified in TS 38.300 [22].

5.2 E-UTRAN solutions

5.2.1 RRC_CONNECTED

UE in RRC Connected does not support Logged MDT in this release of the specification, except for the case of logged MDT for MBSFN measurements as described in clause 5.1.1. In order to support Immediate MDT where MDT measurements are executed in the UE, the existing RRC measurement configuration and reporting procedures apply. Some extensions are used to carry location information.

5.2.1.1 Measurements and reporting triggers for Immediate MDT

Measurements to be performed for Immediate MDT purposes involve reporting triggers and criteria utilized for RRM. An MDT specific UE-based measurement for UL PDCP delay is applied for QoS verification purpose. In addition, there are measurements performed in eNB.

In particular, the following measurements shall be supported for Immediate MDT performance:

Measurements:

- M1: RSRP, RSRQ and SINR measurement by UE, see TS 36.214 [9].
- M2: Power Headroom measurement by UE, see TS 36.213 [11].
- M3: Received Interference Power measurement by eNB, see TS 36.214 [9]. This is a cell measurement. One sample is logged each measurement collection period, where one sample corresponds to a measurement period as specified in TS 36.133 [3].
- M4: Data Volume measurement separately for DL and UL, per QCI per UE, by eNB, see TS 36.314 [13].
- M5: Scheduled IP Throughput for MDT measurement separately for DL and UL, per RAB per UE and per UE for the DL, per UE for the UL, by eNB, see TS 36.314 [13]. QCI values of the RABs that have contributed to a measurement value are logged with the measurement values.
- M6: Packet Delay measurement, separately for DL and UL, per QCI per UE, see UL PDCP Delay, by the UE, and Packet Delay in the DL per QCI, by the eNB, TS 36.314 [13].

NOTE 1: If the UE does not detect any UL PDCP delay based on the delay threshold and delay report interval configured by the network, the UE does not report any UL PDCP delay measurement within that period.

NOTE 2: A UE in EN-DC mode of operation can be configured with UL PDCP Packet Average Delay (*ul-DelayValueConfig*), if UE is capable of performing the UL average PDCP queueing delay.

- M7: Packet Loss rate measurement, separately for DL and UL per QCI per UE, by the eNB, see Packet Loss rate in the UL and Packet Uu Loss rate in the DL TS 36.314 [13].

- M8: RSSI measurement by UE, see TS 36.331 [5].
- M9: RTT measurement by UE, see TS 36.331 [5].

Measurement collection triggers:

- For M1:
  - Event-triggered measurement reports according to existing RRM configuration for events A1, A2, A3, A4, A5 A6, B1 or B2
  - Periodic, A2 event-triggered, or A2 event triggered periodic measurement report according to MDT specific measurement configuration.
- For M2:
  - Reception of Power Headroom Report (PHR) according to existing RRM configuration.

NOTE 3: PHR is carried by MAC signalling. Thus, the existing mechanism of PHR transmission applies, see TS 36.321 [10].

- For M3:
  - End of measurement collection period
- For M4:
  - End of measurement collection period.
- For M5:
  - End of measurement collection period.
- For M6:
  - End of measurement collection period.
- For M7:
  - End of measurement collection period.
- For M8:
  - Associated to M1 and/or M6 related measurement reporting triggers.
- For M9:
  - Associated to M1 and/or M6 related measurement reporting triggers.

5.2.1.2 Enhancement to Radio Link Failure report

The Radio Link Failure report contains information related to the latest connection failure experienced by the UE. The connection failure can be Radio Link Failure (RLF) or Handover Failure (HOF). The contents of the RLF report and the procedure for retrieving it by an eNB are described in TS 36.300 [12].

RLF reports can be collected by OAM. Upon RLF/HOF detection in the UE, *rlfReport* defined in TS 36.331 [5] also includes available location information on where RLF occurred, i.e. if detailed location information (e.g. GNSS location information) is available the reported location information in *rlfReport* consists of:

- Latitude, longitude (mandatory)
- Altitude (conditional on availability)
- Velocity (conditional on availability)
- Uncertainty (conditional on availability)

- Confidence (conditional on availability)
- Direction (conditional on availability).

As an indication of impact to MMTEL calls the UE indicates in the radio link failure report whether a radio bearer with QCI 1 was established when radio link failure was detected.

