TSG-RAN Meeting #7 **_RP-000038_**
Madrid, Spain, 13 – 15 March 2000

Title: **Agreed CRs to TS 25.305**

Source: **TSG-RAN WG2**

Agenda item: **6.3.3**

Doc-1st-	Spec	CR	Rev	Subject	Cat	Version	Versio
R2-000535	25.305	001	3	Network assisted GPS LCS	C	3.0.0	3.1.0
R2-000175	25.305	002	1	Enhancements for cell coverage based	C	3.0.0	3.1.0
R2-000133	25.305	003		Replacement for Figure 4.1	D	3.0.0	3.1.0
R2-000402	25.305	004	1	Restructuring	D	3.0.0	3.1.0
R2-000171	25.305	006		Target UE-RNC signalling model	C	3.0.0	3.1.0
R2-000172	25.305	007		LMU description	D	3.0.0	3.1.0
R2-000553	25.305	008	2	LMU signalling description	C	3.0.0	3.1.0
R2-000210	25.305	009		Incorporation of R1 Liaisons R2-000022	C	3.0.0	3.1.0
R2-000536	25.305	010	3	OTDOA - GPS Location Procedures	C	3.0.0	3.1.0
R2-000530	25.305	011	1	Clarification of the different LMU types	C	3.0.0	3.1.0

3GPP/SMG Meeting RAN WG2 #11
Turin, Italy, 28th Feb - 3rd Mar 2000

***Document* R2-000535**
e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.305 CR 001r3 Current Version: 3.0.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to: TSG-RAN #7	for approval	X	strategic		(for SMG use only)
list expected approval meeting # here ↑	for information		non-strategic		

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

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

Source: TSG-RAN WG2 **Date:** 25/02/2000

Subject: Network assisted GPS LCS; modified sections 4.4.3 and 6.2.4.1.2

Work item: TS 25.305

Category: *(only one category shall be marked with an X)*

F	Correction		**Release:**	Phase 2	
A	Corresponds to a correction in an earlier release			Release 96	
B	Addition of feature			Release 97	
C	Functional modification of feature	X		Release 98	
D	Editorial modification			Release 99	X
				Release 00	

Reason for change: Updated Sections 4.4.3 and 6.2.4.1.2 text for clarification and alignment.

Clauses affected: 4.4.3 and 6.2.4.1.2

Other specs affected:

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

Other comments:

<--------- double-click here for help and instructions on how to create a CR.

4.4.3 Network Assisted GPS Methods

These methods make use of UEs which are equipped with radio receivers capable of receiving signals from the Global Positioning System (GPS).

The operation of the network assisted GPS methods is described in this section.

~~NOTE: the intention is that this description be synergistic with GSM 03.71.~~

~~Methods making use of GPS are being standardised for GSM. In order to facilitate efficient implementation, and seamless location service operation between GSM and UTRAN, the support for GPS based methods must be compatible between these systems.~~

~~There are four main functions for a stand-alone GPS receiver:~~

~~1 Measuring distance from the satellites to the GPS receiver by determining the pseudoranges (code phases);~~

~~2 Extracting the TOA of the signal from the contents of the satellite transmitted message;~~

~~3 Computing the location of the satellites by evaluating the ephemeris data at the indicated TOA.;~~

~~4 Determining the location of the receiving antenna and the clock bias of the receiver by using the above data items.~~

~~To reduce the errors contributed from satellite clock and location modelling, ionospheric delay, tropospheric delay, and selective availability (SA), corrections can be done before the fourth step above. The most important technique for error compensation is DGPS.~~

When GPS is designed to inter-work with the UTRAN, the network assists the UE GPS receiver to improve the performance in several respects. These performance improvements will:

- Reduce the UE GPS start-up and acquisition times; the search window can be limited and the measurements sped up significantly.
- Increase the UE GPS sensitivity; location assistance messages are obtained via UTRAN so the UE GPS can operate also in low SNR situations when it is unable to demodulate UE GPS signals.
- Allow the UE to consume less handset power than with stand-alone GPS ; this is due to rapid start-up times as the GPS can be in idle mode when it is not needed.

The Network assisted GPS methods rely on signalling between possibly reduced complexity UE GPS receivers and a continuously operating GPS reference receiver network which has clear sky visibility of the same GPS constellation as the assisted UEs. GPS ~~R~~reference ~~GPS~~ receivers may be connected to the UTRAN to enable derivation of UE assistance signals.

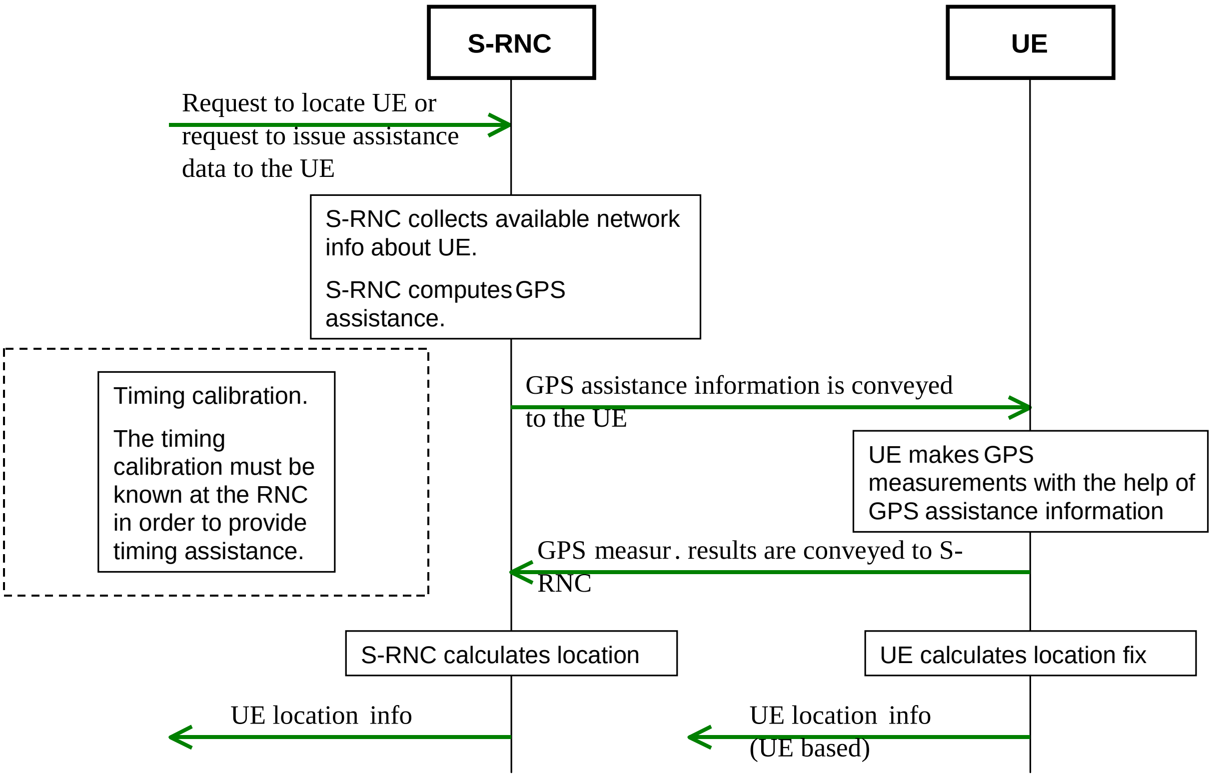


Figure 4.3: Network assisted GPS methods

4.4.3.1 Timing calibration

~~Where timing assistance is needed, the relationship between GPS Time Of Week (see reference: GSM 04.31) and cell-specific UTRAN system timing must be derived.~~

~~In the network assisted GPS methods the inter-system measurement may be used to reduce the signal search space and hence reduce the user delay in obtaining a location fix. Typically, a timing assistance accuracy of several microseconds is required for an acceptable location fix user delay. The relationship between GPS time and UTRAN timing is to be defined as GPS-UTRAN-Reference-Time in a similar way as in GSM 04.31 Annex A Section 4.2.4.~~

~~The UE or LMU optionally derives the cell specific GPS-UTRAN-Reference-Time through measurement at Layer 1.~~

Timing calibration is specified in TS 25.215.

4.4.3.2 Timing assistance

The UTRAN may derive the estimated UE location using UTRAN (eg. Cell-ID or IPDL) parameters and may use this information, in conjunction with satellite specific ephemeris data from the UTRAN based GPS reference receiver, to derive the estimated time difference (code phase) between equivalent GPS satellite signals received by the UTRAN based GPS reference receiver and the UE based GPS receiver. The estimated code phase data may be conveyed, together with $T_{UTRAN\text{-}GPS}$ (as specified in TS 25.215), from the UTRAN to the UE using higher layer signalling; the estimated code phase data value is uncertain to a degree depending on the accuracy of the UTRAN location determination method used.

~~The UTRAN combines the coarse UE location determinations from UTRAN cell-specific information with the GPS-UTRAN-Reference-Time. These coarse determinations can be enhanced through other location methods (e.g. IPDL). Using this information, the UTRAN computes the estimated timing of GPS signals received by the UE and conveys this information to the UE using higher layer signalling. The GPS-UTRAN-Reference-Time is uncertain to a degree depending on the accuracy of the coarse location estimate used. Typically, a window of several microseconds can be attained.~~

~~In addition, other GPS parameters, as described in section 4.4.3.3, are conveyed to the UE to further reduce the signal search space.~~

4.4.3.3 Data assistance

~~GPS signals are modulated with low-rate digital information at a rate of 50 bits/sec. This information is necessary for stand-alone GPS receivers to determine their own location (the low rate digital information conveys satellite ephemeris and other GPS data).~~

The UE may receive GPS information through the UTRAN air interface, using higher layer signalling.

When the UE is unable to detect 4 or more satellites, the assisted GPS method can be combined with other location methods.

~~The UE receives GPS information (e.g. Doppler shifts) through UTRAN air interface, using higher layer signalling, and modulation 'wipe-off' is applied. Therefore, the space that must be searched by the UE, to derive the GPS signals needed, can be reduced beyond that needed by a stand-alone GPS receiver. Thus, a location fix can be derived with an acceptable sensitivity and delay to the user.~~

> ~~NOTE: "modulation wipe-off" is intended here to mean a removal of the GPS modulation in the UE through the use of the UTRAN assistance information.~~

The assistance data signalled to the UE may include all information listed below or a selected subset:

Data assisting the measurements; e.g. reference time, visible satellite list, satellite signal Doppler, code phase search window. This data can be ~~is~~ valid for a few hours (2-4 hrs).

Data providing means for location calculation; e.g. reference time, reference location, satellite ephemeris, clock corrections. This data is valid for four hours.

If DGPS is utilised, then differential corrections may also be transmitted. They are valid for about 30 seconds. The DGPS data is valid for a large geographical area, so one centrally located reference receiver can be used to service this large region.

4.4.3.4 UE search

Both timing and data assistance shall be applied in the UE search procedure.

"Modulation wipe-off" is defined here to mean a removal of the GPS spreading code modulation to GPS signals received at the UE, through the application of UTRAN timing and data assistance provided from the UTRAN to the UE.

Modulation wipe off may be applied at the UE to derive the despread GPS data signal.

~~Application of modulation 'wipe-off' enables the UE to carry out an efficient real-time derivation of the GPS signals needed for a GPS location fix.~~

4.4.3.5 Location determination

Computation of the location fix can either be performed in the network infrastructure (UE-assisted) or in the UE (UE-based).

There are two types of network assisted GPS method, namely UE-based and UE-assisted, which differ according to where the actual location calculation is carried out.

4.4.3.5.1 UE-based method

The UE-based ~~network assisted GPS~~ method maintains a full GPS receiver in the UE, and the location calculation is carried out by the UE.

If the location was requested by an application in the network, then the calculated location is signalled to the proper network element.

4.4.3.5.2 UE-assisted method

In the UE-assisted ~~network assisted GPS~~ method, the UE employs a reduced complexity GPS receiver. This carries out the pseudorange (code phase) measurements~~; (item 1 in the list above), and transmits~~ these are signalled, using higher layer signalling, to the specific network element that estimates the location of the UE and carries out the remaining GPS operations~~ (items 2 – 4 in the list)~~. In this method, accurately timed code phase signalling (as specified in TS 25.215) is required on the downlink. The signalling load in the uplink direction can be larger than in the UE-based method. If DGPS is performed in the UE, then differential corrections must be signalled to it. On the other hand, DGPS corrections can be applied to the final result in the network to improve the location accuracy without extra signalling to the UE.

6.2.4.1.2 Network Assisted GPS Methods~~GPS Assisted~~

~~These methods make use of UE which are equipped with radio receivers capable of receiving signals from the Global Positioning System (GPS).~~

~~The following definitions of "Network-Based", "Mobile-Based" and "Assisted" may be applied :~~

~~1. Mobile-Based~~

~~- The UE performs signal measurements and computes its own location estimate.~~

~~2. Mobile-Assisted (UE-Assisted Network-Based)~~

~~- The UE performs and reports signal measurements to the network and the network computes the UE's location estimate. In addition to those we can have following variant:~~

~~3. Network-Assisted UE-Based~~

~~- The network performs and reports signal measurements to the UE and the UE computes its own location estimate.~~

~~Thus, if GPS is utilised with this mechanism (Network-Assisted UE-Based GPS) it means that the location calculation is fulfilled in UE by using the additional measurements from the network to perform a better location estimate. One example of this kind is using of Differential GPS data.~~

~~UE-Based GPS can be either independent or dependent on network measurements. If it is dependent on the network measurements (then it can be Network-Assisted, UE-Based GPS). The main point is that where the location estimate is finally calculated and from where the assistance data is originated.~~

6.2.4.1.2.1 UE-based method~~Network Assisted, UE Based (GPS)~~

The UE-based method maintains a full GPS receiver in the UE, thus allowing stand-alone location fixes.

If the location was requested by an application in the network, then the calculated location is signalled to the proper network element.

