3GPP TSG-RAN WG2 Meeting #123-bis R2-23xxxxx

Xiamen, P.R. China Oct 9th – 13th, 2023

**Agenda item: 7.24.2**

**Source: Ericsson**

**Title: [Post123bis][403][POS] Bluetooth AoD/AoD (Ericsson)**

**WID/SID: TEI18**

**Document for: Discussion and Agreement**

# 1 Introduction

This document kicks off the following offline discussion:

* [Post123bis][403][POS] BT AoA/AoD (Ericsson)

Scope: Draft and review a CR implementing the agreements from RAN2#123bis on Bluetooth AoA/AoD positioning.

Intended outcome: Report and CR to next meeting

Deadline: Long

The plan is to make a first summary after Thursday October 26th UTC 22.00, but the discussion will continue after that.

# 2 Contact Information

Respondents to the offline discussion are kindly asked to fill in the following table.

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| Company | Contact: Name (E-mail) |
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# 3 References

1. [R2-2310853](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_123bis/Docs/R2-2310853.zip) Adding support for Bluetooth AoA/AoD, Ericsson, AT&T, Polaris Wireless, u-blox, T-Mobile, TEI18
2. [R2-2311394](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_123bis/Docs/R2-2311394.zip) [AT123bis][431][TEI18] Bluetooth AoA/AoD positioning F2F offline discussion summary (Ericsson)

# Discussion

In the online comeback session, it was agreed to draft and review CR implementing the agreements from RAN2#123bis based on contribution [1] in TEI18 on Bluetooth AoA/AoD positioning enhancements:

Agreements:

Support Bluetooth AoA/AoD positioning in the LPP Bluetooth positioning method.

Introduce BT AoA/AoD measurements in LPP.

FFS if further BT control information can be captured in our specs.

In order to make the discussion clear and focused, different parts of the CR draft in Appendix A will be reviewed separately. In addition, the aspect of LMF suggesting a Bluetooth AoA transmission configuration is also addressed, and those parts in the draft CR are marked yellow. During the F2F offline discussion [2], the need for a stage-2 text was also raised. To make the Bluetooth AoA/AoD scope clear, a stage-2 draft is provided in Appendix B, and it will also be addressed in one part of this email discussion.

This means the text proposals in Appendix A and B provides draft CRs for

* the agreed scope of Bluetooth AoA/AoD measurements, questions Q1, Q2.1, Q2.3, Q3, Q4
* the FFS scope where LMF can suggest the AoA transmission configuration to a capable UE, question Q2.2
* the stage-2 additions, question Q5

The LPP CR draft in Appendix A to be discussed has been slightly updated based on companies comments, in particular some incomplete IEs and editorials, as well as a comment to make the AoD assistance data more similar to that of NR AoD to facilitate readability.

## 4.1 Request/Provide Assistance Data

These parts only apply to Bluetooth AoD, and corresponds, since Bluetooth positioning has not had assistance data in previous releases, to an added field of IE *BT-RequestAssistanceData-r18* of to IE *RequestAssistanceData* and an added field of IE *BT-ProvideAssistanceData-r18* of to IE *ProvideAssistanceData*, with the following definitions

BT-RequestAssistanceData-r18 ::= SEQUENCE {

requestedAD-r18 BIT STRING { beacon-location (0),

beacon-antConfig (1),

beacon-transmConfig (2) } (SIZE (1..8)),

...

}

and

BT-ProvideAssistanceData-r18 ::= SEQUENCE {

bt-BeaconInfo-r18 BT-BeaconInfo-r18,

bt-Error-r18 BT-Error-r18 OPTIONAL, -- Need ON

...

}

The Bluetooth AoD AD is needed for the support of both UEA and UEB AoD since the device will in both cases need to estimate the AoD angles (azimuth and zenith) either to report or to use for positioning. The AD is separated into three parts;

* beacon-location corresponds to the location of the Bluetooth beacons
* beacon-antConfig corresponds to the antenna array configuration, antenna orientation and antenna switching pattern
* beacon-transmConfig corresponds to the advertising periodicities and CTE transmission parameters length, count and slot duration

The IE *BT-BeaconInfo-r18* contains a reference point for the beacon location and a list of beacon info elements, each such element is defined by the IE *BT-BeaconInfoElement-r18* with the definition

BT-BeaconInfoElement-r18 ::= SEQUENCE {

btAddr-r18 BIT STRING (SIZE (48)),

bt-BeaconLocation-r18 RelativeLocation-r16 OPTIONAL, -- Need OP

bt-LCS-GCS-TranslationParameter-r18 LCS-GCS-TranslationParameter-r16,

OPTIONAL, -- Cond NotSameAsPrev1

bt-antArrayConfig-r18 BT-AntArrayConfig-r18 OPTIONAL, -- Cond NotSameAsPrev2

bt-antElementList-r18 SEQUENCE (SIZE (2..maxBT-BeaconAntElt-r18)) OF

BT-AntElement-r18 OPTIONAL, -- Cond NotSameAsPrev3 bt-antSwitchingPattern-r18 SEQUENCE (SIZE (2..maxBT-BeaconAntElt-r18)) OF

BT-AntSwitchElement-r18 OPTIONAL, -- Cond NotSameAsPrev4

bt-AoDTransmConfig-r18 BT-AoDTransmConfig-r18 OPTIONAL, -- Cond NotSameAsPrev5

...

}

* btAddr to represent the beacon address
* bt-BeaconLocation to represent the relative location to represent the beacon relative location in relation to the reference point
* bt-LCS-GCS-TranslationParameter to represent the beacon antenna orientation
* bt-antArrayConfig to represent the antenna array configuration with the choices of a uniform linear, rectangular and circular array as well as a generic array with a list of element displacements, where the inter element distance between adjacent elements in the uniform arrays has a value range corresponding to ¼ to slightly more than 1 wavelength (30mm – 135mm)
* bt-antElementList to represent the polarization of each element in the array
* bt-antSwitchingPattern to represent the transmission order over the antennas
* bt-AoDTransmConfig to represent the advertising periodicity at primary and secondary channel, PHY type and CTE length, count and slot duration

**Q1: Any comments to the Request/Provide Assistance Data parts of the LPP draft CR in Appendix A?**

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| Company | Comments |
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## 4.2 Request/Provide Location Information

The request provide location information procedure is considered for three types of updates

* LMF to request, and UE to provide its Bluetooth AoA transmission configuration to enable beacon measurements
* LMF to suggest, and UE to provide its Bluetooth AoA transmission configuration to enable beacon measurements
* LMF to request UE to provide Bluetooth AoD measurements

The *BT-RequestLocationInformation* IE enhancements are described below, with colors indicating which part they concern

BT-RequestLocationInformation-r13 ::= SEQUENCE {

requestedMeasurements-r13 BIT STRING {

rssi (0),

aod-r18 (1) } (SIZE(1..8)),

...,

[[

bt-requestedAoA-Config-r18 BIT STRING {

aoa-advConfig (0),

aoa-cteConfig (1)} (SIZE(1..8)) OPTIONAL,

bt-suggestedAoA-Config-r18 BT-SuggestedAoA-Config-r18 OPTIONAL

]]

}

BT-SuggestedAoA-Config-r18 ::= SEQUENCE {

cteStatus-r18 ENUMERATED {enabled, disabled} OPTIONAL,

primaryAdvInterval-r18 INTEGER (32..16777) OPTIONAL,

secondAdvInterval-r18 INTEGER (6..65535) OPTIONAL,

txPower-r18 INTEGER (-127..20) OPTIONAL,

cteLength-r18 INTEGER (2..20) OPTIONAL,

cteCount-r18 INTEGER (1..16) OPTIONAL,

tx-PHY-M2-r18 NULL OPTIONAL,

...