RLF reports may also include available WLAN measurement results and/or Bluetooth measurement results for calculating UE location.

If available, the UE can indicate NR neighbor cell measurements in measurements results.

5.2.1.3 Detailed Location Information

The M1 measurements are tagged by the UE with location data in the following manner:

- Detailed location information (e.g. GNSS location information) is included if available in the UE when the measurement was taken. If detailed location information is available, the reporting shall consist of latitude and longitude. Depending on availability, altitude, uncertainty and confidence may be also additionally included. The UE should include the available detailed location information only once. If the detailed location information is obtained by GNSS positioning method, GNSS time information shall be included. For both event based and periodic reporting (see 5.2.1.1), the detailed location information is included if the report is transmitted within the validity time after the detailed location information was obtained. The validity evaluation of detailed location information is left to UE implementation.
- To support UE location information in SCG failure, the location information (i.e. commonLocationInfo, see TS 38.331 [15] and WLAN and BT information, if available) is included in *SCGFailureInformation* message, see TS 36.331 [5].

For immediate MDT, the eNB can request the UE to attempt to make GNSS location information available. Standalone GNSS is used as the default baseline. It is desired that the UE provides fresh location information with each immediate MDT measurement report. The details how this is achieved is up to UE implementation.

The eNB may use an Enhanced Cell ID mechanism for location. The eNB forwards the raw E-CID specific measurements to the TCE. When E-CID positioning is requested, the eNB may choose to not use E-CID positioning for collected measurement for which the UE provides detailed location information.

5.2.2 RRC_IDLE

For UE in RRC_IDLE state Logged MDT procedures as described in 5.1.1 apply.

Logged MDT measurements are sent on Signalling Radio Bearer SRB2 in RRC_CONNECTED state.

5.3 UTRAN solutions

5.3.1 UTRA RRC Connected

In CELL_PCH, URA_PCH states and CELL_FACH state when second DRX cycle is used, UE supports Logged MDT as described in 5.1.1. In CELL_DCH state UE supports Immediate MDT as described in 5.1.2. In CELL_FACH state when second DRX cycle is not used, MDT is not supported in the current release.

5.3.1.1 Measurements and reporting events for Immediate MDT

The solutions for Immediate MDT in UTRAN are only applicable for UEs in CELL_DCH state. Measurements to be performed for Immediate MDT purposes involve normal UTRAN reporting triggers and criteria utilized for controlling the RRC connection. In addition, there are measurements defined that are performed in UTRAN. In particular, the following measurements shall be supported for Immediate MDT:

Measurements:

- M1: CPICH RSCP and CPICH Ec/No measurement (FDD) by UE, see TS 25.215 [7].

- M2: P-CCPCH RSCP and Timeslot ISCP for UTRA 1.28 Mcps TDD by UE, see TS 25.225 [8].
- M3: SIR and SIR error (FDD) by NodeB, see TS 25.215 [7] and TS 25.225 [8].
- M4: UE power headroom (UPH) by the UE, applicable for E-DCH transport channels, see TS 25.215 [7] and TS 25.225 [8].
- M5: Received total wideband power (RTWP) by Node B, see TS 25.215 [7] TS 25.225 [8], and TS 25.133 [2]. This is a cell measurement.
- M6: Data Volume measurement, separately for DL and UL, per QoS class per UE, by RNC.
- M7: Throughput measurement, separately for DL and UL, per RAB per UE and per UE, by RNC. Traffic class and Traffic Handling Priority for interactive RABs for the RABs that have contributed to a measurement value are logged with the measurement values.

Measurement collection triggers:

- For M1:
  - Event triggered measurement reports according to existing RRM configuration, for measurement types intra-frequency measurement, inter-frequency measurement and inter-RAT measurement.
  - Periodic, or 1F event-triggered measurement report, primary CPICH becomes worse than an absolute threshold, according to MDT specific measurement configuration.
- For M2:
  - Event triggered measurement reports according to existing RRM configuration, for measurement types intra-frequency measurement, inter-frequency measurement and inter-RAT measurement.
  - Periodic, or 1I event-triggered measurement report, timeslot ISCP above a certain threshold (TDD), according to MDT specific measurement configuration.
- For M3:
  - When available
- For M4:
  - Reception of UPH according to existing RRM configuration
  - Provided by the UE according to RRM configuration.
  - UPH samples may be collected and logged:
    - always
    - periodic, one sample per period.
    - periodic, one sample per period, when measurement value < threshold.
- For M5:
  - When available.
  - End of measurement collection period.
- For M6:
  - End of measurement collection period.
- For M7:
  - End of measurement collection period.