~~In this method, the UE includes a GPS receiver which is capable of measuring and calculating the UE location based on the GPS signals. The operation of this receiver is assisted by information supplied by the UTRAN (LSIF).~~

The following information may be signalled from the UTRAN (LSIF) to the UE:

~~The GPS acquisition and location calculation is assisted by the following information that may be signalled from the UTRAN (LSIF) to the UE:~~

- Number of satellites for which assistance is provided
- Reference time for GPS ($T_{UTRAN\text{-}GPS}$) (specified in TS 25.215)
- Reference location
- Ionospheric corrections
- Satellite ID for identifying the satellites for which the assistance is provided
- IODE: sequence number for the ephemeris for the particular satellite
- Ephemeris to accurately model the orbit of the particular satellite and information when this becomes valid
- Clock corrections
- DGPS corrections
- Almanac data

The following information may be signalled from the UE to the UTRAN (LSIF):

~~The location information message from UE to the UTRAN (PSMF/PCF) contains the location calculated based on GPS measurements. The message may contain the following information:~~

- ~~Reference time for which the computed location is valid~~

- Reference time for GPS ~~($T_{UE\text{-}GPS}$) (specified in TS 25.215)~~
- Serving cell information
- Latitude/Longitude/Altitude/Error ellipse
- Velocity estimate of the UE
- Satellite ID for which the measurement data is valid
- Whole/Fractional chips for information about the code-phase measurements
- C/N_0 of the received signal from the particular satellite used in the measurements.
- Doppler frequency measured by the UE for the particular satellite signal
- Pseudorange RMS error
- Multipath indicator

~~6.2.4.1.2.2 Network Based, UE Assisted (GPS)~~

~~In this method, the UE includes a GPS receiver which is capable of measuring the GPS signals. The operation of this receiver is assisted by information supplied by the UTRAN (LSIF). The GPS measurements are signalled to the UTRAN (PSMF/PCF) where the Position Calculation Function determines the UE location. The GPS acquisition is assisted by the following information that may be signalled from the UTRAN (LSIF) to the UE :~~

- ~~Number of Satellites~~
- ~~Reference Time for GPS~~
- ~~SVID/PRNID~~
- ~~Doppler (0th order term)~~
- ~~Doppler (1st order term) (optional)~~
- ~~Doppler Uncertainty (optional)~~
- ~~Code Phase~~
- ~~Integer Code Phase~~
- ~~GPS Bit Number~~
- ~~Code Phase Search Window~~
- ~~Azimuth~~
- ~~Elevation~~

~~The GPS measurement message from UE to the UTRAN (PSMF/PCF) contains the following information measured from the GPS :~~

- ~~Number of Pseudoranges~~
- ~~Reference Time for GPS~~
- ~~SVID/PRNID~~
- ~~Satellite C/No~~
- ~~Doppler~~
- ~~Satellite Code Phase – Whole Chips~~
- ~~Satellite Code Phase – Fractional Chips~~
- ~~Multipath Indicator~~
- ~~Pseudorange RMS Error~~

6.2.4.1.2.3 UE-assisted method

The following information may be signalled from the UTRAN (LSIF) to the UE:

- Number of satellites for which assistance is provided
- Reference time for GPS ($T_{UTRAN-GPS}$) (specified in TS 25.215)
- Satellite ID for identifying the satellites for which the assistance is provided
- Doppler (0^{th} order term)
- Doppler (1^{st} order term) ~~(optional) ???~~
- Code Phase
- Code Phase center and Search Window width
- ~~Navigation Bits Predicted~~
- ~~Ephemeris (optional)~~
- Ephemeris
- Azimuth
- Elevation
- ~~Round Trip Time (RTT)~~
- ~~Navigation bits for sensitivity assistance~~
- ~~Round Trip Time (RTT)~~
- ~~Navigation bits for sensitivity assistance~~

The following information may be signalled from the UE to the UTRAN (LSIF):

- Reference time for GPS (T_{UE-GPS}) (specified in TS 25.215)
- Number of Pseudoranges
- SVID~~/PRNID~~
- Satellite C/No
- Doppler
- Satellite Code Phase
- ~~pilot PN number,~~
- Multipath Indicator
- Pseudorange RMS Error
- ~~UE RxTx Timing~~
- ~~Time Difference of Arrival of downlink signals from neighboring cells~~
- ~~SIR measured from the downlink signals~~

Additional parameters, such as round trip time (RTT), UE receiving transmitting time (UE RxTx), SFN-SFN observed time difference and CPICH Ec/No, may be used to improve the performance of UE-assisted GPS. All the additional parameters are defined in [2] and can be made available through RRC signalling. Furthermore, some navigation bits, in addition to ephemeris data, may be sent from UTRAN to UE for sensitivity assistance.

3GPP TSG-RAN Meeting #7
Madrid, Spain, 13 - 15 March 2000

Document ***R2-000175***
e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.305 **CR** **002r1** Current Version: 3.0.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to: TSG-RAN #7 — for approval [X] / for information [ ] — strategic [ ] / non-strategic [ ] *(for SMG use only)*
list expected approval meeting # here ↑

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

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

Source:	TSG-RAN WG2
Date:	2000-01-17
Subject:	Enhancements for cell coverage based positioning
Work item:	

Category: *(only one category shall be marked with an X)*

F	Correction	
A	Corresponds to a correction in an earlier release	
B	Addition of feature	
C	Functional modification of feature	X
D	Editorial modification	

Release:

Phase 2	
Release 96	
Release 97	
Release 98	
Release 99	X
Release 00	

Reason for change: This CR enhances the cell ID based location method by introducing a way to determine the cell ID in cases where it is not known by the SRNC.

Clauses affected: 4.4.1.1, 4.4.1.2

Other specs Affected:

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

Other comments:

help.doc

<--------- double-click here for help and instructions on how to create a CR.

4.4.1.1 Cell ID determination

In order for the SRNC to provide the cell-ID(s) and map it to the corresponding Service Area Identifier (SAI) when it is requested, for instance, by LCS, additional operation may be needed if UE is in a soft handover state, and there is no cell ID support in the RRC state.

In a soft state UE may have different signal branches connected to different cells, reporting different cell IDs. Therefore a cell ID selection decision should be made in SRNC to obtain more accurate LCS estimate when mapping the cell ID to the corresponding coverage area. The cell ID may be selected based on following principles:

- The cell ID is selected based on the parameters defining the quality of the received signal branches. That is, the cell ID with the best quality signal branch is selected as the cell ID reference to obtain the UE location estimates.
- The cell ID that was generated during connection set-up proceedings between the mobile station and the serving base station
- The oldest cell ID the mobile station associates with.
- The most recent cell ID the mobile station associates with
- The most recent cell ID of the cell to which the mobile station has been recently handed over from a previous cell.
- The identifier of the latest "new" cell that the mobile station has started to receive, but has not yet been handed over to.
- The cell ID to which UE has the shortest distance (to the site).
- The cell that provides an active connection for the mobile station at the time of receiving a new LCS request at the network controller.

Whenever the selection decision is based on measurement of one or several features of the signals between the mobile station and the respective base stations, it may happen that the measured feature, such as the signal strength or quality, changes rapidly. Therefore it may be advantageous to define a determination window or interval and to determine an average for the feature. The average will then be compared against the corresponding averages for the other signal branches, and the selection is made based on this comparison.

If the selection of the cell ID is based on the signal power or strength, the determination may be based on use of a reference signal. This specific embodiment may be based on one or several of the following principles:

- In a soft handover state or otherwise when there is an active set signal that includes several signal branches, a signal branch is selected and used as a reference branch as long as the selected branch belongs to the active set. If the reference branch is deleted or replaced, the cell identifier can be determined based on the second best reference signal (branch).
- The selected cell identifier can be changed (updated) as soon as a Primary Common Pilot Channel (CPICH, in WCDMA) that is not included in the active set becomes better than a Primary CPICH that belongs to the active set.
- The selected cell identifier may also be changed as soon as a Primary CPICH becomes better than the previously best primary CPICH.
- The selected cell identifier may also be changed as soon as a primary CPICH becomes better than an absolute threshold that may be based on the signal levels of the other active branches or be otherwise determined.
- The selected cell identifier may be changed as soon as a Primary CPICH becomes worse than an absolute threshold.
- The selected cell identifier may be changed as soon as a Primary Common Control Physical Channel (CCPCH) becomes better than the previous best primary CCPCH.
- The selected cell identifier may be changed as soon as a SIR (Signal to Interference) value of a timeslot becomes worse than an absolute threshold value.
- The selected cell identifier may be changed as soon as a Interference on Signal Code Power (ISCP) value of a timeslot becomes worse than an absolute threshold.
- The selected cell identifier may be changed as soon as an ISCP value of a timeslot becomes better than a certain predefined threshold.
- In general, a LCS_MARGIN may be utilized in a cell identifier determination process. The LCS_MARGIN can be based on Time-To-Trigger, pending time, power level of the signal (offset), or any similar approaches. The LCS_MARGIN may be used to prevent the unnecessary cell identifier updating to avoid the system performance to impair. The LCS_MARGIN may be applied either in forbidding or allowing the cell identifier update triggering.

In case of inter-mode environment applications such as Support of Localized Service Area (SoLSA), customized applications for mobile network enhanced logic (CAMEL), etc. the cell identifier based LCS or generally LCS may be implemented using existing toolkits such as a SIM Application Toolkit (SAT) or CAMEL. CAMEL may be used to provide cell based applications in a CAMEL Service Environment (CSE), which can be used with the SoLSA. CSE includes e.g. charging modifications and call barring based on cell information. However, since the network may be implemented by using several service platforms, CAMEL is described herein only as an example.

In these caeses other advanced positioning features of a cellular system should be taken into account. These include Localized Service Area (LSA) priority, LSA Only Access, Exclusive Access, Preferential Access, and so on. The inter-mode environment may include different cellular systems with multi layered cellular structures, including macro-cells, micro-cells, pico-cells, and home-cells. In the following some examples of such features are described in more detail.

In addition, the other relevant mechanisms like Idle Period Downlink, (IPDL), Site Selection Diversity Transmit power control (SSDT), etc. should be taken into account when applying the cell ID selection procedure, for instance, in a soft or softer handover state.

Cell ID based method should support the UE positioning regardless of the UTRAN /RRC states, including URA_PCH, Cell_PCH, Cell_DCH, cell FACH, cell reselection, inter-system modes, as well as an idle mode.

The cell ID may not be obtained if the mobile station is not in an active state, i.e. there is no connection between the mobile station and at least one of the cells. For example, in the UMTS the cell ID can be provided only when a radio resource control (RRC) connection exists between the mobile station and at least one base station. Therefore, if the mobile station is in a mode where the cell identifier (or coverage) can not be provided then mobile station may be forced to a state where the cell identifier may be provided. For example, in a URA_PCH state the Cell identifier may not be available. The MS can be forced to Cell_FACH to define the cell identifier so that the cell identifier may be obtained whenever the LCS node needs it. Moreover, the network can prevent the MS to enter a URA update state in order to receive cell updates when the MS selects a new cell.

If the MS is in an idle mode and there is a need to page for it, then the paging triggering for LCS purposes may be originated either by the core network or the UTRAN access network.

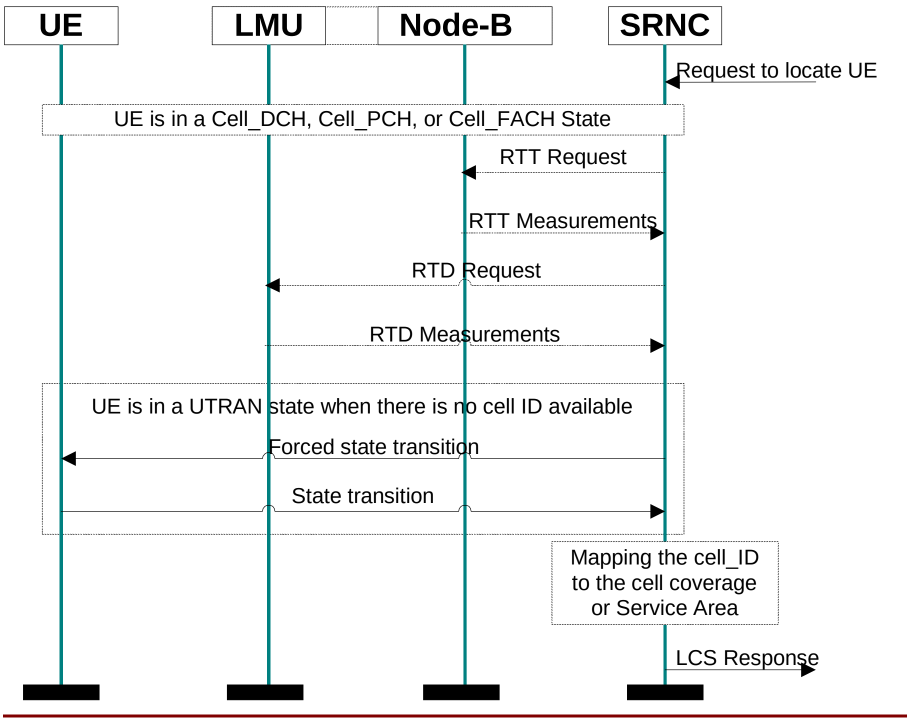


Figure 4.X: Cell Coverage Based Method

4.4.1.2 Mapping the Cell ID to the Cell or Service Area Coverage

In UMTS system, the UTRAN aspects are preferably hidden from the core network. For example, in a 3rd generation system a cell identifier should be mapped to a Service Area parameter to be transport over an Iu interface between a UTRAN network and the core network. The Service Area may include one or several cells. The mapping can be accomplished either in the RNC, in a Network Management System (NMS, including Network Management Unit, NEMU) or by co-operation of various access network elements. In order to determine a cell coverage estimate and to map it to the Service Area parameter, parameters such as the best reference signal, a Round Timing Trip (RTT), as well as antenna beam direction parameter may be utilised in association with the related cell identifier(s). In this case, the controller may use a reference signal RTT that is measured by the base station BS either periodically or on demand.

Alternatively, the range of a cell may be determined by using a reference signal power budget. Based on the reference signal power budget it is possible to obtain, e.g., the base station transmitted power, isotropic path loss, coverage threshold at coverage area border for a given location probability, and a cell range for an indoor and outdoor coverage.

The controller or the LCS node may use a reference signal link budget based cell range (radius) estimate in conjunction with the cell identifier to make a coverage estimation for a service area.

Additionally, the received power levels may be compared against the power budget, whereby more accurate information of the location of the UE may be provided. Computation made by two or more elements may also be combined.

In any above-mentioned cases, the interaction between neighbouring cell coverage areas, including the error margin, can be used to determine the more exact location of the mobile station.

3GPP TSG-RAN Meeting #7
Madrid, Spain, 13 - 15 March 2000

***Document* R2-000133**
e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.305	**CR**	**003**	Current Version:	3.0.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to:	TSG-RAN #7	for approval	X	strategic		*(for SMG use only)*
list expected approval meeting # here ↑		for information		non-strategic		

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

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

Source: TSG-RAN WG2 **Date:** 2000-01-17

Subject: Replacement for Figure 4.1

Work item:

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

Reason for change: The current figure 4.1 in TS 25.305 loads somewhat slowly. This CR contains a figure which contains the same information but is significantly smaller in size measured in bytes.