}

The *BT-ProvideLocationInformation* IE enhancements are described below, with colors indicating which part they concern

BT-ProvideLocationInformation-r13 ::= SEQUENCE {

bt-MeasurementInformation-r13 BT-MeasurementInformation-r13 OPTIONAL,

bt-Error-r13 BT-Error-r13 OPTIONAL,

... ,

[[

bt-AoA-Config-r18 BT-AoA-Config-r18 OPTIONAL,

]]

}

BT-AoA-Config-r18 ::= SEQUENCE {

btAddr-r13 BIT STRING (SIZE (48)),

cteStatus-r18 ENUMERATED {enabled, disabled} OPTIONAL,

primaryAdvInterval-r18 INTEGER (32..16777) OPTIONAL,

secondAdvInterval-r18 INTEGER (6..65535) OPTIONAL,

txPower-r18 INTEGER (-127..20) OPTIONAL,

cteLength-r18 INTEGER (2..20) OPTIONAL,

cteCount-r18 INTEGER (1..16) OPTIONAL,

tx-PHY-M2-r18 NULL OPTIONAL,

...

}

The Bluetooth AoD measurements are introduced in a new R18 *bt-MeasurementList* field to provide the AoD angles

BT-MeasurementInformation-r13 ::= SEQUENCE {

measurementReferenceTime-r13 UTCTime OPTIONAL,

bt-MeasurementList-r13 BT-MeasurementList-r13 OPTIONAL,

...,

bt-MeasurementList-r18 BT-MeasurementList-r18 OPTIONAL,

}

BT-MeasurementList-r13 ::= SEQUENCE (SIZE(1..maxBT-Beacon-r13)) OF BT-MeasurementElement-r13

BT-MeasurementElement-r13 ::= SEQUENCE {

btAddr-r13 BIT STRING (SIZE (48)),

rssi-r13 INTEGER (-128..127) OPTIONAL,

...

}

BT-MeasurementList-r18 ::= SEQUENCE (SIZE(1..maxBT-Beacon-r18)) OF BT-MeasurementElement-r18

BT-MeasurementElement-r18 ::= SEQUENCE {

btAddr-r18 BIT STRING (SIZE (48)),

bt-azimuth-r18 INTEGER (0..359),

bt-elevation-r18 INTEGER (0..180) OPTIONAL, -- Need ON

rssi-r18 INTEGER (-128..127) OPTIONAL,

...

}

**Q2.1: Any comments to the Request/Provide Location Information parts of the LPP draft CR in Appendix A for enabling AoA measurements?**

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The support for LMF suggesting UE AoA transmission configuration is FFS, but it would be relevant to get comments to the related parts of the CR, marked in yellow. Note that the part about requesting the AoA transmission configuration is needed for the AoA measurements. The LMF suggestion of AoA transmission configuration, if agreed, is not mandated to be met by the UE – the UE will provide the AoA transmission configuration it will use in any case.

**Q2.2: Any comments to the Request/Provide Location Information parts of the LPP draft CR in Appendix A for LMF suggesting an AoA transmission configuration?**

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For UE-assisted Bluetooth AoD, the UE is requested to provide AoD angle estimates to LMF, with related parts in the CR above, marked with cyan.

**Q2.3: Any comments to the Request/Provide Location Information parts of the LPP draft CR in Appendix A for UE providing AoD measurements?**

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| Company | Comments |
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## 4.3 Request/Provide Capabilities

The request provide capabilities procedure is considered for three types of updates

* UE capability for LMF to request, and UE to provide its Bluetooth AoA transmission configuration to enable beacon measurements
* UE capability for LMF to suggest, and UE to provide its Bluetooth AoA transmission configuration to enable beacon measurements
* UE capability for LMF to request UE to provide Bluetooth AoD measurements
* UE capability for UE-based Bluetooth AoD positioning

The *BT-ProvideCapabilities* IE enhancements are described below, with colors indicating which part they concern

BT-ProvideCapabilities-r13 ::= SEQUENCE {

bt-Modes-r13 BIT STRING { standalone (0),

ue-assisted (1),

ue-based (2)} (SIZE (1..8)),

bt-MeasSupported-r13 BIT STRING { rssi-r13 (0),

aod-r18 (1) } (SIZE (1..8)),

...,

[[

idleStateForMeasurements-r14

ENUMERATED { required } OPTIONAL,

periodicalReportingSupported-r14

PositioningModes OPTIONAL

]],

[[ scheduledLocationRequestSupported-r17 ScheduledLocationTimeSupportPerMode-r17 OPTIONAL

]],

[[

bt-AoA-r18 ENUMERATED { request-only, suggestion } OPTIONAL

]]

}

**Q3: Any comments to the Request/Provide Capabilities parts of the LPP draft CR in Appendix A?**

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## 4.4 Error handling

A set of error causes have been added. Some are for the location server:

BT-LocationServerErrorCauses-r13 ::= SEQUENCE {

cause-r13 ENUMERATED {undefined, ...,

assistanceDataNotSupportedByServer-v1800,

assistanceDataSupportedButCurrentlyNotAvailableByServer-v1800,

notProvidedAssistanceDataNotSupportedByServer-v1800

},

...

}

while some are for the target device

BT-TargetDeviceErrorCauses-r13 ::= SEQUENCE {

cause-r13 ENUMERATED {undefined,

requestedMeasurementsNotAvailable,

notAllrequestedMeasurementsPossible,

...,

assistanceDataMissing-v1800,

unableToMeasureAnyBT-Beacons-v1800,

thereWereNotEnoughBeaconsReceivedForUeBasedAoD-v1800,

unableToTransmitCTE-v1800

},

bt-Beacon-rssiMeasurementNotPossible-r13 NULL OPTIONAL,

...

}

**Q4: Any comments to the added error causes in the LPP draft CR in Appendix A?**

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## 4.5 Stage-2 Text proposal for TS 38.305

A text proposal with suggested stage-2 updates are provided in Appendix B to facilitate the checking of the stage-3 draft CR but also to ensure that all have the same understanding about the Bluetooth AoA/AoD. Parts about the suggested AoA transmission configuration are marked by yellow.

**Q5: Any comments to the suggested stage-2 text proposal for TS 38.305 in Appendix B?**

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# 5 Conclusion

Rapporteur summary: No companies provided input to the email discussion but several companies including the co-signing companies provided comments during RAN2#123bis and those comments have already been considered in the text proposals in the email discussion template. Therefore, could be seen as an indication that the text proposals represent the agreements well. In addition, there are text proposals for stage-2 and also the location server suggesting AoA transmission configuration for the UE in the text proposals.

All of these text proposals are now moved to draft CRs in the draft folder

Suggested agreeable proposals

1. Agree to the LPP text proposal parts of the draft LPP CR reflecting RAN2#123bis agreement
2. Discuss and agree to the LPP text proposal parts of the draft LPP CR reflecting the location server suggesting an AoA transmission configuration
3. Discuss and agree to the 36305 draft CR
4. Discuss and agree to the 38305 draft CR

# Appendix A Text Proposal to TS 37.355 V.17.6.0

2 References

*[…]*

[xx] Bluetooth Special Interest Group: "Bluetooth Core Specification v5.4", February 2023.

*[…]*

6.3 Message Body IEs

*[…]*

– RequestAssistanceData

The *RequestAssistanceData* message body in a LPP message is used by the target device to request assistance data from the location server.

-- ASN1START

RequestAssistanceData ::= SEQUENCE {

criticalExtensions CHOICE {

c1 CHOICE {

requestAssistanceData-r9 RequestAssistanceData-r9-IEs,

spare3 NULL, spare2 NULL, spare1 NULL

},

criticalExtensionsFuture SEQUENCE {}

}

}

RequestAssistanceData-r9-IEs ::= SEQUENCE {

commonIEsRequestAssistanceData CommonIEsRequestAssistanceData OPTIONAL,

a-gnss-RequestAssistanceData A-GNSS-RequestAssistanceData OPTIONAL,

otdoa-RequestAssistanceData OTDOA-RequestAssistanceData OPTIONAL,

epdu-RequestAssistanceData EPDU-Sequence OPTIONAL,

...,

[[ sensor-RequestAssistanceData-r14

Sensor-RequestAssistanceData-r14 OPTIONAL,

tbs-RequestAssistanceData-r14 TBS-RequestAssistanceData-r14 OPTIONAL,

wlan-RequestAssistanceData-r14 WLAN-RequestAssistanceData-r14 OPTIONAL

]],

[[ nr-Multi-RTT-RequestAssistanceData-r16 NR-Multi-RTT-RequestAssistanceData-r16 OPTIONAL,

nr-DL-AoD-RequestAssistanceData-r16 NR-DL-AoD-RequestAssistanceData-r16 OPTIONAL,

nr-DL-TDOA-RequestAssistanceData-r16 NR-DL-TDOA-RequestAssistanceData-r16 OPTIONAL

]],

[[

bt-RequestAssistanceData-r18 OPTIONAL

]]

}

-- ASN1STOP

– ProvideAssistanceData

The *ProvideAssistanceData* message body in a LPP message is used by the location server to provide assistance data to the target device either in response to a request from the target device or in an unsolicited manner.