5.3.1.2 Detailed Location Information

For Immediate MDT, existing procedures for UE Location information are used to obtain detailed location information.

5.3.2 UTRA Idle

For UEs in UTRA Idle mode Logged MDT procedures as described in 5.1.1 apply.

Logged MDT measurements are sent on Signalling Radio Bearer SRB4 in RRC Connected mode.

5.4 NR solutions

5.4.0 General

The management-based MDT configuration should not overwrite signalling based MDT configuration in all the single connection scenarios and EN-DC scenario.

5.4.1 RRC_CONNECTED

In RRC_CONNECTED state UE supports Immediate MDT as described in 5.1.2. In order to support Immediate MDT, the existing RRC measurement configuration and reporting procedures apply. Some extensions are used to carry location information.

5.4.1.1 Measurements and reporting triggers for Immediate MDT

Measurements to be performed for Immediate MDT purposes involve reporting triggers and criteria utilized for RRM. In addition, there are associated network performance measurements performed in the gNB.

In particular, the following measurements shall be supported for Immediate MDT performance:

Measurements:

- M1: DL signal quantities measurement results for the serving cell and for intra-frequency/Inter-frequency/inter-RAT neighbour cells, including cell/beam level measurement for NR cells only, TS 38.215 [19].
- M2: Power Headroom measurement by UE, TS 38.213 [20].
- M3: Void.
- M4: PDCP SDU Data Volume measurement separately for DL and UL, per DRB per UE, see TS 28.552 [17].
- M5: Average UE throughput measurement separately for DL and UL, per DRB per UE and per UE for the DL, per DRB per UE and per UE for the UL, by gNB, see TS 28.552 [17].
- M6: Packet Delay measurement separately for DL and UL, per DRB per UE, TS 28.552 [17] and TS 38.314 [18].
- M7: Packet loss rate measurement separately for DL and UL, per DRB per UE, TS 28.552 [17] and TS 38.314 [18].
- M8: RSSI measurement by UE (for WLAN/Bluetooth measurement) see TS 38.331 [15].
- M9: RTT Measurement by UE (for WLAN measurement) see TS 38.331 [15].

NOTE 1: M5 ~ M7 do not apply to EN-DC SN terminated MCG/split bearers and MN terminated SCG/split bearers in Rel-16.

Measurement collection triggers:

- For M1:

- Event-triggered measurement reports according to existing RRM configuration for events A1, A2, A3, A4, A5, A6, B1 or B2.
- Periodic, A2 event-triggered, or A2 event triggered periodic measurement report according to MDT specific measurement configuration.

- For M2:
  - Reception of Power Headroom Report (PHR) according to existing RRM configuration.

NOTE 2: PHR is carried by MAC signalling. Thus, the existing mechanism of PHR transmission applies, see TS 38.321 [21].

- For M3:
  - End of measurement collection period.
- For M4:
  - End of measurement collection period.
- For M5:
  - End of measurement collection period.

NOTE 3: If transmission of a data burst is ongoing at the boundary of the measurement collection period, T1 and T2 in throughput evaluations are set to the end and the start of the measurement period, respectively.

- For M6:
  - End of measurement collection period.
- For M7:
  - End of measurement collection period.
- For M8:
  - Associated to M1 and/or M6 related measurement reporting triggers.
- For M9:
  - Associated to M1 and/or M6 related UE measurement reporting triggers.

5.4.1.2 Radio Link Failure report

The Radio Link Failure report contains information related to the latest connection failure experienced by the UE. The connection failure can be Radio Link Failure (RLF) or Handover Failure (HOF). The contents of the RLF report and the procedure for retrieving it by a gNB are specified in TS 38.331 [15].

NR RLF report content required for MDT includes:

- Latest radio measurement results of the serving and neighbouring cells, including SSB/CSI-RS index and associated measurements in the serving and neighbouring cells;

NOTE: The measure quantities are sorted through the same RS type depending on the availability, according to the following priority: RSRP, RSRQ, SINR.