Clauses affected: 4.4.2

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

Other comments:

help.doc

<--------- double-click here for help and instructions on how to create a CR.

4.4.2 OTDOA-IPDL Method with network configurable idle periods

This method involves measurements made by the UE and LMU of the UTRA pilot signal (CPICH) radio transmissions. These measures are then sent to a Position Calculation Function (PCF) in the Serving RNC where the location of the UE is calculated.

Optionally, a PCF may be included in the UE, in which case the calculation of the location from the measurements may alternatively be performed in the UE.

The primary standard measurements are of the observed time difference of arrival (OTDOA) of downlink CPICH signals received at the UE. These measurements, together with other information concerning the surveyed geographic location of the transmitters and the relative time difference (RTD) of the actual transmissions of the downlink signals may be used to calculate an estimate of the location of the UE. Each OTDOA measurement for a pair of downlink transmissions describes a line of constant difference (a hyperbola (see NOTE 1)) along which the UE may be located. The UE's location is determined by the intersection of these lines for at least two pairs of base stations. The accuracy of the location estimates made with this technique depends on the precision of the timing measurements, the relative location of the base stations involved (see NOTE 2), and is also subject to the effects of multipath radio propagation. This is illustrated in the Figure 4.1.

NOTE 1: This is really a figure in three dimensions, a hyperboloid. For convenience here, this will be simplified to the hyperbola representing the intersection of this surface with the surface of the earth. For location service in three dimensions the hyperboloid must be considered.

NOTE 2: The geometry of the base station locations may affect the accuracy of the location estimate. The best results are when the base stations equally surround the UE. If they do not, there is a reduction in accuracy, which is sometimes termed the Geometric Dilution of Position (GDP).

The primary TDOA measurements (made by the UE) are sent to the Position Calculation Function (PCF) in the serving RNC. These measures are sent via signalling over the Uu, Iub (and Iur) interfaces between the UE and the SRNC (PCF). The calculation function makes use of the measurements, the known locations of the transmitter sites and the relative time difference of the transmissions to estimate the UE's location.

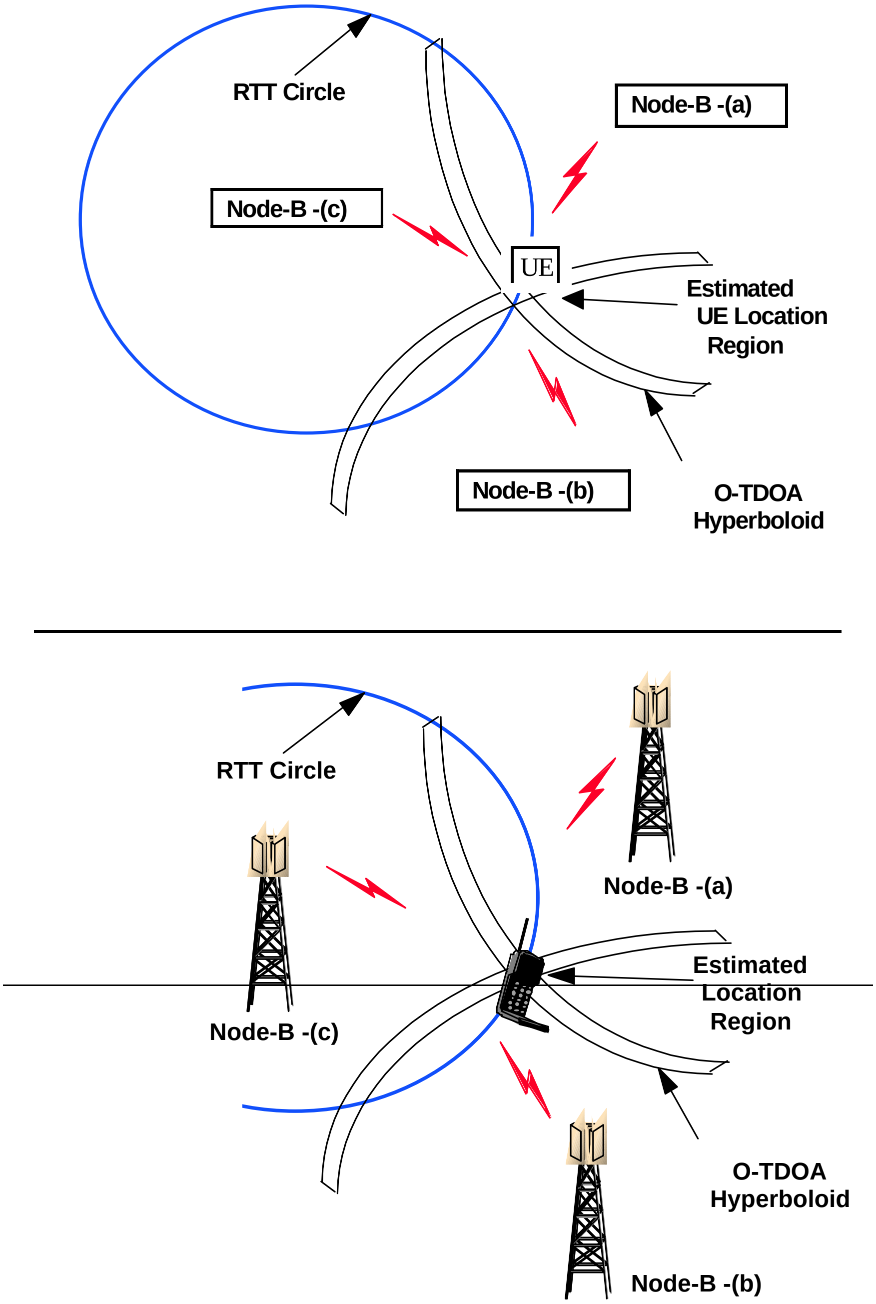


Figure 4.1: OTDOA Location Method

3GPP TSG RAN WG2 #11
Turin, Italy, 28 Feb – 3 Mar 2000

Document ***R2-000402***

e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.305 CR 004r1 Current Version: 3.0.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to: TSG-RAN #7	for approval	X	strategic		(for SMG use only)
list expected approval meeting # here ↑	for information		non-strategic		

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

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

Source: TSG-RAN WG2 **Date:** 23.02.2000

Subject: Restructuring

Work item:

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

Reason for change: In this CR the structure of TS 25.305 has been changed to be in line with GSM 03.71. Rows which begin with [NOTE] are meant to assist in the editing of the final version of this TS and should not be included there. New clause numbering has not been highlighted, but changed references to e.g. pictures and clauses have been highlighted in green.

Clauses affected: 4.4.1, 4.4.2, 4.4.3, 6, 7.4 – 7.11, 8 (new), 9 (new), 10 (new), 11 (new)

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

Other comments:

help.doc

<--------- double-click here for help and instructions on how to create a CR.

4.4.1 Cell ID Based Method

In the cell ID based (i.e. cell coverage) method the location of an UE is estimated with the knowledge of its serving node-B. The information about the serving node-B and cell may be obtained by paging, locating area update, cell update, URA update, or routing area update.

The cell coverage based location information can be indicated as the Cell Identity of the used cell, the Service area identity or as the geographical co-ordinates of a location related to the serving cell. The location information shall include a QoS estimate (e.g. regarding achieved accuracy).

When geographical co-ordinates are used as the location information, the estimated location of the UE can be a fixed geographical location within the serving cell (e.g. location of the serving node-B), the geographical centre of the serving cell coverage area, or some other fixed location within the cell coverage area. The geographical location can also be obtained by combining information on the cell specific fixed geographical location with some other available information, such as the signal Round Trip Time (RTT).

The operation of the cell ID based positioning method is described in clause 8.

4.4.2 OTDOA-IPDL Method with network configurable idle periods

~~This method involves measurements made by the UE and LMU of the UTRA pilot signal (CPICH) radio transmissions. These measures are then sent to a Position Calculation Function (PCF) in the Serving RNC where the location of the UE is calculated.~~

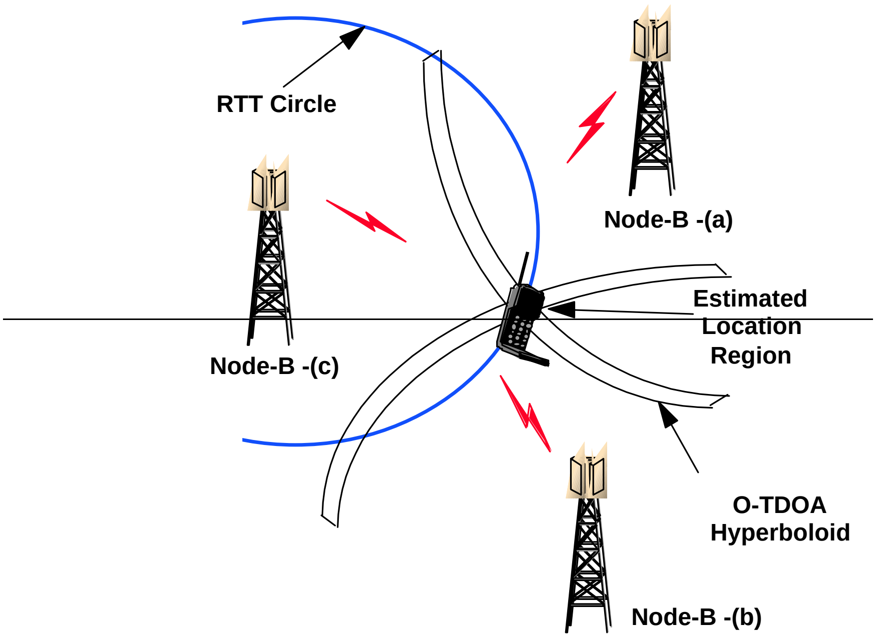
~~Optionally, a PCF may be included in the UE, in which case the calculation of the location from the measurements may alternatively be performed in the UE.~~

~~The primary standard measurements are of the observed time difference of arrival (OTDOA) of downlink CPICH signals received at the UE. These measurements, together with other information concerning the surveyed geographic location of the transmitters and the relative time difference (RTD) of the actual transmissions of the downlink signals may be used to calculate an estimate of the location of the UE. Each OTDOA measurement for a pair of downlink transmissions describes a line of constant difference (a hyperbola (see NOTE 1)) along which the UE may be located. The UE's location is determined by the intersection of these lines for at least two pairs of base stations. The accuracy of the location estimates made with this technique depends on the precision of the timing measurements, the relative location of the base stations involved (see NOTE 2), and is also subject to the effects of multipath radio propagation. This is illustrated in the Figure 4.1.~~

~~NOTE 1: This is really a figure in three dimensions, a hyperboloid. For convenience here, this will be simplified to the hyperbola representing the intersection of this surface with the surface of the earth. For location service in three dimensions the hyperboloid must be considered.~~

~~NOTE 2: The geometry of the base station locations may affect the accuracy of the location estimate. The best results are when the base stations equally surround the UE. If they do not, there is a reduction in accuracy, which is sometimes termed the Geometric Dilution of Position (GDP).~~

~~The primary TDOA measurements (made by the UE) are sent to the Position Calculation Function (PCF) in the serving RNC. These measures are sent via signalling over the Uu, Iub (and Iur) interfaces between the UE and the SRNC (PCF). The calculation function makes use of the measurements, the known locations of the transmitter sites and the relative time difference of the transmissions to estimate the UE's location.~~



~~**Figure 4.1: OTDOA Location Method**~~

~~The OTDOA method may be operated in two modes: UE assisted OTDOA and UE based OTDOA. The two modes differ in where the actual location calculation is carried out. In the *UE assisted* mode, the UE measures the difference in time of arrival of several cells and signals the measurement results to the network, where a network element (the Position Calculation Function (PCF)) carries out the location calculation. In the *UE based* mode, the UE makes the measurements and also carries out the location calculation, and thus requires additional information (such as the location of the measured base stations) that is required for the location calculation. The signalling requirements for the two OTDOA modes are described in a later sub-section. As the LCS involves measurements, there is always uncertainty in the results. Physical conditions, errors and resolution limits in the apparatus all contribute to uncertainty. To minimise the uncertainty in the LCS result, it is important that as many measurements of RTT and TDOA (and others) as are possible for a UE are provided to the PCF. Thus it is important that the standard method for LCS not be restricted to rely on a single measure. The UE thus provides OTDOA measures for as many pilot signals as it can receive. The pilot signals to be measured shall include those in the "cell reselection and monitoring set" and those in the "cell selection set".~~

~~In order to support the OTDOA method, the locations of the UTRAN transmitters needs to be accurately known by the calculation function (PCF). This information may be measured by appropriate conventional surveying techniques (see NOTE). The surveyed location should be the electrical centre of the transmitting antenna (and not the location of the radio equipment building). The use of antenna diversity, beamforming or beam steering techniques may cause the effective antenna location to change with time and this information will need to be communicated to the PCF to assist with its calculations. The methods of measuring the location of the UTRAN transmitters are outside the scope of this document.~~

~~NOTE: These surveying methods may, for example, make use of a GPS receiver.~~

~~In order to support the OTDOA method, the relative time difference (RTD) of the downlink transmissions must also be known by the calculation function (PCF). If the UTRAN transmitters are unsynchronised, the RTD will change over time as the individual clocks drift. Thus, measurements of RTD may need to be made regularly and the calculation function updated appropriately. The measurement of the RTD is outside the scope of this document (see NOTE).~~

~~NOTE: One convenient method is to make use of an LMU at a fixed location. This unit measures the observed time differences of all the local transmitters and reports these to the PCF. These measures may then be converted (translated) into the actual (absolute) relative time difference for each of the transmitters by making use of the known location of the LMU and the transmitters.~~

~~In some conditions a sufficient number of downlink pilot signals may not be available for measure at the UE. This may occur, for example, if the UE is located quite close to the UTRAN transmitter and its receiver is blocked by the strong local transmissions. This is referred to as the "hearability" problem.~~

~~4.4.2.1 Use of Idle Periods~~

~~For realising location based services the support of physical layer is a prerequisite, so that the measurements required for the terminal location calculation can be carried out. In UTRAN there are several factors that must be taken into account while considering the physical layer procedures related to location services:~~

- ~~hearability: a basic consequence of a CDMA radio system is that a terminal near its serving base station cannot hear other base stations on the same frequency. In order to calculate terminal location the terminal should be able to receive at least three base stations. To facilitate this some special means are required.~~
- ~~asynchronous network causes significant uncertainty to the time-difference-of-arrival (TDOA) measurements. To compensate for the effects of this, the relative time difference (the synchronicity) between base station transmissions must be measured, and used for correcting TDOA measurement.~~
- ~~capacity loss: signalling related to location calculation may take capacity from other services. This capacity loss should be minimised.~~