-- ASN1START

ProvideAssistanceData ::= SEQUENCE {

criticalExtensions CHOICE {

c1 CHOICE {

provideAssistanceData-r9 ProvideAssistanceData-r9-IEs,

spare3 NULL, spare2 NULL, spare1 NULL

},

criticalExtensionsFuture SEQUENCE {}

}

}

ProvideAssistanceData-r9-IEs ::= SEQUENCE {

commonIEsProvideAssistanceData CommonIEsProvideAssistanceData OPTIONAL, -- Need ON

a-gnss-ProvideAssistanceData A-GNSS-ProvideAssistanceData OPTIONAL, -- Need ON

otdoa-ProvideAssistanceData OTDOA-ProvideAssistanceData OPTIONAL, -- Need ON

epdu-Provide-Assistance-Data EPDU-Sequence OPTIONAL, -- Need ON

...,

[[

sensor-ProvideAssistanceData-r14 Sensor-ProvideAssistanceData-r14 OPTIONAL, -- Need ON

tbs-ProvideAssistanceData-r14 TBS-ProvideAssistanceData-r14 OPTIONAL, -- Need ON

wlan-ProvideAssistanceData-r14 WLAN-ProvideAssistanceData-r14 OPTIONAL -- Need ON

]],

[[ nr-Multi-RTT-ProvideAssistanceData-r16

NR-Multi-RTT-ProvideAssistanceData-r16

OPTIONAL, -- Need ON

nr-DL-AoD-ProvideAssistanceData-r16

NR-DL-AoD-ProvideAssistanceData-r16 OPTIONAL, -- Need ON

nr-DL-TDOA-ProvideAssistanceData-r16

NR-DL-TDOA-ProvideAssistanceData-r16

OPTIONAL -- Need ON

]],

[[

bt-ProvideAssistanceData-r18 BT-ProvideAssistanceData-r18 OPTIONAL -- Need ON

]]

}

-- ASN1STOP

*[…]*

6.5.7.1 Bluetooth Location Information

*–* *BT-ProvideLocationInformation*

The IE *BT-ProvideLocationInformation* is used by the target device to provide measurements for one or more Bluetooth beacons to the location server. It may also be used to provide Bluetooth positioning specific error reason or to provide Bluetooth AoA configuration of the target device.

-- ASN1START

BT-ProvideLocationInformation-r13 ::= SEQUENCE {

bt-MeasurementInformation-r13 BT-MeasurementInformation-r13 OPTIONAL,

bt-Error-r13 BT-Error-r13 OPTIONAL,

... ,

[[

bt-AoA-Config-r18 BT-AoA-Config-r18 OPTIONAL

]]

}

BT-AoA-Config-r18 ::= SEQUENCE {

btAddr-r13 BIT STRING (SIZE (48)),

cteStatus-r18 ENUMERATED {enabled, disabled} OPTIONAL,

primaryAdvInterval-r18 INTEGER (32..16777) OPTIONAL,

secondAdvInterval-r18 INTEGER (6..65535) OPTIONAL,

txPower-r18 INTEGER (-127..20) OPTIONAL,

cteLength-r18 INTEGER (2..20) OPTIONAL,

cteCount-r18 INTEGER (1..16) OPTIONAL,

tx-PHY-M2-r18 NULL OPTIONAL,

...

}

-- ASN1STOP

| ***BT-*** ***ProvideLocationInformation* field descriptions** |
| --- |
| ***btAddr***  This field specifies the Bluetooth address of the device [xx]. In case the device updates its address during an established LPP session, the device shall provide the new address as unsolicited location information to the server |
| ***cteStatus***  This field provides the Bluetooth AoA transmission status of the device  enabled: Bluetooth AoA transmission is enabled  disabled: Bluetooth AoA transmission is disabled |
| ***primaryAdvInterval***  This field specifies the Bluetooth primary advertisement channel periodicity that the device will use, scaling factor 0.625 ms [xx]. |
| ***secondAdvInterval***  This field specifies the Bluetooth periodic advertising interval on secondary advertisement channels that the device will use, scaling factor 0.625 ms [xx]. |
| ***txPower***  This field specifies the Bluetooth advertising TX power in dBm that the device will use. |
| ***cteLength***  This field specifies the configured CTE length to be used by the device in number of 8us segments. |
| ***cteCount***  This field specifies the number of Bluetooth packets that include a CTE that the device will transmit each periodic advertising. |
| ***tx-PHY-M2***  This field, if present, indicates that Bluetooth TX PHY 2 Megasymbols/s will be used for AoA, otherwise Bluetooth TX PHY 1 Megasymbols/s will be used, |

6.5.7.2 Bluetooth Location Information Elements

– BT-MeasurementInformation

-- ASN1START

BT-MeasurementInformation-r13 ::= SEQUENCE {

measurementReferenceTime-r13 UTCTime OPTIONAL,

bt-MeasurementList-r13 BT-MeasurementList-r13 OPTIONAL,

...,

[[

bt-MeasurementList-r18 BT-MeasurementList-r18 OPTIONAL, ]]

}

BT-MeasurementList-r13 ::= SEQUENCE (SIZE(1..maxBT-Beacon-r13)) OF BT-MeasurementElement-r13

BT-MeasurementElement-r13 ::= SEQUENCE {

btAddr-r13 BIT STRING (SIZE (48)),

rssi-r13 INTEGER (-128..127) OPTIONAL,

...

}

BT-MeasurementList-r18 ::= SEQUENCE (SIZE(1..maxBT-Beacon-r18)) OF BT-MeasurementElement-r18

BT-MeasurementElement-r18 ::= SEQUENCE {

btAddr-r18 BIT STRING (SIZE (48)),

bt-azimuth-r18 INTEGER (0..359),

bt-elevation-r18 INTEGER (0..180) OPTIONAL, -- Need ON

rssi-r18 INTEGER (-128..127) OPTIONAL,

...

}

-- ASN1STOP

| ***BT-MeasurementInformation* field descriptions** |
| --- |
| ***measurementReferenceTime***  This field provides the UTC time when the Bluetooth measurements are performed and should take the form of *YYMMDDhhmmssZ*. |
| ***bt-MeasurementList***  This field provides the Bluetooth measurements for up to 32 Bluetooth beacons. |
| ***btAddr***  This field specifies the Bluetooth public address of the Bluetooth beacon [25]. |
| ***rssi***  This field provides the beacon received signal strength indicator (RSSI) in dBm. |
| ***bt-azimuth***  This field represents the estimated AoD azimuth in GCD relative the Bluetooth beacon reference position. |
| ***bt-elevation***  This field represents the estimated AoD elevation in GCD relative the Bluetooth beacon reference position. |

6.5.7.3 Bluetooth Location Information Request

*–* *BT-RequestLocationInformation*

The IE *BT-RequestLocationInformation* is used by the location server to request Bluetooth measurements or request/ suggest AoA configuration from/to a target device.

-- ASN1START

BT-RequestLocationInformation-r13 ::= SEQUENCE {

requestedMeasurements-r13 BIT STRING {

rssi (0),

aod-v1800 (1) } (SIZE(1..8)),

...,

[[

bt-requestedAoA-Config-r18 BIT STRING {

aoa-advConfig (0),

aoa-cteConfig (1)} (SIZE(1..8)) OPTIONAL,

bt-suggestedAoA-Config-r18 BT-SuggestedAoA-Config-r18 OPTIONAL

]]

}

BT-SuggestedAoA-Config-r18 ::= SEQUENCE {

cteStatus-r18 ENUMERATED {enabled, disabled} OPTIONAL,

primaryAdvInterval-r18 INTEGER (32..16777) OPTIONAL,

secondAdvInterval-r18 INTEGER (6..65535) OPTIONAL,

txPower-r18 INTEGER (-127..20) OPTIONAL,

cteLength-r18 INTEGER (2..20) OPTIONAL,

cteCount-r18 INTEGER (1..16) OPTIONAL,

tx-PHY-M2-r18 NULL OPTIONAL,

...