- WLAN and Bluetooth measurement results, if were configured prior RLF and are available for reporting;
- "No suitable cell is found" flag when T311 expires;
- Indication per SSB/CSI-RS beams reporting whether it is configured to RLM purpose;
- Available sensor information;
- Available detailed location information;

- RACH failure report (in case, the cause for RLF is random access problem or Beam Failure Recovery failure):
  - Tried SSB/CSI-RS index and number of Random Access Preambles transmitted for each tried SSB/CSI-RS in chronological order of attempts;

    Contention detected as per RACH attempt;
  - Indication whether the selected SSB is above or below the rsrp-ThresholdSSB threshold, as per RACH attempt;
  - TAC of the cell in which the UE performs the RA procedure;
  - Frequency location related information of the RA resources used by the UE as specified in TS 38.331 [15].

If detailed location information (e.g. GNSS location information) is available the reported location information in *rlf-Report* consists of:

- Latitude, longitude (mandatory);
- Altitude (conditional on availability);
- Velocity (conditional on availability);
- Uncertainty (conditional on availability);
- Confidence (conditional on availability);
- Direction (conditional on availability).

If sensor information is available, the sensor information may convey uncompensated barometric pressure, UE speed, and UE orientation.

In addition, the RLF report may include additional information required for MRO solutions, as specified in TS 38.300 [22].

5.4.1.3 Immediate MDT for MR-DC

Immediate MDT is supported for EN-DC scenario.

In signalling based immediate MDT, MME provides MDT configuration for both MN and SN towards MN including multi RAT SN configuration, specifically E-UTRA and NR MDT configuration. MN then forwards the NR MDT configuration towards SN (EN-DC scenario, SN is always NR).

In management-based immediate MDT, OAM provides the MDT configuration to both MN and SN independently. For both MN and SN, Management based MDT should not overwrite signalling based MDT.

For immediate MDT configuration, MN and SN can independently configure and receive measurement from the UE.

5.4.2 RRC_IDLE & RRC_INACTIVE

For UE in RRC_IDLE and RRC_INACTIVE states Logged MDT procedures as described in 5.1.1 apply.

For Logged MDT measurement collection for RRC INACTIVE UEs, the actual process of logging within the UE, takes place in RRC INACTIVE state and may be continued in RRC IDLE state; or vice versa.

The logged measurement stored in UE during RRC INACTIVE and RRC IDLE state are kept for a given common period before they are deleted as in LTE MDT.

If the signalling based logged MDT received by the NG-RAN when UE is in RRC_INACTIVE:

- The NG-RAN stores the logged MDT configuration in the UE context;
- When the UE resumes the RRC connection in the last serving NG-RAN, the NG-RAN can configure the MDT configuration for the UE;

- When the UE resumes the RRC connection in one new NG-RAN, the new NG-RAN can configure the MDT configuration for the UE, only if the signalling based logged MDT was received by the new NG-RAN from the previous NG-RAN or AMF.

If the management based logged MDT received by the NG-RAN when UE is in RRC_INACTIVE,

- No requirement for the NG-RAN to store the logged MDT configuration in the UE context;
- When the UE resumes the RRC connection in the last serving NG-RAN, the NG-RAN can configure the MDT configuration for the UE;
- When the UE resumes the RRC connection in another NG-RAN, the source NG-RAN will not propagate the management based logged MDT configuration. The source NG-RAN should inform the target NG-RAN of UE consents.

Logged MDT measurements are sent on Signalling Radio Bearer SRB2 in RRC_CONNECTED state.

Annex A (informative): Coverage use cases

The MDT data reported from UEs and the RAN may be used to monitor and detect coverage problems in the network. Some examples of use cases of coverage problem monitoring and detection are described in the following:

- **Coverage hole:** A coverage hole is an area where the signal level SNR (or SINR) of both serving and allowed neighbor cells is below the level needed to maintain basic service (SRB & DL common channels), i.e. coverage of PDCCH. Coverage holes are usually caused by physical obstructions such as new buildings, hills, or by unsuitable antenna parameters, or just inadequate RF planning. UE in coverage hole will suffer from call drop and radio link failure. Multi-band and/or Multi-RAT UEs may go to other network layer instead.

- **Weak coverage:** Weak coverage occurs when the signal level SNR (or SINR) of serving cell is below the level needed to maintain a planned performance requirement (e.g. cell edge bit-rate).