~~Based on the results of the work done in ARIB SWG2/ST9 (see reference [16]) a solution for the above mentioned hearability problem is the IPDL (Idle Period DownLink) method. In this method each base station ceases its transmission for short periods of time (idle periods). During an idle period of a base station, terminals within the cell can measure other base stations and the hearability problem is reduced. Also, during idle periods the real time difference measurements can be carried out. Because the IPDL method is based on forward link (downlink) the location service can be provided efficiently to a large number of terminals simultaneously.~~

~~The specification and operation of the IPDL technique are provided in the following sub-section.~~

~~4.4.2.1.1 Operation and specification of idle periods~~

~~There are several requirements on the provisioning of idle periods, listed in the following:~~

~~System requirements:~~

- ~~Many idle period pseudo random patterns~~
- ~~Co-located sectors shall have the same idle period timing~~

~~Operator flexibility:~~

- ~~Continuous operation or activated on demand~~
~~Variable average frequency of idle periods~~
- ~~Variable idle period length~~
~~Burst mode for regular updating of location~~

~~Implementation restrictions:~~

- ~~Minimum spacing between idle periods~~
- ~~Maximum spacing between idle periods~~

~~The following are the parameters for the idle periods (IP) :~~

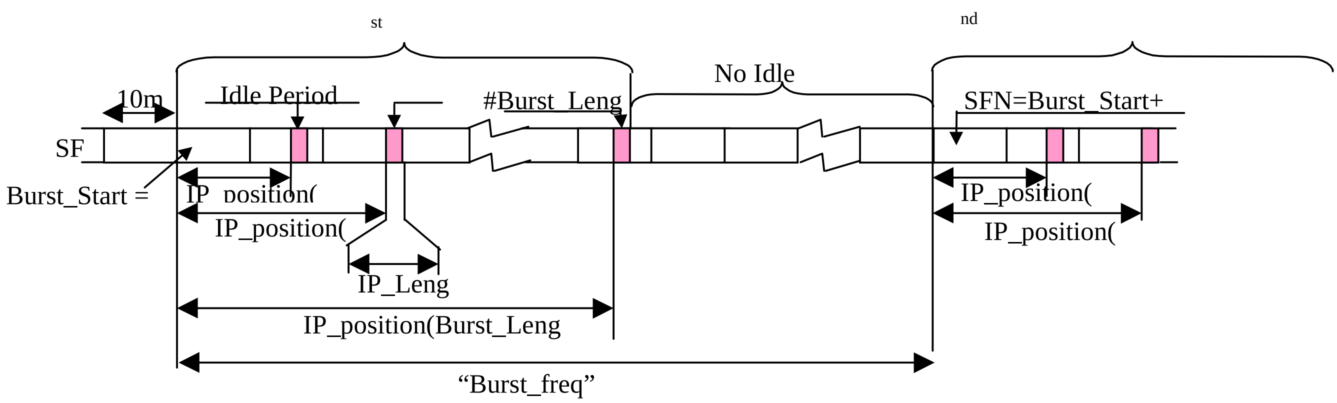
~~Parameter~~	~~Min value~~	~~Max value~~	~~Bits Required~~	~~Units (see note 1)~~	~~Description~~
~~IP_spacing~~	~~2^2+1~~	~~2^6~~	~~4~~	~~frames~~	~~Number of frames between Idle Periods.~~
~~IP_status~~	~~0~~	~~1~~	~~1~~	~~Logic Value~~	~~0 = Idle Periods active in continuous mode~~ ~~1 = Idle Periods active in burst mode~~
~~IP_length~~	~~5~~	~~10~~	~~1~~	~~symbols~~	~~Length of Idle Periods~~
~~Max_dev~~	~~140~~	~~145~~	~~0 (depends on IP length)~~	~~symbols~~	~~Maximum deviation in time from beginning of frame~~
~~Seed~~	~~0 - 63~~			~~(no units)~~	~~Seed for random function "rand(x)"~~
~~rand(x)~~	~~= (106.rand(x-1) + 1283)%6075,~~				~~Random function used in the calculation of the Idle Periods. Note: rand(0) = Seed.~~
~~IP_position(x)~~	~~= x.IP_spacing + rand(x)%Max_dev~~			~~symbols~~	~~Function for generating the exact positions of the x^{th} Idle Period. (see notes 2 & 4 below)~~
~~Extra parameters used in the case of burst mode operation (i.e. IP_status = 1)~~					
~~Burst_Start~~	~~[0]~~	~~[2^4-1]*256~~	~~[4]~~	~~SFN (in steps of 256 frames)~~	~~The frame number where the 1st Idle Period Burst occurs within an SFN cycle.~~
~~Burst_Length~~	~~[10]~~	~~[10+2^4]~~	~~[4]~~	~~IPs~~	~~Number of Idle Periods in a 'burst' of Idle Periods~~
~~Burst_freq~~	~~[2^8]~~	~~[2^{12}]~~	~~[4]~~	~~frames~~	~~Number of 10ms frames between consecutive Idle Period bursts.~~

~~NOTE 1: The unit 'symbol' refers to symbols on the CPiCH channel.~~

~~NOTE 2: The function IP_position(x) yields the position of the x^{th} Idle Period relative to a) the start of the SFN cycle when in continuous mode or b) the start of a burst when in burst mode.~~

~~NOTE 3: The operator "%" denotes the modulo operator~~

~~NOTE 4: Regardless of mode of operation, the Idle Period pattern is reset at the start of every SFN cycle.~~



~~Figure 4.2: IPDL Timing~~

~~4.4.2.1.2 Time Aligned IPDL~~

~~Use of the Time Aligned method is dependent upon there being a demonstrated benefit at layer 1 and limited signalling overhead at layer 3.~~

~~In areas where traffic is high or pilot visibility is low (due for example to irregular site topology or low pilot levels), it is possible to configure IPDL in order to further increase the probability of accurate TDOA measurements. This can be achieved by approximately time aligning the occurrences of idle periods, and enabling CPICH transmission during some of these periods. The alignment can typically be to within half a CPICH symbol.~~

~~During the 'common' idle period, the node B transmits the CPICH randomly, pseudo-randomly or periodically. Thus in each idle period, the only radio activity will be due to the CPICH and in addition, only a fraction of node B's are active (and this set will change for different idle periods). Finally, it is also possible to increase the CPICH power during the idle period in order to increase range for location purposes.~~

~~In this configuration, location performance is not dependent on the traffic load. Additionally, it is possible to increase the range of pilots in rural areas or for indoor coverage purposes .~~

~~Idle period alignment requires that the offsets between the transmission times of each node B be known, ideally to a resolution better than half a symbol period i.e. 33.33 µs or less. Due to drift between different node Bs the idle period timing will need to be updated at regular intervals. The update rate is a function of network clock stability.~~

~~Measurement of time offsets can be achieved in a number of ways. A possible option is for these to be estimated by the LMUs (Location Measurement Units) which may be employed to measure the node B transmission time offsets so as to enable TOA based location as discussed in section 4.4.2.~~

~~In comparison with standard IPDL, the UE requires similar information regarding the occurrences of idle periods. Since each node B is active during a fraction of the idle periods only, complexity reduction at the UE can be obtained if knowledge of the actual activity of node Bs in the idle periods is provided, via additional signalling. In the RAN, the additional requirements to standard IPDL are:~~

~~(a) the node B should be able to leave the CPICH on in some of the periods, possibly ramping up the power if requested to do so~~

~~(b) signalling from the UTRAN Position Radio Resource Management (U-PRRM) to the node B is required to maintain partial synchronisation.~~

~~The following table provides a set of parameters which may be used to configure idle periods for both time aligned and non-time aligned operation.~~

~~Parameter~~	~~Min value~~	~~Max value~~	~~Bits Required~~	~~Units (see note 1)~~	~~Description~~
~~IP_spacing~~	~~2~~	~~72~~	~~4~~	~~frames~~	~~Number of frames between Idle Periods (4 bit represent exponents in 2^i x2^j x3^k x3^l)~~
~~IP_status~~	~~0~~	~~1~~	~~1~~	~~Logic Value~~	~~0 = Idle Periods active in continuous mode~~ ~~1 = Idle Periods active in burst mode)~~
~~TA_status~~	~~0~~	~~1~~	~~1~~	~~Logic value~~	~~0 = Time Alignment not enabled~~ ~~1 = Time Alignment enabled~~
~~IP_length~~	~~3~~	~~10~~	~~2~~	~~symbols~~	~~Length of Idle Periods~~
~~Max_dev (S)~~	~~140~~	~~145~~	~~0 (depends on IP length)~~	~~symbols~~	~~Maximum deviation in time from beginning of frame~~
~~Seed (S)~~	~~0-63~~			~~no units~~	~~Seed for random function "rand(x)"~~
~~rand(x) (S)~~	~~= (106.rand(x-1) + 1283)%6075~~				~~Random function used in the calculation of the Idle Periods. Note: rand(0) = Seed.~~
~~IP_position(x)~~	~~= x.IP_spacing *10 + rand(x)%Max_dev +(IP_offset/2)~~			~~symbols~~	~~Function for generating the exact positions of the x^{th} Idle Period. (see notes 2 & 4 below)~~ ~~For standard IPDL, IP_offset=0~~ ~~For TA IPDL, Max_dev=0~~
~~**Extra parameters used in the case of the time aligned configuration**~~					
~~IP_offset (T)~~	~~0~~	~~2^{15}-1~~	~~15~~	~~Half symbol~~	~~Offset giving start of idle period with respect to reference point~~
~~IP-CPICH_up (T)~~	~~0~~	~~15~~	~~4~~	~~dB~~	~~CPICH power step up relative to current level~~
~~IP_TA_prob (T)~~	~~0.2~~	~~0.5~~	~~4~~	~~-~~	~~Probability of CPICH being on during idle period~~
~~IP_TA_seed (T)~~	~~0~~	~~63~~	~~6~~	~~-~~	~~Number used to point to CPICH power on pattern in TA mode, actual pattern is for FFS (same pattern must be provided to co-located cells)~~
~~**Extra parameters used in the case of burst mode operation (i.e. IP_status = 1)**~~					
~~Burst_Start~~	~~[0]~~	~~[2^4-1]*256~~	~~[4]~~	~~SFN (in steps of 256 frames)~~	~~The frame number where the 1st Idle Period Burst occurs within an SFN cycle.~~
~~Burst_Length~~	~~[10]~~	~~[10+2^4]~~	~~[4]~~	~~IPs~~	~~Number of Idle Periods in a ‘burst’ of Idle Periods~~
~~Burst_freq~~	~~[2^8]~~	~~[2^{12}]~~	~~[4]~~	~~frames~~	~~Number of 10ms frames between consecutive Idle Period bursts.~~

~~NOTE 1: The unit ‘symbol’ refers to symbols on the CPiCH channel.~~

~~NOTE 2: For standard IPDL, the function IP_position(x) yields the position if the x^{th} Idle Period relative to a) the start of the SFN cycle when in continuous mode or b) the start of a burst when in burst mode. For the TA configuration the function IP_position(x) always yields the position of the x^{th} Idle Period relative to the start of the SFN cycle (in this case, the burst parameters in burst mode define the frames when IPs are enabled).~~

~~NOTE 3: The operator "%" denotes the modulo operator~~

~~NOTE 4: Regardless of mode of operation (except TA), the Idle Periods pattern is reset at the start of every SFN cycle. For TA, the IP spacing must be kept across SFN boundaries, hence the first IP_position after a new SFN cycle should be calculated modulo (no of symbols in SFN cycle).~~

~~NOTE 5: (S) refers to parameter required only in standard IPDL, (T) refers to parameter required only in time aligned configuration~~

~~4.4.2.2 Accuracy~~

~~In the OTDOA technique, generally, the location is being determined by means of an estimate of the transit time (time-of-flight) of the radio signals. The radio path and the geographical path are assumed to be the same with unobstructed line-of-sight. The radio signals travel about 0,3 metres per nanosecond. To achieve an uncertainty of less than 50 metres in the location estimate requires an uncertainty in timing of less than 166 nanoseconds. With a 4 Mchip/s rate, the chip duration is 250 nanoseconds and ultimately, LCS requires timing measurements of the radio signals to the sub-chip level. Many current receivers are capable of combining multipath signal components to the sub-chip level of timing (often to better than 1/4 chip), and so such timing accuracy is already available, although in a different form.~~

~~The radio signal path is, unfortunately, not always equal to the geographic separation. The effects of multipath and obstructions combine to make the radio path typically longer (but never shorter) than the geographic path. A distance estimate derived from radio signal timing will generally be longer than the true distance. The techniques to mitigate the effects of multipath in the LCS are beyond the scope of this specification and are, in any case, subjects of current active technology research. These can be expected to improve with experience in system operation and the measurement function and calculation function designs can be expected to evolve to give better performance over the lifetime of deployed UTRAN LCS.~~

~~The accuracy of the location estimate may thus vary from area to area within an operator's territory due to the effects of multipath propagation. Some operators may choose to add extra base stations or extra transmissions to provide better location service accuracy in areas they deem critical for their service. Other operators may choose to have fewer base stations and consequently a lower accuracy service in some areas.~~

~~The objective is to provide the best estimate available with the equipment, measurements and propagation conditions prevailing at the time and place of the UE. Not all results will be of the same precision and there is a cost associated with increased precision. Making use of a downlink based measurement technique minimises the network traffic and provides a system that scales with increased usage by UE. In some jurisdictions, the equipment must meet some minimum requirements to satisfy regulatory requirements for accuracy of the location service (e.g. the FCC in the United States) and this must be taken into consideration in the design of equipment for operation in these areas.~~

~~Generally the measurement of location is a statistical process and not all measurements of the same location will yield the same result. The overall system accuracy of its reports (e.g. less than 50 metres error in 80% of measurements) will involve a statistical measure of many operations at may times and at many locations through the UTRAN coverage area. The accuracy reported together with an individual report must take into account the individual measurements, environmental conditions and the time of the measurement. The accuracy reported for an individual measurement may vary considerably from the overall system performance statistic.~~

~~4.4.2.3 Relative Time Difference (RTD)~~

~~In order to calculate the estimate of the location of the UE, the calculation function needs to know~~

- ~~the OTDOA measurements,~~
- ~~the surveyed geographic locations of the base stations that have had their signals measured, and~~
- ~~the actual relative time difference between the transmissions of the base stations at the time the OTDOA measurements were made.~~