}

-- ASN1STOP

| ***BT-RequestLocationInformation* field descriptions** |
| --- |
| ***requestedMeasurements***  This field specifies the Bluetooth measurements requested. This is represented by a bit string, with a one‑value at the bit position means the particular measurement is requested; a zero‑value means not requested. The following measurement requests can be included.  rssi: Bluetooth beacon signal strength at the target  aod: Estimated AoD per Bluetooth beacon |
| ***bt-requestedAoA-Config***  This field specifies the Bluetooth AoA configuration parameters requested. This is represented by a bit string, with a one‑value at the bit position means the particular measurement is requested; a zero‑value means not requested. The following information requests can be included.  aoa-advConfig: The Bluetooth advertisement address and periodic intervals of the device  aoa-cteConfig: The configured CTE status, length, count and PHY |
| ***cteStatus***  This field suggests the Bluetooth AoA transmission status of the device, and is used by the location server to suggest BLE AoA transmission of the device to be enabled or disabled.  enabled: Bluetooth AoA transmission is suggested enabled  disabled: Bluetooth AoA transmission is suggested disabled |
| ***primaryAdvInterval***  This field suggests the Bluetooth primary advertisement channel periodicity of the device, scaling factor 0.625 ms [xx]. |
| ***secondAdvInterval***  This field suggests the Bluetooth periodic advertising interval on secondary advertisement channels of the device, scaling factor 0.625 ms [xx]. |
| ***txPower***  This field suggests the Bluetooth advertising TX power in dBm of the device [xx]. |
| ***cteLength***  This field suggests the CTE length ofthe device in number of 8us segments. |
| ***cteCount***  This field suggests the number of Bluetooth packets that include a CTE of the device each periodic advertising event |
| ***tx-PHY-M2***  This field, if present, suggests that Bluetooth TX PHY 2 Megasymbols/s is used for AoA, otherwise Bluetooth TX PHY 1 Megasymbols/s is suggested to be used by the device, |

6.5.7.4 Bluetooth Capability Information

*–* *BT-ProvideCapabilities*

The IE *BT-ProvideCapabilites* is used by the target device to provide its capabilities for Bluetooth positioning to the location server.

-- ASN1START

BT-ProvideCapabilities-r13 ::= SEQUENCE {

bt-Modes-r13 BIT STRING { standalone (0),

ue-assisted (1),

ue-based-v1800 (2)} (SIZE (1..8)),

bt-MeasSupported-r13 BIT STRING { rssi-r13 (0),

aod-v1800 (1) } (SIZE (1..8)),

...,

[[

idleStateForMeasurements-r14

ENUMERATED { required } OPTIONAL,

periodicalReportingSupported-r14

PositioningModes OPTIONAL

]],

[[ scheduledLocationRequestSupported-r17 ScheduledLocationTimeSupportPerMode-r17 OPTIONAL

]],

[[

bt-AoA-r18 ENUMERATED { request-only, suggestion } OPTIONAL

]]

}

-- ASN1STOP

| ***BT-ProvideCapabilities* field descriptions** |
| --- |
| ***bt-Modes***  This field specifies the Bluetooth mode(s) supported by the target device. This is represented by a bit string, with a one value at the bit position means the Bluetooth mode is supported; a zero value means not supported. NOTE: ue-based is only supported for AoD with assistance data in this release. |
| ***bt-MeasSupported***  This field specifies the Bluetooth measurements supported by the target device. This is represented by a bit string, with a one‑value at the bit position means the particular measurement is supported; a zero‑value means not supported. A zero-value in all bit positions in the bit string means only the basic Bluetooth positioning method is supported by the target device which is reporting of the Bluetooth beacon identity. The following bits are assigned for the indicated measurements.  rssi: Bluetooth beacon signal strength at the target device  aod: Bluetooth beacon AoD at the target device |
| ***idleStateForMeasurements***  This field, if present, indicates that the target device requires idle state to perform BT measurements. |
| ***periodicalReportingSupported***  This field, if present, specifies the positioning modes for which the target device supports *periodicalReporting*. This is represented by a bit string, with a one value at the bit position means *periodicalReporting* for the positioning mode is supported; a zero value means not supported. If this field is absent, the location server may assume that the target device does not support *periodicalReporting* in *CommonIEsRequestLocationInformation*. |
| ***scheduledLocationRequestSupported***  This field, if present, specifies the positioning modes for which the target device supports scheduled location requests – i.e., supports the IE *ScheduledLocationTime* in IE *CommonIEsRequestLocationInformation* – and the time base(s) supported for the scheduled location time for each positioning mode. If this field is absent, the target device does not support scheduled location requests. |
| ***bt-AoA***  This field, if present, indicates that the target device supports Bluetooth AoA, where  *request-only*: Target device supports to provide its Bluetooth AoA transmission configuration to LMF upon request  *suggestion*: Target device supports obtaining a suggestion from LMF about device Bluetooth AoA transmission configuration and device supports to provide its Bluetooth AoA transmission configuration based on the suggestion back to LMF |
| ***bt-AoD***  This field, if present, indicates that the target device supports Bluetooth AoD |

6.5.7.5 Bluetooth Capability Information Request

*–* *BT-RequestCapabilities*

The IE *BT-RequestCapabilities* is used by the location server to request Bluetooth positioning capabilities from a target device.

-- ASN1START

BT-RequestCapabilities-r13 ::= SEQUENCE {

...

}

-- ASN1STOP

6.5.7.6 BT Error Elements

*–* *BT-Error*

The IE *BT-Error* is used by the location server or target device to provide error reasons for Bluetooth positioning to the target device or location server, respectively.

-- ASN1START

BT-Error-r13 ::= CHOICE {

locationServerErrorCauses-r13 BT-LocationServerErrorCauses-r13,

targetDeviceErrorCauses-r13 BT-TargetDeviceErrorCauses-r13,

...

}

-- ASN1STOP

*–* *BT-LocationServerErrorCauses*

The IE *BT-LocationServerErrorCauses* is used by the location server to provide error reasons for Bluetooth positioning to the target device.

-- ASN1START

BT-LocationServerErrorCauses-r13 ::= SEQUENCE {

cause-r13 ENUMERATED {undefined, ...,

assistanceDataNotSupportedByServer-v1800,

assistanceDataSupportedButCurrentlyNotAvailableByServer-v1800,

notProvidedAssistanceDataNotSupportedByServer-v1800

},

...

}

-- ASN1STOP

– *BT-TargetDeviceErrorCauses*

The IE *BT-TargetDeviceErrorCauses* is used by the target device to provide error reasons for Bluetooth positioning to the location server.

-- ASN1START

BT-TargetDeviceErrorCauses-r13 ::= SEQUENCE {

cause-r13 ENUMERATED {undefined,

requestedMeasurementsNotAvailable,

notAllrequestedMeasurementsPossible,

...,

assistanceDataMissing-v1800,

unableToMeasureAnyBT-Beacons-v1800,

thereWereNotEnoughBeaconsReceivedForUeBasedAoD-v1800,

unableToTransmitCTE-v1800

},

bt-Beacon-rssiMeasurementNotPossible-r13 NULL OPTIONAL,

...

}

-- ASN1STOP

| ***BT-TargetDeviceErrorCauses* field descriptions** |
| --- |
| ***cause***  This field provides a Bluetooth specific error cause. If the cause value is 'notAllRequestedMeasurementsPossible', the target device was not able to provide all requested Bluetooth measurements (but may be able to provide some measurements). In this case, the target device should include *bt-Beacon-rssiMeasurementNotPossible* field. |

6.5.7.7 Bluetooth Assistance Data

*–* *BT-ProvideAssistanceData*

The IE *BT-ProvideAssistanceData* is used by the location server to provide assistance data to enable UE‑based and UE-assisted AoD positioning. It may also be used to provide Bluetooth positioning specific error reasons.

-- ASN1START

BT-ProvideAssistanceData-r18 ::= SEQUENCE {

bt-BeaconInfo-r18 BT-BeaconInfo-r18,

bt-Error-r18 BT-Error-r13 OPTIONAL, -- Need ON

...