- **Pilot Pollution:** In areas where coverage of different cells overlap a lot, interference levels are high, power levels are high, energy consumption is high and cell performance may be low. This problem phenomenon has been called "pilot pollution", and the problem can be addressed by reducing coverage of cells. Typically in this situation UEs may experience high SNR to more than one cell and high interference levels.

- **Overshoot coverage:** Overshoot occurs when coverage of a cell reaches far beyond what is planned. It can occur as an "island" of coverage in the interior of another cell, which may not be a direct neighbor. Reasons for overshoot may be reflections in buildings or across open water, lakes etc. UEs in this area may suffer call drops or high interference. Possible actions to improve the situation include changing the coverage of certain cells and mobility blacklisting of certain cells.

- **Coverage mapping:** There should be knowledge about the signal levels in the cell areas in order to get a complete view for the coverage and be able to assess the signal levels that can be provided in the network. This means that there should be measurements collected in all parts of the network, and not just in the areas where there are potential coverage issues.

- **UL coverage:** Poor UL coverage might impact user experience in terms of call setup failure / call drop / poor UL voice quality. Therefore, coverage should be balanced between uplink and downlink connections. Possible UL coverage optimization comprises adapting the cellular coverage by changing the site configuration (antennas) but also about adjusting the UL related parameters in the way that they allow optimized usage of UL powers in different environments.

- **Cell boundary mapping:** There should be knowledge about the location of (intra/inter RAT) cell boundaries in order to compare to the expected/planned network setting. Poor handover performance may be caused by changed cell boundaries due to changes in the physical condition of the surrounding area, e.g., construction of new buildings, bridge or tunnel near the handover area.

- **Coverage mapping for pico cell in CA scenario:** As a realization of CA scenario 4 in TS 36.300 [12], pico cell may be deployed in area where high traffic occurs. The location where a pico cell is available to be added as an SCell may show whether the deployment of pico cell is according to the needs of capacity increase.

Annex B (informative): QoS verification use cases

The MDT data reported from UEs and the RAN may be used to verify Quality of Service, assess user experience from RAN perspective, and to assist network capacity extension. Use cases are described in the following:

- **Traffic Location:** MDT functionality to obtain information of where data traffic is transferred within a cell.
- **User QoS Experience:** MDT functionality to assess the QoS experience for a specific UE together with location information.
  - Data Throughput measurements can be collected, aiming to reflect QoS for bandwidth limited traffic.
  - For E-UTRA, Data Loss and Latency measurements can be collected, aiming to reflect QoS for conversational traffic.

Annex C (informative): Measurements

This annex provides information on measurements that are used for MDT and are not specified elsewhere.

Throughput measurement for UMTS. The throughput is measured on PDCP or RLC level. A measurement value for a UE and each RAB of the UE is provided each measurement period, except if the value is zero. The measurement is performed separately for UL and DL, and is performed for PS RABs. Idle periods shall not be taken into account, when there is no data buffered or no data being transmitted.

Data Volume measurement for UMTS. Data Volume is measured on PDCP or RLC (without Layer 2 overhead). A measurement value for a QoS class for a UE is provided each measurement period, except if the value is zero, where the QoS class is one of conversational, interactive, streaming or background. The measurement is performed separately for UL and DL, and is performed for PS RABs.

Annex D (informative): MBSFN use cases

The MDT data reported from UEs may be used to verify signal strength, signal quality and block error rates for MBSFN reception, to support network verification, re-planning of MBSFN areas, and optimization of MBSFN operation parameters.