~~The accuracy of each of these measurements contributes to the overall accuracy of the location estimate. The measurement of the RTD is described in the following.~~

~~There are several approaches to determining the RTD. One is to synchronise the transmissions of the base stations. In this technique the RTD are known constant values (see NOTE) that may be entered in the database and used by the calculation function when making a location estimate. The synchronisation must be done to a level of accuracy of the order of tens of nanoseconds (as 10 nanoseconds uncertainty contributes 3 metres error in the location estimate). Drift and jitter in the synchronisation timing must also be well controlled as these also contribute uncertainty in the location estimate. Synchronisation to this level of accuracy is currently only readily available through satellite based time-transfer techniques. Generally in the TDD operating mode, the base stations are synchronised.~~

~~NOTE: The transmission times may all be aligned to a common reference (such as UTC) in which case all RTD have a common value. However, in a more general case the transmissions may have a fixed offset with reference to UTC, and thus the RTD values are non-zero and may be stored in the database for use by the calculation function.~~

~~Alternatively (typically in FDD mode), the base stations may be left to free run within some constraint of maximum frequency error. In this scenario, the RTD will change (slowly) with time. The rate of change will depend on the frequency difference and jitter between base stations. If, for example, the maximum frequency difference between two base stations is $\pm 10^{-9}$, then the start of transmission of a 10 millisecond code sequence will drift through a cycle in about 1390 hours (or 57 days). With this relatively slow rate of drift the RTD can be measured by fixed units at known locations (these are LMUs, Location Measurement Units) and stored in the database for use by the calculation function. The jitter and drift of the individual oscillators in each base station may cause the change of timing to slow, remain constant or reverse direction over time. Ongoing measurements of the RTD may be made to assure the most current values are available for the calculation function. The RTD measurement units may be co-located with the base stations or installed at other convenient locations in the UTRAN coverage area, and report their results through the UTRAN signalling channels.~~

~~4.4.2.4 Time of Day (ToD)~~

~~If there are frequency differences between the (unsynchronised) base stations, as noted in the previous sub-section, the OTDOA measurements must be reported together with the time-of-day they were made (timestamp). This is necessary so that the appropriate value of the RTD may be used by the calculation function.~~

~~In order to assure less than a 20 nanosecond uncertainty in the RTD value, the time of day must be known to better than 10 seconds (if the maximum frequency difference between the base stations is $\pm 10^{-9}$). The method by which the ToD is measured is FFS [, but the frame number (which provides a 10 millisecond resolution) or encryption counter used in the downlink transmissions may provide a convenient measure].~~

~~4.4.2.5 Base Station Synchronisation~~

~~It is preferable that the location methods do not require the base station network to be synchronised. The needed level of synchronisation accuracy for LCS is not by any means straightforward to achieve. The necessary information of Relative Time Differences (RTD) between base stations can be measured by dedicated units (LMU, Location Measurement Unit) and distributed in the network (e.g. as broadcast information). Also, the measurements of RTD may benefit from the Idle Period DownLink (IPDL) option.~~

~~In the TDD operating mode the base stations will typically be synchronised and this may be of assistance to the LCS technique.~~

4.4.3 Network Assisted GPS Methods

~~The operation of the network assisted GPS methods is described in this section.~~

NOTE: the intention is that this description be synergistic with GSM 03.71.

Methods making use of GPS are being standardised for GSM. In order to facilitate efficient implementation, and seamless location service operation between GSM and UTRAN, the support for GPS based methods must be compatible between these systems.

There are four main functions for a stand-alone GPS receiver:

1 Measuring distance from the satellites to the GPS receiver by determining the pseudoranges (code phases);

2 Extracting the TOA of the signal from the contents of the satellite transmitted message;

3 Computing the location of the satellites by evaluating the ephemeris data at the indicated TOA.;

4 Determining the location of the receiving antenna and the clock bias of the receiver by using the above data items.

To reduce the errors contributed from satellite clock and location modelling, ionospheric delay, tropospheric delay, and selective availability (SA), corrections can be done before the fourth step above. The most important technique for error compensation is DGPS.

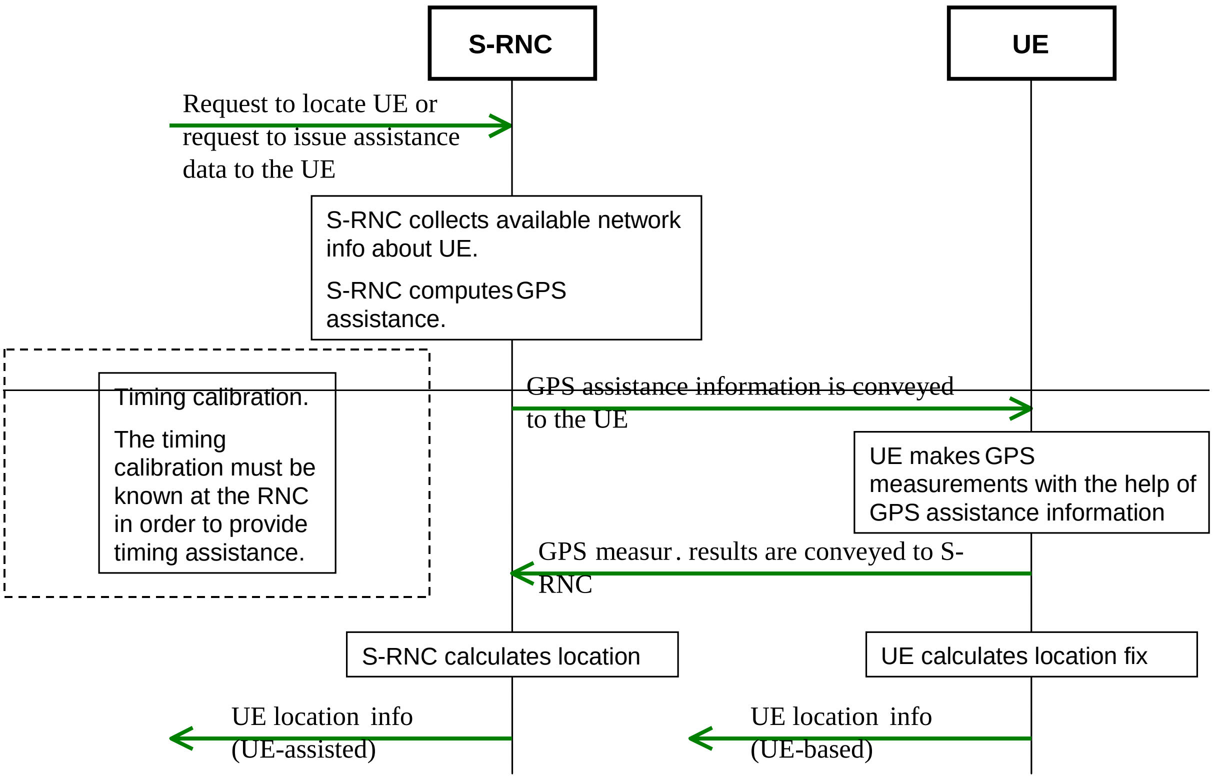
When GPS is designed to inter-work with the UTRAN, the network assists the UE GPS receiver to improve the performance in several respects. These performance improvements will:

- Reduce the UE GPS start-up and acquisition times; the search window can be limited and the measurements sped up significantly.
- Increase the UE GPS sensitivity; location assistance messages are obtained via UTRAN so the UE GPS can operate also in low SNR situations when it is unable to demodulate UE GPS signals.
- Allow the UE to consume less handset power than with stand-alone GPS ; this is due to rapid start-up times as the GPS can be in idle mode when it is not needed.

The Network assisted GPS methods rely on signalling between reduced complexity UE GPS receivers and a continuously operating GPS reference receiver network which has clear sky visibility of the same GPS constellation as the assisted UEs. Reference GPS receivers may be connected to the UTRAN to enable derivation of UE assistance signals. The operation of the assisted GPS methods is described in clause 10.

~~NOTE: labels in Figure 4.3 below may need to be aligned with GSM 03.71.~~

~~NOTE: charging and billing operations are not illustrated in Figure 4.3 below.~~



~~**Figure 4.3: Network assisted GPS methods**~~
~~**NOTE: see reference [1] (23.171, section 8.7**~~

~~4.4.3.1 Timing calibration~~

~~Where timing assistance is needed, the relationship between GPS Time Of Week (see reference: GSM 04.31) and cell-specific UTRAN system timing must be derived.~~

~~In the network assisted GPS methods the inter-system measurement may be used to reduce the signal search space and hence reduce the user delay in obtaining a location fix. Typically, a timing assistance accuracy of several microseconds is required for an acceptable location fix user delay. The relationship between GPS time and UTRAN timing is to be defined as GPS-UTRAN-Reference-Time in a similar way as in GSM 04.31 Annex A Section 4.2.4.~~

~~The UE or LMU optionally derives the cell specific GPS-UTRAN-Reference-Time through measurement at Layer 1.~~

~~4.4.3.2 Timing assistance~~

~~The UTRAN combines the coarse UE location determinations from UTRAN cell-specific information with the GPS-UTRAN-Reference-Time. These coarse determinations can be enhanced through other location methods (e.g. IPDL). Using this information, the UTRAN computes the estimated timing of GPS signals received by the UE and conveys this information to the UE using higher layer signalling. The GPS-UTRAN-Reference-Time is uncertain to a degree depending on the accuracy of the coarse location estimate used. Typically, a window of several microseconds can be attained.~~

~~In addition, other GPS parameters, as described in section 4.4.3.3, are conveyed to the UE to further reduce the signal search space.~~

~~4.4.3.3 Data assistance~~

~~GPS signals are modulated with low-rate digital information at a rate of 50 bits/sec. This information is necessary for stand-alone GPS receivers to determine their own location (the low rate digital information conveys satellite ephemeris and other GPS data).~~

~~The UE receives GPS information (e.g. Doppler shifts) through UTRAN air interface, using higher layer signalling, and modulation 'wipe-off' is applied. Therefore, the space that must be searched by the UE, to derive the GPS signals needed, can be reduced beyond that needed by a stand-alone GPS receiver. Thus, a location fix can be derived with an acceptable sensitivity and delay to the user.~~

> ~~NOTE: "modulation wipe-off" is intended here to mean a removal of the GPS modulation in the UE through the use of the UTRAN assistance information.~~

~~The assistance data signalled to the UE may include all information listed below or a selected subset:~~

~~Data assisting the measurements; e.g. reference time, visible satellite list, satellite signal Doppler, code phase search window. This data is valid for few hours (2-4 hrs).~~

~~Data providing means for location calculation; e.g. reference time, reference location, satellite ephemeris, clock corrections. This data is valid for four hours.~~

~~If DGPS is utilised, then differential corrections may also be transmitted. They are valid for about 30 seconds. The DGPS data is valid for a large geographical area, so one centrally located reference receiver can be used to service this large region.~~

~~4.4.3.4 UE search~~

~~Application of modulation 'wipe-off' enables the UE to carry out an efficient real-time derivation of the GPS signals needed for a GPS location fix.~~

~~4.4.3.5 Location determination~~

~~Computation of the location fix can either be performed in the network infrastructure (UE-assisted) or in the UE (UE-based).~~

~~There are two types of network assisted GPS method, namely UE-based and UE-assisted, which differ according to where the actual location calculation is carried out.~~

~~4.4.3.5.1 UE-based method~~

~~The UE-based network assisted GPS method maintains a full GPS receiver in the UE, and the location calculation is carried out by the UE.~~

~~If the location was requested by an application in the network, then the calculated location is signalled to the proper network element.~~

~~4.4.3.5.2 UE-assisted method~~

~~In the UE-assisted network assisted GPS method, the UE employs a reduced complexity GPS receiver.~~

~~This carries out the pseudorange (code phase) measurements (item 1 in the list above), and transmits these to the specific network element that estimates the location of the UE and carries out the remaining GPS operations (items 2 – 4 in the list). In this method, accurately timed code phase signalling is required on the downlink. The signalling load in the uplink direction can be larger than in the UE-based method. If DGPS is performed in the UE, then differential corrections must be signalled to it. On the other hand, DGPS corrections can be applied to the final result in the network to improve the location accuracy without extra signalling to the UE.~~

6 ~~Interfaces and Information Flow~~Signaling protocols and interfaces

NOTE: This chapter describes the information flows, the detailed messages and protocols is described in other chapters.

6.1 Generic signaling model for LCS

6.1.1 Protocol layering

6.1.2 Message segmentation

6.2 LCS signaling between SRNC and MSC/SGSN

6.3 SRNC signaling to a target UE

6.4 Associated RNC signaling to a standalone LMU

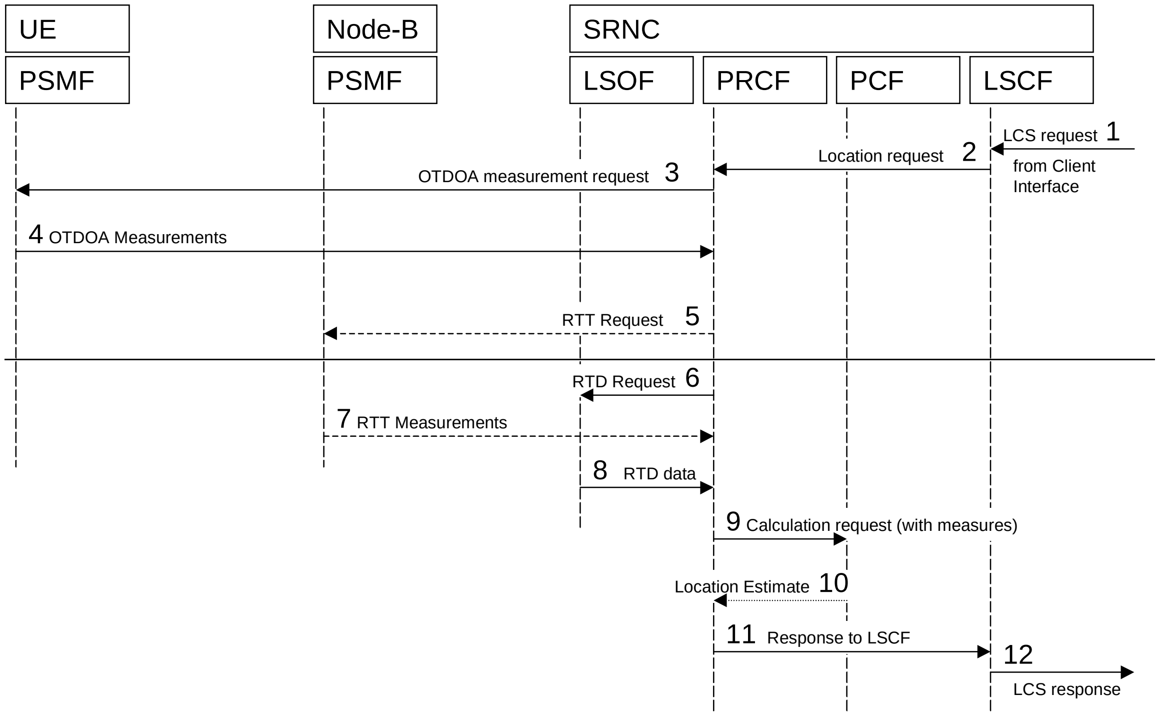
6.5 Associated RNC signaling to a LMU in Node B