}

-- ASN1STOP

| ***BT-ProvideAssistanceData* field descriptions** |
| --- |
| ***bt-BeaconInfo*** This field provides data for aset of Bluetooth beacons. |
| ***bt-Error*** This field provides error information and may be included when a Provide Assistance Data is sent in response to a Request Assistance Data. |

6.5.7.8 Bluetooth Assistance Data Elements

– *BT-BeaconInfo*

The IE *BT-BeaconInfo* is used by the location server to provide Bluetooth beacon information for one set of Bluetooth beacons.

-- ASN1START

BT-BeaconInfo-r18 ::= SEQUENCE {

referencePoint-r18 ReferencePoint-r16 OPTIONAL,

bt-BeaconInfoList-r18 SEQUENCE (SIZE (1..maxBT-beaconAD-r18)) OF BT-BeaconInfoElement-r18,

...

}

BT-BeaconInfoElement-r18 ::= SEQUENCE {

btAddr-r18 BIT STRING (SIZE (48)),

bt-BeaconLocation-r18 RelativeLocation-r16 OPTIONAL, -- Need OP

bt-LCS-GCS-TranslationParameter-r18 LCS-GCS-TranslationParameter-r16,

OPTIONAL, -- Cond NotSameAsPrev1

bt-antArrayConfig-r18 BT-AntArrayConfig-r18 OPTIONAL, -- Cond NotSameAsPrev2

bt-antElementList-r18 SEQUENCE (SIZE (2..maxBT-BeaconAntElt-r18)) OF

BT-AntElement-r18 OPTIONAL, -- Cond NotSameAsPrev3 bt-antSwitchingPattern-r18 SEQUENCE (SIZE (2..maxBT-BeaconAntElt-r18)) OF

BT-AntSwitchElement-r18 OPTIONAL, -- Cond NotSameAsPrev4

bt-AoDTransmConfig-r18 BT-AoDTransmConfig-r18 OPTIONAL, -- Cond NotSameAsPrev5

...

}

AntArrayConfig-r18 ::= CHOICE {

bt-UniformLinearArray-r18 BT-UniformLinearArray-r18,

bt-UniformRectangularArray-r18 BT-UniformRectangularArray-r18,

bt-UniformCircularArray-r18 BT-UniformCircularArray-r18,

bt-GenericArray-r18 BT-GenericArray-r18

}

AntElement-r18 ::= SEQUENCE {

polarization-r18 ENUMERATED (m45, zero, p45, p90, circ),

...

}

AntSwitchElement-r18 ::= SEQUENCE {

antElementIndexShort-r18 INTEGER (1..16),

antElementIndexOffset-r18 ENUMERATED (o16, o32, o48, o64) OPTIONAL,

...

}

BT-AoDTransmConfig-r18 ::= SEQUENCE {

primaryAdvInterval-r18 INTEGER (32..16777),

secondAdvInterval-r18 INTEGER (6..65535),

cteLength-r18 INTEGER (2..20),

cteCount-r18 INTEGER (1..16),

cteType2us-r18 NULL OPTIONAL,

tx-PHY-M2-r18 NULL OPTIONAL,

...

}

-- ASN1STOP

| ***BT-BeaconInfo* field descriptions** |
| --- |
| ***btAddr***  This field specifies the Bluetooth public address of the Bluetooth beacon [xx]. |
| ***referencePoint***  This field specifies the reference point used to define the locations of the set of Bluetooth beacons. |
| ***bt-LCS-GCS-TranslationParameter***  This field provides the angles α (bearing angle), β (downtilt angle) and γ (slant angle) for the translation of a Local Coordinate System (LCS) to a Global Coordinate System (GCS) as defined in TR 38.901 [44]. |
| ***polarization***  This field specifies the antenna element polarization in degrees relative the positive y-axis, where *m45*, *zero*, *p45*, *p90* represents -45, zero, 45 and 90 degrees respectively towards the z-axis, and *circ* represents circular polarization. |
| ***bt-AoDTransmConfig***  This field specifies Bluetooth beacon AoD transmission configuration in terms of advertising periodicities and CTE configuration to support the device to configure its scan windows and intervals. |
| ***primaryAdvInterval***  This field specifies the Bluetooth primary advertisement channel periodicity used by the Bluetooth beacon, scaling factor 0.625 ms [xx]. |
| ***secondAdvInterval***  This field specifies the Bluetooth periodic advertising interval on secondary advertisement channels used by the Bluetooth beacon, scaling factor 0.625 ms [xx]. |
| ***cteLength***  This field specifies the configured CTE length to be used by the beacon in number of 8us segments. |
| ***cteCount***  This field specifies the number of Bluetooth packets that include a CTE that are transmitted each periodic advertising event |
| ***cteType2us***  This field, if present, indicates that 2us antenna switching slot duration is used by the beacon, otherwise 1us antenna switching slot duration is used, |
| ***tx-PHY-M2***  This field, if present, indicates that Bluetooth TX PHY 2 Megasymbols/s is used by the beacon, otherwise Bluetooth TX PHY 1 Megasymbols/s is used, |
| ***antSwitchingPattern***  This field specifies the Bluetooth antenna switching pattern as a list of indices, where each index is the order value of a specific antenna element in the *antElementList-r18* attribute of the IE *BT-BeaconInfoElement-r18* – first element in the list corresponds to index 1 and so on. If the antenna switching pattern is shorter than the number of available sample slots, then the antenna switching patterns continues from the beginning of the *antSwitchingPattern-r18*. If antenna switching pattern is longer than the number of available sample slots, then the elements in *antSwitchingPattern-r18* are discarded. If this field is not present, the target device can assume an antenna switching pattern with the configured antenna element in the same order as in the *antElementList-r18.* |
| ***antElementIndexShort***  This field specifies short part of the antenna element index |
| ***antElementIndexOffset***  This field specifies offsett of the antenna element index, where o16, o32, o48 and o64 respresents 16, 32, 48 and 64 respectively to offset the short part of the antenna element index. If not present, the offset is zero. |

– *BT-UniformLinearArray*

The IE *BT-UniformLinearArray* is used by the location server to define a linear antenna array as a formula based on the antenna element index.

-- ASN1START

BT-UniformLinearArray-r18 ::= SEQUENCE {

bt-NoElements-r18 INTEGER (2..maxBT-BeaconAntElt-r18),

bt-InterElementDistelta-r18 INTEGER (30..130)

}

-- ASN1STOP

| ***BT-UniformLinearArray* field descriptions** |
| --- |
| ***bt-NoElements***  This field specifies the number of antenna elements in the linear antenna array. It is the same as the number of antenna elements in the *antElementList-r18* of the IE *BT-BeaconInfoElement-r18*. |
| ***bt-InterElementDist***  This field specifies the distance between to adjacent elements in the uniform linear antenna array between ¼ and just above 1 wavelength. Scale factor 1mm. |

The antenna element locations of the antenna array are defined along the y-axis from the reference point. The coordinates of the elements are *x=0, z=0* and *y = (index-1)\*bt-InterElementsDist-r18*, where *index* is the order value of a specific antenna element in the *antElementList-r18* attribute of the IE *BT-BeaconInfoElement-r18* – first element in the list corresponds to index 1 and so on.

– *BT-UniformRectangularArray*

The IE *BT-UniformRectangularArray* is used by the location server to define a rectangular antenna array as a formula based on the antenna element index.