Annex E (informative): Change history

Change history					
Date	**WG #**	**WG Doc.**	**Subject/Comment**	**Old**	**New**
2010/01	R2#68bis	R2-100845	Skeleton TS endorsed	0.0.0	0.1.0
2010/01	R2#68bis	R2-100846	Initial content provided	0.1.0	0.2.0
2010/02	R2#69	R2-101800	Logged and Immediate MDT definitions added Requirements introduced Measurement Configuration/Reporting principles clarified	0.2.0	0.2.1
2010/02	R2#69	R2-101891	RAN2 approved TS v0.3.0	0.2.1	0.3.0
2010/04	R2#69bis	R2-102623	- General principles for support of Logged MDT included - Location Information principles for Logged MDT introduced - MDT Context handling for Logged MDT introduced - Report availability indicator added to 5.1.3 - Annex A	0.3.0	0.3.1
2010/04	R2#69bis	R2-102656	- Editorial changes	0.3.1	0.3.2
2010/04	R2#69bis	R2-102667	RAN2 approved TS v0.4.0	0.3.2	0.4.0
2010/05	R2#70	R2-103400	Logged MDT configuration and reporting principles added Periodical measurement configuration rules for Logged MDT added SRB for Logged MDT identified Measurements and triggers for Immediate MDT identified	0.4.0	0.4.1
2010/05	R2#70	R2-103456	RAN2 approved TS v0.5.0	0.4.1	0.5.0
2010/06	R2#70bis	R2-103991	Editorial changes: - New text organization in 5.1: split in two clauses for Logged MDT and Immediate MDT - MDT Reporting mode in 4.1 update to clarify the requirement on feature support - FFS on extension across RAT aligned to RAN#69 agreement - Retrieved data removal requirement aligned to RAN2#70 agreement	0.5.0	0.5.1
2010/06	R2#70bis	R2-104073	RAN2 approved TS v0.6.0	0.5.1	0.6.0
2010/06	R2#70bis	R2-104074	- Logged MDT configuration message sequence added in 5.1.1.1 - Measurement area scope identified - Time stamping principles added - MDT configuration/log handling at PLMN change introduced - Validity timer for non-retrieved data defined - GNSS location information details defined - RLF enhancements on location information defined - MDT applicability for UTRA states added	0.6.0	0.6.1
2010/06	R2#70bis	R2-104206	Clarification on sending availability indicator in another RAT added	0.6.1	0.6.2
2010/06	R2#70bis	R2-104212	RAN2 approved TS v0.7.0	0.6.2	0.7.0
2010/08	R2#71	R2-104950	Agreed text proposal in R2-104303 on clarification on logged MDT data retrieval added MDT applicability for particular UE states clarified in corresponding clauses Time stamp details included in 5.1.1.3.3 MDT handling during handover added in 5.1.2.3 Agreed text proposal in R2-104678 to address SA5 progress added in 5.1.3 Assumptions on memory size limit capability added in 5.1.4 Further RLF enhancements listed as FFS in 5.2.1.2	0.7.0	0.7.1
2010/08	R2#71	R2-105238	Clarification on idle logging applicability to "camped normally" state in 5.1.1.2. added FFS on logged data clearance in shared network scenarios added Submitted to TSG RAN for information	0.7.1	1.0.0
2010/10	R2#71b	R2-105787	Editorial and formatting changes	1.0.0	1.0.1
2010/10	R2#71b	R2-105877	Logged MDT reports details on neighbours details added Accurate location information validity clarified UE memory size reserved for Logged MDT added Transport of MDT logs using multiple RRC messages defined Logging handling at PLMN change clarified	1.0.1	1.0.2
2010/10	R2#71b	R2-106018	RAN2 approved TS v1.1.0	1.0.2	1.1.0

2010/11	R2#72	R2-106682	Requirement on Dependency on Trace added Validity time for accurate location information in Immediate MDT added Introduction of UTRA 1.28 TDD metrics	1.1.0	1.1.1
2010/11	R2#72	R2-106936	RAN2 approved TS v2.0.0	1.1.1	2.0.0