6.6 RNC-to-RNC signalling for LCS support

~~6.1 Generic information flow for LCS in UMTS~~

~~The following diagram illustrates the operations for the OTDOA-LCS when the request for location information is initiated by an LCS application signalled from the Core Network. As these operations are internal to the RNC, this diagram is to illustrate information flow and implementations may use alternate arrangements.~~

~~This illustration only includes the information flow related to LCS operations and does not indicate other operations that may be required, for example, to establish a signalling connection between the UE and the SRNC. Also not illustrated is the signalling used to initiate the location service request (from the Location Client Function) from the Core Network or a UE based application.~~



~~Figure 6.1: OTDOA Signalling Operations~~

1. ~~The OTDOA operation begins with an authenticated request for location information about a UE from an application in the core network being received at the LSCF. The LSCF acts as interface between the Core Network and the LCS entities in the UTRAN.~~

2. ~~The LSCF considers the request and the capabilities of the UE and the network and forwards the request to the appropriate PRCF in the Serving RNC.~~

3. ~~The PRCF requests from the UE the measurement of the OTDOA for the signals in the active and neighbourhood sets. These measurements may be made while the UE is in the idle state or while it is connected.~~

4. ~~The UE returns the OTDOA measures to the PRCF. The PRCF receives the OTDOA information and co-ordinates obtaining other information to support the calculation request (not illustrated).~~

5. ~~If there are insufficient OTDOA measures, or it is otherwise considered advantageous to do so, the PRCF requests the RTT measure for the UE from the PSMF in the serving Node-B.~~

6. ~~The PRCF requests the RTD measures for the associated transmitters from the LSOF (database). These may be stored locally if they are constant over time, otherwise they must be updated to represent the RTD timing at the time-of-day the OTDOA measurements were made.~~

7. ~~The PSMF in the Node-B returns the RTT measures to the PRCF if they were requested.~~

8. ~~The LSOF returns the RTD information to the PRCF.~~

9. ~~The PRCF passes the OTDOA, RTD and, if necessary, RTT information to the PCF and requests a location calculation. The calculation may include a co-ordinate transformation to the geographic system requested by the application.~~

10. ~~The PCF returns the location estimate to the PRCF. This estimate includes the location, the estimated accuracy of the results and the time of day of the estimate.~~

11. ~~The PRCF passes the location estimate to the LSCF.~~

12. ~~The LSCF passes the location estimate to the Core Network.~~

6.7~~2~~ Interfaces

There are four interfaces through which the LCS entities communicate. These are the Iu, the Iur, Iub and the Uu.

NOTE: the interfaces between the Internal or External LCS applications and the 3G-MSC or 3G-SGSN are outside the scope of this document.

6.7~~2~~.1 Iu Interface

The Iu interface is used to communicate between the LCS functional entities in the Core Network and the LCS entities in the UTRAN. Further specification of the messages and operations for LCS across the Iu interface may be found in reference [1].

6.7~~2~~.2 Iur Interface

LCS operations at the Iur interface are defined in [14].

The Iur interface is used to communicate between the LCS functional entities associated with the serving RNC and other RNC in the UTRAN. The Iur interface is also used to communicate between the serving RNC and the Internal LCS Applications in the UTRAN. The LCS entities associated with the serving RNC are responsible for co-ordinating and responding to location requests received from the LCS entities in the core network or Internal Clients

When communicating between the serving RNC and the UTRAN Internal LCS Applications (ILA), the messages and protocols are the same as those used over the Iur interface.

The Iur interface is also used to communicate between the LCS Entities in the serving RNC and those in other RNC. The location method, for example, may require measurements by several LMU or Node-B, some of which may be associated with other RNC. Commands and responses from these LCS Entities are communicated over the Iur interface. In some cases, the LCS Entities in the serving RNC may make use of entities associated with other RNC. For example, a calculating function (PCF) may be used in another RNC if the serving RNC is too busy or does not contain the function or database information required by the chosen location method.

The Iur interface may also pass messages relating to changes or reporting of the data associated with the Location System Operations Function (LSOF) in the RNC.

Iur shall be used for LCS signalling whenever it is available, even in the case when the RNCs connected to different 3G-MSCs or 3G-SGSN.

Within UTRAN, Iur supports inter-RNC soft handover. Inter-RNC handover should also include LCS, meaning that whenever an inter-RNC soft handover occurs, Iur should be able to support the functionality of the LCS entities in RNCs, including PCF, PRRM, PSMF, and LSOF.

In addition, in case of SRNC relocation Iur should support the relocation mechanism in order for DRNC to be able to handle the responsibility of SRNC in LCS process. That is, to transfer the PCF, PRRM, PSMF, and LSOF functionality from SRNC to DRNC. Iur shall be used also to collect RTD and other LCS information from base stations under different RNCs that are not involved in handover.

~~6.2.2.1 Signalling between RNCs~~

6.7~~2~~.3 Iub Interface

LCS operations at the Iub interface are defined in [15].

The Iub interface is used to communicate among the LCS entities associated with the serving RNC, the Node-B and the associated Location Measurement Units (LMU).

This interface passes the request for measurements, the measurement results and requests for LCS related transmissions or other radio operations needed by the location method (e.g. broadcast of parameters needed for a UE based location method).

The Iub interface may also pass messages relating to changes or reporting of the data associated with the Location System Operations Function (LSOF) in the Node-B or the LMU.

~~6.2.3.1 Signalling between RNC and Node B (LMU)~~

6.~~2~~7.4 Uu Interface

LCS operations at the Uu interface are generally defined in [1]. This specification defines in more detail the procedures needed for messaging for each individual location method.

The Uu interface is used to communicate among the LCS entities associated with the RNC, the UEs and the stand-alone Location Measurement Units (LMU). (The Uu interface is also used to communicate between the LCS entities in the core network and the UE. Those communications are beyond the scope of this specification.)

This interface may pass measurement requests and results to and from the UE or the stand-alone LMU.

The Uu interface may also pass location requests from internal or external LCS Applications at the UE.

NOTE: These requests may require the services of the LCS entities associated with the core network to authenticate clients and subscriber subscriptions to aspects of the LCS.

The Uu interface may also be used for broadcast of information that may be used by the UE or stand-alone LMU for their LCS operations. This may, for example, include timing and code information about nearby Node-B transmissions that may assist the UE or LMU in making their measurements.

The Uu interface may also pass messages relating to changes or reporting of the data associated with the Location System Operations Function (LSOF) in the UE or the remote LMU.

~~6.2.4.1 Signalling between RNC and Target UE~~

~~6.2.4.1.1 OTDOA-IPDL~~

~~There are two modes of operation for the OTDOA method. In the *UE assisted* mode, the UE measures the difference in time of arrival of several cells and signals the measurement results to the network, where a network element (the Position Calculation Function (PCF)) carries out the location calculation. In the *UE based* mode, the UE makes the measurements and also carries out the location calculation, and thus requires additional information (such as the location of the measured base stations) that is required for the location calculation. This information is provided by the Location System Information Function (LSIF).~~

~~Table 6.1 lists the required information for both OTDOA modes. The range of values for the listed parameters are FFS. The required information can be signalled to the UE either in a broadcast channel or partly also as dedicated signalling.~~

~~Table 6.1: Information required for UE assisted and UE based OTDOA in the UTRAN (LSIF) to UE direction~~
~~('Yes' = information required, 'No' = Information not required)~~

~~Information~~	~~UE assisted OTDOA~~	~~UE based OTDOA~~
~~Intra frequency Cell Info (neighbour list).~~	~~Yes~~	~~Yes~~
~~Ciphering information for LCS~~ ~~NOTE: The idea behind LCS specific ciphering information is e.g. that the operator can sell information that the UE needs for calculating its location. For reference in the GSM world see [3].~~	~~No~~	~~Yes~~
~~Measurement control information (idle period locations)~~	~~Yes~~	~~Yes~~
~~Sectorisation of the neighbouring cells~~	~~No~~	~~Yes~~
~~Measured RTD values for Cells mentioned at Intra frequency Cell Info~~	~~No~~	~~Yes~~
~~RTD accuracy~~	~~No~~	~~Yes~~
~~Measured roundtrip delay for primary serving cell~~	~~No~~	~~Yes~~
~~Geographical location of the primary serving cell.~~	~~No~~	~~Yes~~
~~Relative neighbour cell geographical location~~	~~No~~	~~Yes~~
~~Accuracy range of the geographic location values~~	~~No~~	~~Yes~~

~~The information required from UE to UTRAN (PSMF/PCF) is listed in Table 6.2.~~

~~Table 6.2: Information required for UE assisted and UE based OTDOA in the UE to UTRAN (PSMF/PCF) direction~~

~~Information~~	~~UE assisted OTDOA~~	~~UE based OTDOA~~
~~OTDOA measurement results~~	~~Yes~~	~~No~~
~~OTDOA measurement accuracy~~	~~Yes~~	~~No~~
~~UE geographical location~~	~~No~~	~~Yes~~
~~Location accuracy indicator (based on the signalled and measurement accuracies)~~	~~No~~	~~Yes~~

~~6.2.4.1.2 GPS Assisted~~

~~These methods make use of UE which are equipped with radio receivers capable of receiving signals from the Global Positioning System (GPS).~~

~~The following definitions of "Network-Based", "Mobile-Based" and "Assisted" may be applied :~~

1. ~~Mobile-Based~~

- ~~The UE performs signal measurements and computes its own location estimate.~~

2. ~~Mobile-Assisted (UE-Assisted Network-Based)~~

- ~~The UE performs and reports signal measurements to the network and the network computes the UE's location estimate. In addition to those we can have following variant:~~

3. ~~Network-Assisted UE-Based~~

- ~~The network performs and reports signal measurements to the UE and the UE computes its own location estimate.~~

~~Thus, if GPS is utilised with this mechanism (Network-Assisted UE-Based GPS) it means that the location calculation is fulfilled in UE by using the additional measurements from the network to perform a better location estimate. One example of this kind is using of Differential GPS data.~~

~~UE-Based GPS can be either independent or dependent on network measurements. If it is dependent on the network measurements (then it can be Network-Assisted, UE-Based GPS). The main point is that where the location estimate is finally calculated and from where the assistance data is originated.~~

~~6.2.4.1.2.1 Network Assisted, UE Based (GPS)~~

~~In this method, the UE includes a GPS receiver which is capable of measuring and calculating the UE location based on the GPS signals. The operation of this receiver is assisted by information supplied by the UTRAN (LSIF). The GPS acquisition and location calculation is assisted by the following information that may be signalled from the UTRAN (LSIF) to the UE:~~

- ~~Number of satellites for which assistance is provided~~
- ~~Reference time for GPS~~
- ~~Reference location~~
- ~~Ionospheric corrections~~
- ~~Satellite ID for identifying the satellites for which the assistance is provided~~
- ~~IODE: sequence number for the ephemeris for the particular satellite~~
- ~~Ephemeris to accurately model the orbit of the particular satellite and information when this becomes valid~~
- ~~Clock corrections~~
- ~~DGPS corrections~~

- ~~Almanac data~~

~~The location information message from UE to the UTRAN (PSMF/PCF) contains the location calculated based on GPS measurements. The message may contain the following information:~~

- ~~Reference time for which the computed location is valid~~
- ~~Serving cell information~~
- ~~Latitude/Longitude/Altitude/Error ellipse~~
- ~~Velocity estimate of the UE~~
- ~~Satellite ID for which the measurement data is valid~~
- ~~Whole/Fractional chips for information about the code-phase measurements~~
- ~~C/N_0 of the received signal from the particular satellite used in the measurements.~~
- ~~Doppler frequency measured by the UE for the particular satellite signal~~
- ~~Pseudorange RMS error~~
- ~~Multipath indicator~~

~~6.2.4.1.2.2 Network Based, UE Assisted (GPS)~~

~~In this method, the UE includes a GPS receiver which is capable of measuring the GPS signals. The operation of this receiver is assisted by information supplied by the UTRAN (LSIF). The GPS measurements are signalled to the UTRAN (PSMF/PCF) where the Position Calculation Function determines the UE location. The GPS acquisition is assisted by the following information that may be signalled from the UTRAN (LSIF) to the UE :~~

- ~~Number of Satellites~~
- ~~Reference Time for GPS~~
- ~~SVID/PRNID~~
- ~~Doppler (0^{th} order term)~~
- ~~Doppler (1^{st} order term) (optional)~~
- ~~Doppler Uncertainty (optional)~~
- ~~Code Phase~~
- ~~Integer Code Phase~~
- ~~GPS Bit Number~~
- ~~Code Phase Search Window~~
- ~~Azimuth~~
- ~~Elevation~~

~~The GPS measurement message from UE to the UTRAN (PSMF/PCF) contains the following information measured from the GPS :~~

- ~~Number of Pseudoranges~~
- ~~Reference Time for GPS~~
- ~~SVID/PRNID~~
- ~~Satellite C/No~~
- ~~Doppler~~
- ~~Satellite Code Phase – Whole Chips~~
- ~~Satellite Code Phase – Fractional Chips~~
- ~~Multipath Indicator~~
- ~~Pseudorange RMS Error~~

~~6.2.4.1.3 Round Trip Time (RTT)~~

~~This method makes use of measurements by the Node-B or LMU of the round trip time for transmissions to and from the UE. The RTT measurement message from Node-B or LMU to the UTRAN (PSMF/PCF) contains the following information :~~

- ~~Round trip time (in fractional chips)~~
- ~~Time of measurement~~
- ~~Received sector~~
- ~~Doppler of received signal (Hz)~~
- ~~Multipath Indicator~~

7 General UMTS location procedures

NOTE: To be adapted from GSM 03.71

7.1 State description for RNC (for LCS)

7.2 State description for LMU (stand-alone)

7.3 State description for Node-B (for LCS)

7.4 General network positioning procedures

[NOTE] The following text is taken from clause 6.1.