-- ASN1START

BT-UniformRectangularArray-r18 ::= SEQUENCE {

bt-NoElementsY-r18 INTEGER (1..maxBT-BeaconAntElt-r18),

bt-NoElementsZ-r18 INTEGER (1..maxBT-BeaconAntElt-r18),

bt-InterElementDistY-r18 INTEGER (30..135),

bt-InterElementDistZ-r18 INTEGER (30..135)

}

-- ASN1STOP

| ***BT-ULA-Rectangular* field descriptions** |
| --- |
| ***bt-NoElementsY***  This field specifies the number of antenna elements in the L-shaped antenna array along the y-axis. The product *bt-ElementDeltaY\** *bt-ElementDeltaZ* is the same as the number of antenna elements in the *antElementList-r18* of the IE *BT-BeaconInfoElement-r18*. |
| ***bt-NoElementsZ***  This field specifies the number of antenna elements in the linear antenna array along the z-axis. |
| ***bt-InterElementDistY***  This field specifies the distance between to adjacent elements in the uniform rectangular antenna array along the y-axis. |
| ***bt-InterElementDistZ***  This field specifies the distance between to adjacent elements in the uniform rectangular antenna array along the z-axis. |

The antenna element locations of the uniform rectangular antenna array are defined row by row along the y-axis with an increasing offset in the z-direction for each row from the reference point. The coordinates of the elements of the

* first row are *x=0, z=0* and *y = (index-1)\*bt-InterElementsDistY-r18*, for index 1 to *bt-NoElementsY*
* second row are *x=0, z =* *bt-InterElementDistZ* and *y = (index-bt-NoElementsY-1)\*bt-InterElementsDistY-r18*, for index (*bt-NoElementsY*+1) to 2\**bt-NoElementsY*
* row *N* are *x=0, z =* *(N-1)\*bt-InterElementDistZ* and *y = (index-(N-1)\*bt-NoElementsY-1)\*bt-InterElementsDistY-r18*, for index (*(N-1)\*bt-NoElementsY*+1) to *N*\**bt-NoElementsY*, where *N = 1* to *NoElementsZ.*

– *BT-UniformCircularArray*

The IE *BT-UniformCircularArray* is used by the location server to define a uniform circular antenna array as a formula based on the antenna element index.

-- ASN1START

BT-UniformCircularArray-r18 ::= SEQUENCE {

bt-NoElements-r18 INTEGER (2..maxBT-BeaconAntElt-r18),

bt-InterElementDist-r18 INTEGER (30..130)

}

-- ASN1STOP

| ***BT-UniformCircularArray* field descriptions** |
| --- |
| ***bt-NoElements***  This field specifies the number of antenna elements in the circular antenna array. It is the same as the number of antenna elements in the *antElementList-r18* of the IE *BT-BeaconInfoElement-r18* |
| ***bt-InterElementDist***  This field specifies the distance between to adjacent elements in the uniform circular antenna array between ¼ and just above 1 wavelengths. Scale factor 1mm. |

The antenna element locations of the antenna array are defined along a circle with the reference point as center. The coordinates of the elements are:

* *x=0*
* *y = bt-Radius\** cos*(2\*p\*(index-1)/ bt-NoElements-r18)*
* *z = bt-Radius\** sin*(2\*p\*(index-1)/ bt-NoElements-r18)*

where *index* is the order value of a specific antenna element in the *antElementList-r18* attribute of the IE *BT-BeaconInfoElement-r18* – first element in the list corresponds to index 1 and so on, and

*bt-Radius* = *bt-InterElementDist*/(2\*sin(*p / bt-NoElements-r18*))

– *BT-GenericArray*

The IE *BT-GenericArray* is used by the location server to define a generic antenna array as a list of offset locations for each antenna element, where each ordered entry in *BT-GenericArray-r18* is associated to the same ordered entry in the *antElementList-r18* attribute of the IE *BT-BeaconInfoElement-r18.*

-- ASN1START

BT-GenericArray-r18 ::= SEQUENCE (SIZE (2..maxBT-BeaconAntElt-r18)) OF BT-ULA-GenericAntElement-r18

BT-ULA-GenericAntElement-r18 ::= SEQUENCE {

deltaY-r18 INTEGER (-135..135) OPTIONAL, -- Need OP

deltaX-r18 INTEGER (-135..135) OPTIONAL, -- Need OP

deltaZ-r18 INTEGER (-135..135) OPTIONAL -- Need OP

}

-- ASN1STOP

| ***BT-GenericArray* field descriptions** |
| --- |
| ***deltaX, deltaY, deltaZ***  This field specifies the antenna element location offset in X, Y, Z directions respectively. Scale factor 1mm. |

6.5.7.9 Bluetooth Assistance Data Request

*–* *BT-RequestAssistanceData*

The IE *BT-RequestAssistanceData* is used by the target device to request BT assistance data from a location server.

-- ASN1START

BT-RequestAssistanceData-r18 ::= SEQUENCE {

requestedAD-r18 BIT STRING { beacon-location (0),

beacon-antConfig (1),

beacon-transmConfig (2) } (SIZE (1..8)),

...

}

-- ASN1STOP

| ***BT-RequestAssistanceData* field descriptions** |
| --- |
| ***requestedAD*** This field specifies the Bluetooth assistance data requested. This is represented by a bit string, with a one-value at the bit position means the particular assistance data is requested; a zero-value means not requested. The following assistance data types are included:   * *beacon-location*: Bluetooth beacon location information * *beacon-antConfig*: Bluetooth beacon antenna orientation, array configuration information and antenna switching pattern for AoD estimation * *beacon-transmConfig*: Bluetooth beacon advertisement and CTE configuration information |

*[…]*

6.6 Multiplicity and type constraint values

*– Multiplicity and type constraint definitions*

-- ASN1START

maxEARFCN INTEGER ::= 65535 -- Maximum value of EUTRA carrier frequency

maxEARFCN-Plus1 INTEGER ::= 65536 -- Lowest value extended EARFCN range

maxEARFCN2 INTEGER ::= 262143 -- Highest value extended EARFCN range

maxMBS-r14 INTEGER ::= 64

maxWLAN-AP-r13 INTEGER ::= 64

maxKnownAPs-r14 INTEGER ::= 2048

maxVisibleAPs-r14 INTEGER ::= 32

maxWLAN-AP-r14 INTEGER ::= 128

maxWLAN-DataSets-r14 INTEGER ::= 8

maxBT-Beacon-r13 INTEGER ::= 32

maxBT-Beacon-r18 INTEGER ::= 32

maxBT-BeaconAntElt-r18 INTEGER ::= 74

maxBT-BeaconAD-r18 INTEGER ::= 64

nrMaxBands-r16 INTEGER ::= 1024 -- Maximum number of supported bands in

-- UE capability.

nrMaxFreqLayers-r16 INTEGER ::= 4 -- Max freq layers

nrMaxFreqLayers-1-r16 INTEGER ::= 3

nrMaxNumDL-PRS-ResourcesPerSet-1-r16 INTEGER ::= 63

nrMaxNumDL-PRS-ResourceSetsPerTRP-1-r16 INTEGER ::= 7

nrMaxResourceIDs-r16 INTEGER ::= 64 -- Max Resource IDs

nrMaxResourceOffsetValue-1-r16 INTEGER ::= 511

nrMaxResourcesPerSet-r16 INTEGER ::= 64 -- Maximum resources for one set

nrMaxSetsPerTrpPerFreqLayer-r16 INTEGER ::= 2 -- Maximum resource sets for one TRP

nrMaxSetsPerTrpPerFreqLayer-1-r16 INTEGER ::= 1

nrMaxTRPs-r16 INTEGER ::= 256 -- Max TRPs per UE

nrMaxTRPsPerFreq-r16 INTEGER ::= 64 -- Max TRPs per freq layers

nrMaxTRPsPerFreq-1-r16 INTEGER ::= 63

maxSimultaneousBands-r16 INTEGER ::= 4 -- Maximum number of simultaneously

-- measured bands

maxBandComb-r16 INTEGER ::= 1024

nrMaxConfiguredBands-r16 INTEGER ::= 16

maxNumOfRxTEGs-r17 INTEGER ::= 32

maxNumOfRxTEGs-1-r17 INTEGER ::= 31

maxNumOfTxTEGs-1-r17 INTEGER ::= 7

maxTxTEG-Sets-r17 INTEGER ::= 256 -- Maximum applicable number is 64

maxNumOfRxTxTEGs-1-r17 INTEGER ::= 255

maxNumOfTRP-TxTEGs-1-r17 INTEGER ::= 7

maxNumOfSRS-PosResources-r17 INTEGER ::= 64

maxNumOfSRS-PosResources-1-r17 INTEGER ::= 63

maxNumResourcesPerAngle-r17 INTEGER ::= 24

maxNumPrioResources-r17 INTEGER ::= 24

maxAddMeasTDOA-r17 INTEGER ::= 31

maxAddMeasAoD-r17 INTEGER ::= 23

maxAddMeasRTT-r17 INTEGER ::= 31

maxOD-DL-PRS-Configs-r17 INTEGER ::= 8

maxCellIDsPerArea-r17 INTEGER ::= 256

maxNrOfAreas-r17 INTEGER ::= 16

maxMeasInstances-r17 INTEGER ::= 32

-- ASN1STOP

# Appendix B Text Proposal for TS 38.305 V.17.6.0

*[…]*

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 23.501 "System Architecture for the 5G System; Stage 2".