Change history

Date	TSG #	TSG Doc.	CR	Rev	Cat	Subject/Comment	New version
2010-12	RP-50	RP-101162	-	-		TS 37.320 approved b RAN #50	10.0.0
2011-03	RP-51	RP-110282	0001	-		Clarifications on MDT initiation	10.1.0
	RP-51	RP-110282	0002	-		Clear MDT configuration and logs when the UE is not registered	10.1.0
	RP-51	RP-110282	0003	1		MDT stage 2 clarifications	10.1.0
	RP-51	RP-110282	0004	-		On memory size limitation for Logged MDT	10.1.0
	RP-51	RP-110282	0005	-		UE Capabilities for MDT	10.1.0
	RP-51	RP-110282	0006	-		Validity time for location information in Immediate MDT	10.1.0
	RP-51	RP-110282	0008	-		Correction to include CDMA2000 reporting for neighbouring cells	10.1.0
	RP-51	RP-110282	0012	-		Small Clarifications and Corrections to 37.320	10.1.0
	RP-51	RP-110282	0013	-		Trace parameters for MDT configuration	10.1.0
2011-06	RP-52	RP-110843	0014	-		Clarification for logged MDT measurement configuration effectiveness	10.2.0
	RP-52	RP-110843	0015	-		Correction of log availability reporting	10.2.0
	RP-52	RP-110843	0016	-		Immediate MDT context handling during inter-PLMN handover	10.2.0
	RP-52	RP-110843	0017	1		MDT UL network measurements	10.2.0
	RP-52	RP-110843	0018	-		Signalling based Immediate MDT initiation with area scope configuration	10.2.0
	RP-52	RP-110843	0019	-		TCE ID parameter for logged MDT	10.2.0
	RP-52	RP-110843	0020	-		Miscellaneous corrections to 37.320	10.2.0
	RP-52	RP-110843	0025	1		MDT Stage-2 Cleanup	10.2.0
	RP-52	RP-110843	0026	1		Introduction of the User consent	10.2.0
	RP-52	RP-110843	0027	-		CR to 37.320 to clean up description of RLF Reporting	10.2.0
2011-09	RP-53	RP-111285	0033	-		Immediate MDT context handling during inter-PLMN handover	10.3.0
	RP-53	RP-111285	0034	-		Miscellaneous corrections to 37.320	10.3.0
	RP-53	RP-111285	0037	-		Editorial corrections	10.3.0
2011-12	RP-54	RP-111714	0038	-		CR to 37.320 on Immediate MDT handling at handover	10.4.0
	RP-54	RP-111714	0039	-		Small Corrections to 37.320	10.4.0
2012-06	RP-56	RP-120819	0045	1		Introduction of MDT enhancements	11.0.0
2012-09	RP-57	RP-121370	0046	1		Updates for MDT enhancements	11.1.0
2012-12	RP-58	RP-121946	0051	-		MDT Open Issues Resolutions	11.2.0
	RP-58	RP-121946	0052	-		Removing the IE Contention Detected in Accessiability Measurement(option 3)	11.2.0
	RP-58	RP-121946	0054	-		Stage-2 update for MDT enhancements	11.2.0
	RP-58	RP-121730	0055	-		Multi-PLMN MDT	11.2.0
2013-03	RP-59	RP-130240	0056	-		Miscellaneous MDT corrections	11.3.0
	RP-59	RP-130240	0057	-		Correction to E-CID positioning for MDT	11.3.0
	RP-59	RP-130240	0058	-		Corrections for multi-PLMN MDT	11.3.0
2014-03	RP-63	RP-140347	0061	-		Introduction of Cell_FACH with Second DRX to 3G Logged MDT	12.0.0
2014-06	RP-64	RP-140889	0062	1		Introduction of MBMS operations Support for E-UTRA	12.1.0
2014-09	RP-65	RP-141507	0066	-		Minor corrections to MDT Stage-2	12.2.0
	RP-65	RP-141496	0064	1		Reporting and measurement collection triggers for immediate MDT	12.2.0
2015-12	RP-70	RP-152082	0067	1		Further Enhancements of MDT for E-UTRA	13.0.0
2016-03	RP-71	RP-160470	0069	-		Reporting of UL PDCP delay measurements for FeMDT	13.1.0
2017-03	RP-75					Upgrade to Rel-14, no technical change	14.0.0
2018-06	RP-80	RP-181227	0071	2	B	37.320 CR to introduce BT and WLAN in MDT	15.0.0
	RP-80	RP-181228	0072	-	B	Support for logging of 'Any cell selection' state	15.0.0
2020-03	RP-87	RP-200354	0077	2	B	CR to Introduce NR MDT	16.0.0
2020-07	RP-88	RP-201184	0085	2	F	CR to 37.320 to support NR MDT	16.1.0
2020-09	RP-89	RP-201931	0090	-	F	Corrections to TS37.320	16.2.0
2020-12	RP-90	RP-202776	0098	1	F	Merged Corrections for TS37.320	16.3.0
2021-03	RP-91	RP-210693	0103	-	F	Merged Corrections to TS 37.320	16.4.0
2021-06	RP-92	RP-211471	0107	2	F	Merged Corrections to TS 37.320	16.5.0
2021-09	RP-93	RP-212443	0110	1	F	On UL delay configuration in LTE	16.6.0
2021-12	RP-94	RP-213344	0112	-	F	TS37.320 title update	16.7.0

History

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V16.1.0	July 2020	Publication
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