The following diagram illustrates the operations for the OTDOA-LCS when the request for location information is initiated by an LCS application signalled from the Core Network. As these operations are internal to the RNC, this diagram is to illustrate information flow and implementations may use alternate arrangements.

This illustration only includes the information flow related to LCS operations and does not indicate other operations that may be required, for example, to establish a signalling connection between the UE and the SRNC. Also not illustrated is the signalling used to initiate the location service request (from the Location Client Function) from the Core Network or a UE based application.

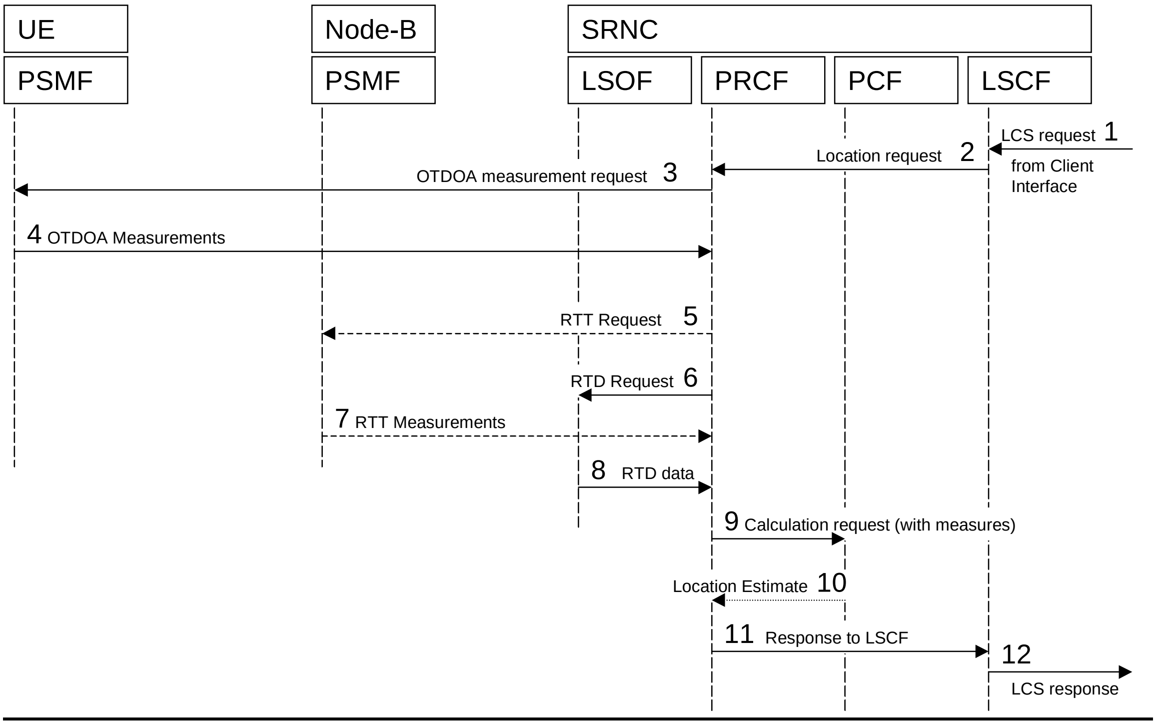


Figure 7.1: OTDOA Signalling Operations

1. The OTDOA operation begins with an authenticated request for location information about a UE from an application in the core network being received at the LSCF. The LSCF acts as interface between the Core Network and the LCS entities in the UTRAN.

2. The LSCF considers the request and the capabilities of the UE and the network and forwards the request to the appropriate PRCF in the Serving RNC.

3. The PRCF requests from the UE the measurement of the OTDOA for the signals in the active and neighbourhood sets. These measurements may be made while the UE is in the idle state or while it is connected.

4. The UE returns the OTDOA measures to the PRCF. The PRCF receives the OTDOA information and co-ordinates obtaining other information to support the calculation request (not illustrated).

5. If there are insufficient OTDOA measures, or it is otherwise considered advantageous to do so, the PRCF requests the RTT measure for the UE from the PSMF in the serving Node-B.

6. The PRCF requests the RTD measures for the associated transmitters from the LSOF (database). These may be stored locally if they are constant over time, otherwise they must be updated to represent the RTD timing at the time-of-day the OTDOA measurements were made.

7. The PSMF in the Node-B returns the RTT measures to the PRCF if they were requested.

8. The LSOF returns the RTD information to the PRCF.

9. The PRCF passes the OTDOA, RTD and, if necessary, RTT information to the PCF and requests a location calculation. The calculation may include a co-ordinate transformation to the geographic system requested by the application.

10. The PCF returns the location estimate to the PRCF. This estimate includes the location, the estimated accuracy of the results and the time of day of the estimate.

11. The PRCF passes the location estimate to the LSCF.

12. The LSCF passes the location estimate to the Core Network.

~~7.4 General network location procedures~~

7.5 Signaling procedures from the UMTS system point of view

7.6 Common procedures to support positioning

7.6.1 Information transfer between a SRNC and a target UE

7.7 Common procedures to support access to a LMU

7.8 Common control procedures for LMUs

7.8.1 Reset procedure

7.8.2 Status query procedure

7.8.3 Status update procedure

7.9 Common procedures supporting LCS interaction between RNCs

7.9.1 LCS information transfer between RNCs

7.10~~5~~ Exception procedures

7.10.1 Procedures in the SRNC

7.10.2 Procedures in a LMU

7.10.3 Procedures in the target UE

7.10.4 Further procedures for handover

7.11 Radio interface timing procedures

7.11.1 LMU functions

7.11.2 SRNC functions

7.11.3 LMU-SRNC interactions

8 ~~Location method management (signalling flows)~~Cell coverage based positioning

~~NOTE: Here are the detailed messages and the protocols for LCS contributions are invited on these topics.~~

9~~8.1~~ OTDOA positioning

[NOTE] The text in clauses 9 to 9.5 was moved from clause 4.4.2.

This method involves measurements made by the UE and LMU of the UTRA pilot signal (CPICH) radio transmissions. These measures are then sent to a Position Calculation Function (PCF) in the Serving RNC where the location of the UE is calculated.

Optionally, a PCF may be included in the UE, in which case the calculation of the location from the measurements may alternatively be performed in the UE.

The primary standard measurements are of the observed time difference of arrival (OTDOA) of downlink CPICH signals received at the UE. These measurements, together with other information concerning the surveyed geographic location of the transmitters and the relative time difference (RTD) of the actual transmissions of the downlink signals may be used to calculate an estimate of the location of the UE. Each OTDOA measurement for a pair of downlink transmissions describes a line of constant difference (a hyperbola (see NOTE 1)) along which the UE may be located. The UE's location is determined by the intersection of these lines for at least two pairs of base stations. The accuracy of the location estimates made with this technique depends on the precision of the timing measurements, the relative location of the base stations involved (see NOTE 2), and is also subject to the effects of multipath radio propagation. This is illustrated in the Figure 9.1.

NOTE 1: This is really a figure in three dimensions, a hyperboloid. For convenience here, this will be simplified to the hyperbola representing the intersection of this surface with the surface of the earth. For location service in three dimensions the hyperboloid must be considered.

NOTE 2: The geometry of the base station locations may affect the accuracy of the location estimate. The best results are when the base stations equally surround the UE. If they do not, there is a reduction in accuracy, which is sometimes termed the Geometric Dilution of Position (GDP).

The primary TDOA measurements (made by the UE) are sent to the Position Calculation Function (PCF) in the serving RNC. These measures are sent via signalling over the Uu, Iub (and Iur) interfaces between the UE and the SRNC (PCF). The calculation function makes use of the measurements, the known locations of the transmitter sites and the relative time difference of the transmissions to estimate the UE's location.

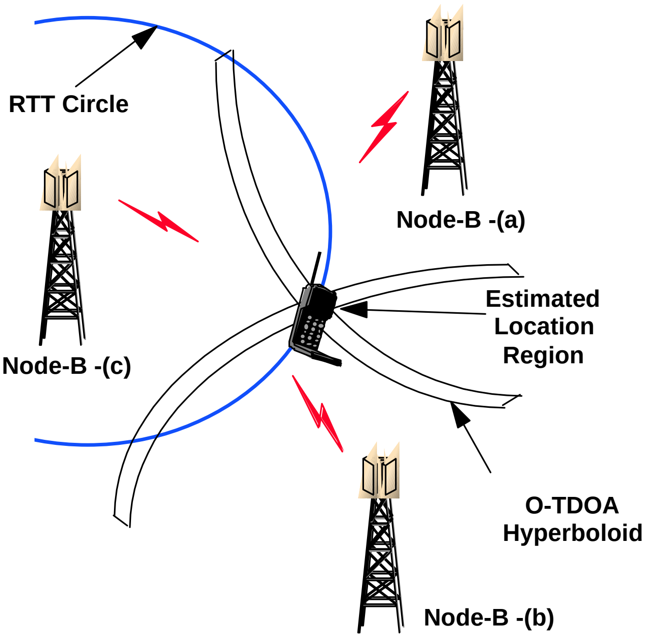


Figure 9.1: OTDOA Location Method

The OTDOA method may be operated in two modes: UE assisted OTDOA and UE based OTDOA. The two modes differ in where the actual location calculation is carried out. In the *UE assisted* mode, the UE measures the difference in time of arrival of several cells and signals the measurement results to the network, where a network element (the Position Calculation Function (PCF)) carries out the location calculation. In the *UE based* mode, the UE makes the measurements and also carries out the location calculation, and thus requires additional information (such as the location of the measured base stations) that is required for the location calculation. The signalling requirements for the two OTDOA modes are described in a later sub-section. As the LCS involves measurements, there is always uncertainty in the results. Physical conditions, errors and resolution limits in the apparatus all contribute to uncertainty. To minimise the uncertainty in the LCS result, it is important that as many measurements of RTT and TDOA (and others) as are possible for a UE are provided to the PCF. Thus it is important that the standard method for LCS not be restricted to rely on a single measure. The UE thus provides OTDOA measures for as many pilot signals as it can receive. The pilot signals to be measured shall include those in the "cell reselection and monitoring set" and those in the "cell selection set".

In order to support the OTDOA method, the locations of the UTRAN transmitters needs to be accurately known by the calculation function (PCF). This information may be measured by appropriate conventional surveying techniques (see NOTE). The surveyed location should be the electrical centre of the transmitting antenna (and not the location of the radio equipment building). The use of antenna diversity, beamforming or beam steering techniques may cause the effective antenna location to change with time and this information will need to be communicated to the PCF to assist with its calculations. The methods of measuring the location of the UTRAN transmitters are outside the scope of this document.

NOTE: These surveying methods may, for example, make use of a GPS receiver.

In order to support the OTDOA method, the relative time difference (RTD) of the downlink transmissions must also be known by the calculation function (PCF). If the UTRAN transmitters are unsynchronised, the RTD will change over time as the individual clocks drift. Thus, measurements of RTD may need to be made regularly and the calculation function updated appropriately. The measurement of the RTD is outside the scope of this document (see NOTE).

NOTE: One convenient method is to make use of an LMU at a fixed location. This unit measures the observed time differences of all the local transmitters and reports these to the PCF. These measures may then be converted (translated) into the actual (absolute) relative time difference for each of the transmitters by making use of the known location of the LMU and the transmitters.

In some conditions a sufficient number of downlink pilot signals may not be available for measure at the UE. This may occur, for example, if the UE is located quite close to the UTRAN transmitter and its receiver is blocked by the strong local transmissions. This is referred to as the "hearability" problem.

9.1 Use of Idle Periods

For realising location based services the support of physical layer is a prerequisite, so that the measurements required for the terminal location calculation can be carried out. In UTRAN there are several factors that must be taken into account while considering the physical layer procedures related to location services:

- hearability: a basic consequence of a CDMA radio system is that a terminal near its serving base station cannot hear other base stations on the same frequency. In order to calculate terminal location the terminal should be able to receive at least three base stations. To facilitate this some special means are required.

- asynchronous network causes significant uncertainty to the time-difference-of-arrival (TDOA) measurements. To compensate for the effects of this, the relative time difference (the synchronicity) between base station transmissions must be measured, and used for correcting TDOA measurement.

- capacity loss: signalling related to location calculation may take capacity from other services. This capacity loss should be minimised.

Based on the results of the work done in ARIB SWG2/ST9 (see reference [16]) a solution for the above mentioned hearability problem is the IPDL (Idle Period DownLink) method. In this method each base station ceases its transmission for short periods of time (idle periods). During an idle period of a base station, terminals within the cell can measure other base stations and the hearability problem is reduced. Also, during idle periods the real time difference measurements can be carried out. Because the IPDL method is based on forward link (downlink) the location service can be provided efficiently to a large number of terminals simultaneously.

The specification and operation of the IPDL technique are provided in the following sub-section.

9.1.1 Operation and specification of idle periods

There are several requirements on the provisioning of idle periods, listed in the following:

System requirements:

- Many idle period pseudo random patterns

- Co-located sectors shall have the same idle period timing

Operator flexibility:

- Continuous operation or activated on demand
  Variable average frequency of idle periods

- Variable idle period length
  Burst mode for regular updating of location

Implementation restrictions:

- Minimum spacing between idle periods

- Maximum spacing between idle periods

The following are the parameters for the idle periods (IP) :

Parameter	Min value	Max value	Bits Required	Units (see note 1)	Description
IP_spacing	2^2+1	2^6	4	frames	Number of frames between Idle Periods.
IP_status	0	1	1	Logic Value	0 = Idle Periods active in continuous mode 1 = Idle Periods active in burst mode
IP_length	5	10	1	symbols	Length of Idle Periods
Max_dev	140	145	0 (depends on IP length)	symbols	Maximum deviation in time from beginning of frame
Seed	0 – 63			(no units)	Seed for random function "rand(x)"
Rand(x)	= (106.rand(x-1) + 1283)%6075,				Random function used in the calculation of the Idle Periods. Note: rand(0) = Seed.
IP_position(x)	= x.IP_spacing + rand(x)%Max_dev			symbols	Function for generating the exact positions of the x^{th} Idle Period. (see notes 2 & 4 below)
Extra parameters used in the case of burst mode operation (i.e. IP_status = 1)					
Burst_Start	[0]	[2^4-1]*256	[4]	SFN (in steps of 256 frames)	The frame number where the 1^{st} Idle Period Burst occurs within an SFN cycle.
Burst_Length	[10]	[10+2^4]	[4]	IPs	Number of Idle Periods in a ‘burst’ of Idle Periods
Burst_freq	[2^8]	[2^{12}]	[4]	frames	Number of 10ms frames between consecutive Idle Period bursts.