[3] 3GPP TS 22.071: "Location Services (LCS); Service description, Stage 1".

[4] 3GPP TS 23.032: "Universal Geographical Area Description (GAD)".

[5] IS-GPS-200, Revision D, Navstar GPS Space Segment/Navigation User Interfaces, March 7th, 2006.

[6] IS-GPS-705, Navstar GPS Space Segment/User Segment L5 Interfaces, September 22, 2005.

[7] IS-GPS-800, Navstar GPS Space Segment/User Segment L1C Interfaces, September 4, 2008.

[8] Galileo OS Signal in Space ICD (OS SIS ICD), Draft 0, Galileo Joint Undertaking, May 23rd, 2006.

[9] Global Navigation Satellite System GLONASS Interface Control Document, Version 5, 2002.

[10] IS-QZSS, Quasi Zenith Satellite System Navigation Service Interface Specifications for QZSS, Ver.1.0, June 17, 2008.

[11] Specification for the Wide Area Augmentation System (WAAS), US Department of Transportation, Federal Aviation Administration, DTFA01-96-C-00025, 2001.

[12] RTCM 10402.3, RTCM Recommended Standards for Differential GNSS Service (v.2.3), August 20, 2001.

[13] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[14] 3GPP TS 38.331: "NR Radio Resource Control (RRC) protocol specification".

[15] OMA-AD-SUPL-V2\_0: "Secure User Plane Location Architecture Approved Version 2.0".

[16] OMA-TS-ULP-V2\_0\_6: "UserPlane Location Protocol Approved Version 2.0.6".

[17] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer – Measurements".

[18] 3GPP TS 36.302: "Evolved Universal Terrestrial Radio Access (E-UTRA); Services provided by the physical layer".

[19] 3GPP TS 36.355: "Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)".

[20] BDS-SIS-ICD-B1I-3.0: "BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1I (Version 3.0)", February, 2019.

[21] IEEE 802.11: "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications"

[22] Bluetooth Special Interest Group: "Bluetooth Core Specification v4.2", December 2014.

[23] ATIS-0500027: "Recommendations for Establishing Wide Scale Indoor Location Performance", May 2015.

[24] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation".

[25] 3GPP TS 36.305: "Stage 2 functional specification of User Equipment (UE) positioning in E‑UTRA".

[26] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[27] 3GPP TS 38.455: "NG-RAN; NR Positioning Protocol A (NRPPa)".

[28] 3GPP TS 29.518: "5G System; Access and Mobility Management Services; Stage 3".

[29] 3GPP TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

[30] 3GPP TS 38.413: "NG-RAN; NG Application Protocol (NGAP)".

[31] RTCM 10403.3, "RTCM Recommended Standards for Differential GNSS Services (v.3.3)", October 7, 2016.

[32] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".

[33] 3GPP TS 29.572: "Location Management Services; Stage 3".

[34] BDS-SIS-ICD-B1C-1.0: "BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1C (Version 1.0)", December, 2017

[35] 3GPP TS 23.273: "5G System (5GS) Location Services (LCS); Stage 2".

[36] IS-QZSS-L6-001, Quasi-Zenith Satellite System Interface Specification – Centimetre Level Augmentation Service, Cabinet Office, November 5, 2018.

[37] 3GPP TS 38.215: "NR; Physical layer – Measurements".

[38] 3GPP TS 38.401: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NG-RAN; Architecture description".

[39] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification".

[40] 3GPP TS 38.212: "NR; Multiplexing and channel coding".

[41] 3GPP TS 24.571: "Control plane Location Services (LCS) procedures".

[42] 3GPP TS 37.355: "Technical Specification Group Radio Access Network; LTE Positioning Protocol (LPP)".

[43] IRNSS Signal-In-Space (SPS) Interface Control Document (ICD) for standard positioning service version 1.1, August 2017.

[44] BDS-SIS-ICD-B2a-1.0: "BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B2a (Version 1.0)", December, 2017.

[45] BDS-SIS-ICD-B3I-1.0: "BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B3I (Version 1.0)", February, 2018.

[xx] Bluetooth Special Interest Group: "Bluetooth Core Specification v5.4", February 2023.

*[…]*

4.3.7 Bluetooth positioning

The Bluetooth positioning method makes use of Bluetooth to determine the location of the UE. In one option, the UE measures received signals from Bluetooth [22] beacons, associated to beacon identifiers. In another option, the UE transmits a Bluetooth Continuous Tone Extension (CTE) signal to enable Bluetooth beacons to estimate AoA from the UE [xx]. In yet another option, the UE, based on assistance data from the positioning server about Bluetooth beacon’s antenna configuration, estimates AoD from the Bluetooth beacons. [xx]. Using the measurement results and a references database, the location of the UE is calculated. The Bluetooth methods may be combined with other positioning methods (e.g. WLAN) to improve positioning accuracy of the UE.

The operation of the Bluetooth positioning method is described in clause 8.6.

*[…]*

8.6 Bluetooth positioning

8.6.1 General

In the Bluetooth positioning method, the UE position is estimated with the knowledge of geographical coordinate of reference Bluetooth beacons. This is accomplished by collecting a certain amount of measurements from UE's Bluetooth receiver and/or from the receiver of the Bluetooth beacons, and applying a location determination algorithm using databases of the estimated position’s references points, reference points antenna configuration and orientation.

The UE Bluetooth measurements may include:

- Bluetooth beacon's Received Signal Strength (RSSI).

- Bluetooth beacon's estimated AoD (azimuth and zenith angles).

The Bluetooth beacon measurements may include:

- Bluetooth beacon's estimated AoA (azimuth and zenith angles).

Three positioning modes are supported:

- *Standalone*:  
The UE performs Bluetooth position measurements and location computation.

- *UE-assisted*:  
The UE provides Bluetooth position measurements with or without assistance from the network to the LMF for computation of a location estimate by the network.

- *UE-based*:  
The UE performs Bluetooth position measurements and computation of a location estimate with network assistance.

8.6.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and UE.

8.6.2.1 Information that may be transferred from the LMF to UE

Table 8.6.2.1-1 lists Bluetooth transmission parameters that LMF may suggest to the UE to consider for UE-assisted Bluetooth AoA positioning. LMF may instead only request to the UE to provide its Bluetooth transmission parameters used for UE-assisted Bluetooth AoA positioning.

NOTE: The provision of these elements and the usage of these elements by the UE depend on the NG-RAN/5GC and UE capabilities, respectively.

**Table 8.6.2.1-2: Suggested UE Bluetooth AoA transmission parameters that may be transferred from LMF to the UE**

|  |
| --- |
| **Information** |
| Transmission configuration (advertising periodicities, PHY type, TX power, CTE length and repetition) |

The AoA transmission configuration is described in more detail in 8.6.2.2.

Table 8.6.2.1-2 lists assistance data for both UE-assisted and UE-based modes that may be sent from the LMF to the UE to support Bluetooth AoD positioning.

NOTE: The provision of these assistance data elements and the usage of these elements by the UE depend on the NG-RAN/5GC and UE capabilities, respectively.

**Table 8.6.2.1-2: Assistance data that may be transferred from LMF to the UE**

|  |  |  |
| --- | --- | --- |
| **Information** | **UE-assisted** | **UE-based** |
| **Bluetooth beacon list:** |  |  |
| Bluetooth advertising address | Yes | Yes |
| Geographical coordinate | Yes | Yes |
| Antenna array orientation (LCS to GCS translation) | Yes | Yes |
| Antenna array configuration (antenna relative location and polarization) and antenna switching pattern | Yes | Yes |
| Transmission configuration (advertising periodicities, PHY type, CTE type, length and repetition) | Yes | Yes |

8.6.2.1.1 Bluetooth beacon advertising address

This assistance data provides the Bluetooth advertising address btAddr of the Bluetrooth beacon [xx].

8.6.2.1.2 Bluetooth beacon locatiom

This assistance data provides the location of the Bluetooth beacon [xx].

8.6.2.1.3 Bluetooth beacon antenna array orientation

This assistance data provides the Bluetooth antenna array orientation of the Bluetooth beacon by parameters bearing, downtilt and slant for the translation of a Local Coordinate System (LCS) to a Global Coordinate System (GCS).

8.6.2.1.4 Bluetooth beacon antenna array configuration and switching pattern

This assistance data provides the Bluetooth antenna array configuration of the Bluetooth beacon, where each the antenna of the array is characterized by a relative position to an antenna array reference point and a polarization, and the antenna switching pattern lists the order antennas are used for transmissions [xx]. One generic antenna array and three parameterized antenna arrays can be defined (linear, rectangular or circular).

8.6.2.1.5 Bluetooth beacon AoD transmission configuration

This assistance data provides the Bluetooth beacon AoD transmission configuration parameters for the primary and secondary advertising periodicities, Bluetooth PHY type (1 or 2 Msymbol/s), CTE type (1 us or 2 us switching slot lengths), CTE length (8 to 160 us) and CTE repeated transmission instants (1 - 16).

8.6.2.2 Information that may be transferred from the UE to LMF

The information that may be signalled from the UE to the LMF is summarized in Table 8.6.2.2-1.

**Table 8.6.2.2-1: Information that may be transferred from the UE to the LMF**

|  |  |  |
| --- | --- | --- |
| **Information** | **UE‑Assisted** | **Standalone** |
| **Bluetooth Location Information** |  |  |
| MAC Address | Yes | No |
| Received Signal Strength (RSSI) | Yes | No |
| Time Stamp | Yes | No |
| Measurement characteristics | Yes | No |
| AoD angles (azimuth and zenith | Yes | No | |
| **UE Location Information** |  |  |
| UE position estimate with uncertainty shape | No | Yes |
| Position Time Stamp | No | Yes |
| Location Source (method(s) used to compute location) | No | Yes |
| UE AoA transmission configuration |  |  |
| Address and address type | Yes | No |
| Primary and secondary channel advertising periodicity | Yes | No |
| Primary and secondary advertising periodicity | Yes | No |
| TX Power | Yes | No |
| CTE transmission configuration | Yes | No |

Bluetooth AoA positioning is enabled by the UE transmitting Bluetooth periodic advertising with a CTE, configured by the following parameters:

* UE advertisement address that can be of three different types - public (MAC address), random-static (static random number) or random-private-resolvable (regularly updated random number).
* primary channel advertising periodicity, related to the Bluetooth beacon acquisition time of the UE Bluetooth signal.
* periodic advertising interval on the secondary advertising channel, related to how often the Bluetooth beacons will be able to estimate AoA of the UE
* TX power related to how strong the UE Bluetooth signal is received at the Bluetooth beacons.
* CTE length (16 – 160 us) of every CTE transmission

CTE repeated transmissions instants (1-16) each transmission instant.8.6.2.2.1 Standalone mode

In Standalone mode, the UE reports the latitude, longitude and possibly altitude, together with an estimate of the location uncertainty, if available.

The UE should also report an indication of Bluetooth method and possibly other location methods have been used to calculate a fix.

8.6.2.2.2 UE-assisted mode

In UE-assisted mode, the UE should either report:

- The MAC addresses of the measured Bluetooth beacons and one or more of.

- associated RSSI

- associated AoD, assisted by the positioning server

or transmit:

- periodic advertisements with CTE to enable Bluetooth beacon AoA estimation

8.6.2.2.3 UE-based mode

In UE-based mode using Bluetooth AoD, the UE reports the estimated location coordinates together with an estimate of the location uncertainty, if available.

The UE should also report an indication that Bluetooth method is used and possibly other positioning methods used to calculate the fix.8.6.3 Bluetooth Positioning Procedures

8.6.3.1 Capability Transfer Procedure

The Capability Transfer procedure for Bluetooth positioning is described in clause 7.1.2.1.

8.6.3.2 Assistance Data Transfer Procedure

The purpose of this procedure is to enable the UE to request Bluetooth AoD assistance data from the LMF (e.g., as part of a positioning procedure) and the LMF to provide assistance data to the UE (e.g., as part of a positioning procedure).

8.6.3.2.1 LMF initiated Assistance Data Delivery

Figure 8.6.3.2.1-1 shows the Assistance Data Delivery operations for the network-assisted Bluetooth AoD method when the procedure is initiated by the LMF

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**Figure 8.6.3.2.1: LMF-initiated Assistance Data Delivery Procedure**

(1) The LMF determines that assistance data needs to be provided to the UE (e.g., as part of a positioning procedure) and sends an LPP Provide Assistance Data message to the UE. This message may include any of the Bluetooth assistance data defined in clause 8.6.2.1.

8.6.3.2.2 UE initiated Assistance Data Transfer

Figure 8.6.3.2.2-1 shows the Assistance Data Transfer operations for the network-assisted Bluetooth AoD method when the procedure is initiated by the UE.

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**Figure 8.6.3.2.2-1: UE-initiated Assistance Data Transfer Procedure**

(1) The UE determines that certain Bluetooth assistance data is desired (e.g., as part of a positioning procedure when the LMF provided assistance data are not sufficient for the UE to fulfil the request) and sends a LPP Request Assistance Data message to the LMF. This request includes an indication of which specific Bluetooth assistance data is requested.

(2) The LMF provides the requested assistance data in a LPP Provide Assistance Data message, if available at the LMF. The entire set of assistance data may be delivered in one or several LPP messages. In this case, this step may be repeated by the LMF several times. If any of the UE requested assistance data in step (1) are not provided in step 2, the UE shall assume that the requested assistance data are not supported, or currently not available at the LMF. If none of the UE requested assistance data in step (1) can be provided by the LMF, return any information that can be provided in an LPP message of type Provide Assistance Data which includes a cause indication for the not provided assistance data.

8.6.3.3 Location Information Transfer Procedure

The purpose of this procedure is to enable the LMF to request position measurements or location estimate from the UE, or to enable the UE to provide location measurements to the LMF for position calculation.

The purpose can also be to enable LMF to request or suggest UE Bluetooth AoA configuration and enable the UE to provide the Bluetooth AoA configuration it will use to enable Bluetooth beacons to provide AoA measurements to LMF.

8.6.3.3.1 LMF initiated Location Information Transfer Procedure

Figure 8.6.3.3.1-1 shows the Location Information Transfer operations for the Bluetooth method when the procedure is initiated by the LMF.

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**Figure 8.6.3.3.1-1: LMF-initiated Location Information Transfer Procedure**

(1) The LMF sends a LPP Request Location Information message to the UE for invocation of Bluetooth positioning. This request includes positioning instructions such as the positioning mode (UE-assisted, Standalone), specific requested UE measurements if any, quality of service parameters (accuracy, response time) , request/suggestion of UE Bluetooth AoA transmission configuration.

(2) The UE performs the requested measurements and possibly calculates its own location. The UE sends an LPP Provide Location Information message to the LMF before the Response Time provided in step (1) elapsed. If the UE is unable to perform the requested measurements, or if the Response Time provided in step 1 elapsed before any of the requested measurements have been obtained, the UE returns any information that can be provided in an LPP message of type Provide Location Information which includes a cause indication for the not provided location information.

Alternatively, for AoA, the UE provides Bluetooth AoA transmission configuration that it will use in an LPP Provide Location Information message to the LMF before the Response Time provided in step (1) elapsed.8.6.3.3.2 UE-initiated Location Information Delivery Procedure

Figure 8.6.3.3.2-1 shows the Location Information delivery operations for the Bluetooth method when the procedure is initiated by the UE.

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**Figure 8.6.3.3.2-1: UE-initiated Location Information Delivery Procedure**

(1) The UE sends an LPP Provide Location Information message to the LMF. The Provide Location Information message may include UE Bluetooth information or location estimate already available at the UE. For AoA, the UE provides Bluetooth AoA transmission configuration in a Provide Location Information message that it will use. Specifically, the UE will trigger such a message when it has changed Bluetooth advertising address – only applicable for the random-private-resolvable address type.