NOTE 1: The unit ‘symbol’ refers to symbols on the CPiCH channel.

NOTE 2: The function IP_position(x) yields the position of the x^{th} Idle Period relative to a) the start of the SFN cycle when in continuous mode or b) the start of a burst when in burst mode.

NOTE 3: The operator "%" denotes the modulo operator

NOTE 4: Regardless of mode of operation, the Idle Period pattern is reset at the start of every SFN cycle.

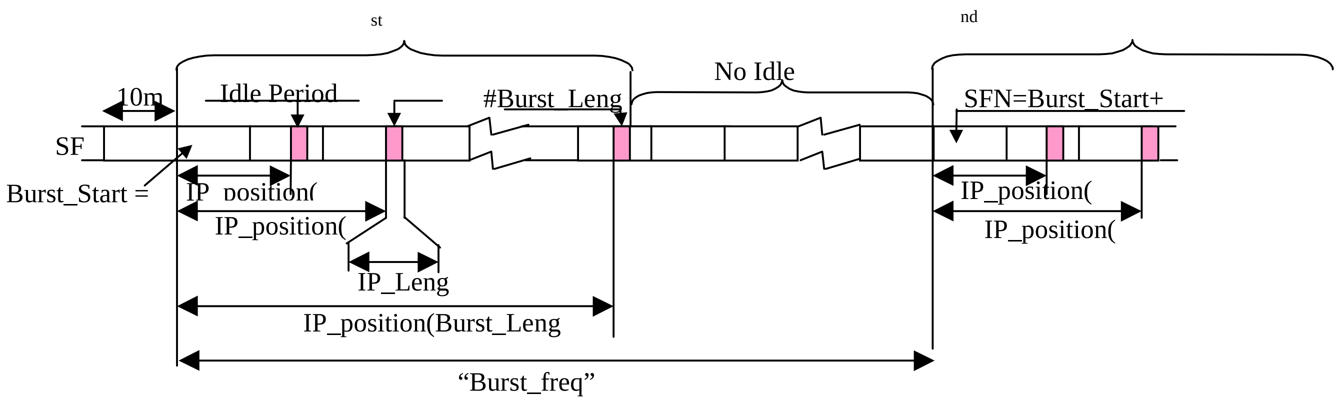


Figure 9.2: IPDL Timing

9.1.2 Time Aligned IPDL

Use of the Time Aligned method is dependent upon there being a demonstrated benefit at layer 1 and limited signalling overhead at layer 3.

In areas where traffic is high or pilot visibility is low (due for example to irregular site topology or low pilot levels), it is possible to configure IPDL in order to further increase the probability of accurate TDOA measurements. This can be achieved by approximately time aligning the occurrences of idle periods, and enabling CPICH transmission during some of these periods. The alignment can typically be to within half a CPICH symbol.

During the ‘common’ idle period, the node B transmits the CPICH randomly, pseudo-randomly or periodically. Thus in each idle period, the only radio activity will be due to the CPICH and in addition, only a fraction of node B’s are active (and this set will change for different idle periods). Finally, it is also possible to increase the CPICH power during the idle period in order to increase range for location purposes.

In this configuration, location performance is not dependent on the traffic load. Additionally, it is possible to increase the range of pilots in rural areas or for indoor coverage purposes .

Idle period alignment requires that the offsets between the transmission times of each node B be known, ideally to a resolution better than half a symbol period i.e. 33.33 µs or less. Due to drift between different node Bs the idle period timing will need to be updated at regular intervals. The update rate is a function of network clock stability.

Measurement of time offsets can be achieved in a number of ways. A possible option is for these to be estimated by the LMUs (Location Measurement Units) which may be employed to measure the node B transmission time offsets so as to enable TOA based location as discussed in section 9.

In comparison with standard IPDL, the UE requires similar information regarding the occurrences of idle periods. Since each node B is active during a fraction of the idle periods only, complexity reduction at the UE can be obtained if knowledge of the actual activity of node Bs in the idle periods is provided, via additional signalling. In the RAN, the additional requirements to standard IPDL are:

(a) the node B should be able to leave the CPICH on in some of the periods, possibly ramping up the power if requested to do so

(b) signalling from the UTRAN Position Radio Resource Management (U-PRRM) to the node B is required to maintain partial synchronisation.

The following table provides a set of parameters which may be used to configure idle periods for both time aligned and non-time aligned operation.

Parameter	**Min value**	**Max value**	**Bits Required**	**Units (see note 1)**	**Description**
IP_spacing	2	72	4	frames	Number of frames between Idle Periods (4 bit represent exponents in 2^i x2^j x3^k x3^l)
IP_status	0	1	1	Logic Value	0 = Idle Periods active in continuous mode 1 = Idle Periods active in burst mode)
TA_status	0	1	1	Logic value	0 = Time Alignment not enabled 1 = Time Alignment enabled
IP_length	3	10	2	Symbols	Length of Idle Periods
Max_dev (S)	140	145	0 (depends on IP length)	Symbols	Maximum deviation in time from beginning of frame
Seed (S)	0-63			No units	Seed for random function "rand(x)"
rand(x) (S)	= (106.rand(x-1) + 1283)%6075				Random function used in the calculation of the Idle Periods. Note: rand(0) = Seed.
IP_position(x)	= x.IP_spacing *10 + rand(x)%Max_dev +(IP_offset/2)			Symbols	Function for generating the exact positions of the x^th Idle Period. (see notes 2 & 4 below) For standard IPDL, IP_offset=0 For TA IPDL, Max_dev=0
Extra parameters used in the case of the time aligned configuration					
IP_offset (T)	0	2^{15}-1	15	Half symbol	Offset giving start of idle period with respect to reference point
IP-CPICH_up (T)	0	15	4	dB	CPICH power step up relative to current level
IP_TA_prob (T)	0.2	0.5	4	-	Probability of CPICH being on during idle period
IP_TA_seed (T)	0	63	6	-	Number used to point to CPICH power on pattern in TA mode, actual pattern is for FFS (same pattern must be provided to co-located cells)
Extra parameters used in the case of burst mode operation (i.e. IP_status = 1)					
Burst_Start	[0]	[2^4-1]*256	[4]	SFN (in steps of 256 frames)	The frame number where the 1st Idle Period Burst occurs within an SFN cycle.
Burst_Length	[10]	[10+2^4]	[4]	IPs	Number of Idle Periods in a 'burst' of Idle Periods
Burst_freq	[2^8]	[2^{12}]	[4]	frames	Number of 10ms frames between consecutive Idle Period bursts.

NOTE 1: The unit 'symbol' refers to symbols on the CPiCH channel.

NOTE 2: For standard IPDL, the function IP_position(x) yields the position if the x^{th} Idle Period relative to a) the start of the SFN cycle when in continuous mode or b) the start of a burst when in burst mode. For the TA configuration the function IP_position(x) always yields the position of the x^{th} Idle Period relative to the start of the SFN cycle (in this case, the burst parameters in burst mode define the frames when IPs are enabled).

NOTE 3: The operator "%" denotes the modulo operator

NOTE 4: Regardless of mode of operation (except TA), the Idle Periods pattern is reset at the start of every SFN cycle. For TA, the IP spacing must be kept across SFN boundaries, hence the first IP_position after a new SFN cycle should be calculated modulo (no of symbols in SFN cycle).

NOTE 5: (S) refers to parameter required only in standard IPDL, (T) refers to parameter required only in time aligned configuration

9.2 Accuracy

In the OTDOA technique, generally, the location is being determined by means of an estimate of the transit time (time-of-flight) of the radio signals. The radio path and the geographical path are assumed to be the same with unobstructed line-of-sight. The radio signals travel about 0,3 metres per nanosecond. To achieve an uncertainty of less than 50 metres in the location estimate requires an uncertainty in timing of less than 166 nanoseconds. With a 4 Mchip/s rate, the chip duration is 250 nanoseconds and ultimately, LCS requires timing measurements of the radio signals to the sub-chip level. Many current receivers are capable of combining multipath signal components to the sub-chip level of timing (often to better than 1/4 chip), and so such timing accuracy is already available, although in a different form.

The radio signal path is, unfortunately, not always equal to the geographic separation. The effects of multipath and obstructions combine to make the radio path typically longer (but never shorter) than the geographic path. A distance estimate derived from radio signal timing will generally be longer than the true distance. The techniques to mitigate the effects of multipath in the LCS are beyond the scope of this specification and are, in any case, subjects of current active technology research. These can be expected to improve with experience in system operation and the measurement function and calculation function designs can be expected to evolve to give better performance over the lifetime of deployed UTRAN LCS.

The accuracy of the location estimate may thus vary from area to area within an operator's territory due to the effects of multipath propagation. Some operators may choose to add extra base stations or extra transmissions to provide better location service accuracy in areas they deem critical for their service. Other operators may choose to have fewer base stations and consequently a lower accuracy service in some areas.

The objective is to provide the best estimate available with the equipment, measurements and propagation conditions prevailing at the time and place of the UE. Not all results will be of the same precision and there is a cost associated with increased precision. Making use of a downlink based measurement technique minimises the network traffic and provides a system that scales with increased usage by UE. In some jurisdictions, the equipment must meet some minimum requirements to satisfy regulatory requirements for accuracy of the location service (e.g. the FCC in the United States) and this must be taken into consideration in the design of equipment for operation in these areas.

Generally the measurement of location is a statistical process and not all measurements of the same location will yield the same result. The overall system accuracy of its reports (e.g. less than 50 metres error in 80% of measurements) will involve a statistical measure of many operations at may times and at many locations through the UTRAN coverage area. The accuracy reported together with an individual report must take into account the individual measurements, environmental conditions and the time of the measurement. The accuracy reported for an individual measurement may vary considerably from the overall system performance statistic.

9.3 Relative Time Difference (RTD)

In order to calculate the estimate of the location of the UE, the calculation function needs to know

- the OTDOA measurements,

- the surveyed geographic locations of the base stations that have had their signals measured, and

- the actual relative time difference between the transmissions of the base stations at the time the OTDOA measurements were made.

The accuracy of each of these measurements contributes to the overall accuracy of the location estimate. The measurement of the RTD is described in the following.

There are several approaches to determining the RTD. One is to synchronise the transmissions of the base stations. In this technique the RTD are known constant values (see NOTE) that may be entered in the database and used by the calculation function when making a location estimate. The synchronisation must be done to a level of accuracy of the order of tens of nanoseconds (as 10 nanoseconds uncertainty contributes 3 metres error in the location estimate). Drift and jitter in the synchronisation timing must also be well controlled as these also contribute uncertainty in the location estimate. Synchronisation to this level of accuracy is currently only readily available through satellite based time-transfer techniques. Generally in the TDD operating mode, the base stations are synchronised.

NOTE: The transmission times may all be aligned to a common reference (such as UTC) in which case all RTD have a common value. However, in a more general case the transmissions may have a fixed offset with reference to UTC, and thus the RTD values are non-zero and may be stored in the database for use by the calculation function.

Alternatively (typically in FDD mode), the base stations may be left to free run within some constraint of maximum frequency error. In this scenario, the RTD will change (slowly) with time. The rate of change will depend on the frequency difference and jitter between base stations. If, for example, the maximum frequency difference between two base stations is $\pm 10^{-9}$, then the start of transmission of a 10 millisecond code sequence will drift through a cycle in about 1390 hours (or 57 days). With this relatively slow rate of drift the RTD can be measured by fixed units at known locations (these are LMUs, Location Measurement Units) and stored in the database for use by the calculation function. The jitter and drift of the individual oscillators in each base station may cause the change of timing to slow, remain constant or reverse direction over time. Ongoing measurements of the RTD may be made to assure the most current values are available for the calculation function. The RTD measurement units may be co-located with the base stations or installed at other convenient locations in the UTRAN coverage area, and report their results through the UTRAN signalling channels.

9.4 Time of Day (ToD)

If there are frequency differences between the (unsynchronised) base stations, as noted in the previous sub-section, the OTDOA measurements must be reported together with the time-of-day they were made (timestamp). This is necessary so that the appropriate value of the RTD may be used by the calculation function.

In order to assure less than a 20 nanosecond uncertainty in the RTD value, the time of day must be known to better than 10 seconds (if the maximum frequency difference between the base stations is $\pm 10^{-9}$). The method by which the ToD is measured is FFS [, but the frame number (which provides a 10 millisecond resolution) or encryption counter used in the downlink transmissions may provide a convenient measure].

9.5 Base Station Synchronisation

It is preferable that the location methods do not require the base station network to be synchronised. The needed level of synchronisation accuracy for LCS is not by any means straightforward to achieve. The necessary information of Relative Time Differences (RTD) between base stations can be measured by dedicated units (LMU, Location Measurement Unit) and distributed in the network (e.g. as broadcast information). Also, the measurements of RTD may benefit from the Idle Period DownLink (IPDL) option.

In the TDD operating mode the base stations will typically be synchronised and this may be of assistance to the LCS technique.

9.6~~8.1.1~~ Idle Period DownLink timing procedures (OTDOA-IPDL)

[NOTE] The text in clause 9.6 was moved from clause 6.2.4.1.1.

There are two modes of operation for the OTDOA method. In the *UE assisted* mode, the UE measures the difference in time of arrival of several cells and signals the measurement results to the network, where a network element (the Position Calculation Function (PCF)) carries out the location calculation. In the *UE based* mode, the UE makes the measurements and also carries out the location calculation, and thus requires additional information (such as the location of the measured base stations) that is required for the location calculation. This information is provided by the Location System Information Function (LSIF).

Table 6.1 lists the required information for both OTDOA modes. The range of values for the listed parameters are FFS. The required information can be signalled to the UE either in a broadcast channel or partly also as dedicated signalling.

Table 9.1: Information required for UE assisted and UE based OTDOA in the UTRAN (LSIF) to UE direction ('Yes' = information required, 'No' = Information not required)

Information	UE assisted OTDOA	UE based OTDOA
Intra frequency Cell Info (neighbour list).	Yes	Yes
Ciphering information for LCS NOTE: The idea behind LCS specific ciphering information is e.g. that the operator can sell information that the UE needs for calculating its location. For reference in the GSM world see [3].	No	Yes
Measurement control information (idle period locations)	Yes	Yes
Sectorisation of the neighbouring cells	No	Yes
Measured RTD values for Cells mentioned at Intra frequency Cell Info	No	Yes
RTD accuracy	No	Yes
Measured roundtrip delay for primary serving cell	No	Yes
Geographical location of the primary serving cell.	No	Yes
Relative neighbour cell geographical location	No	Yes
Accuracy range of the geographic location values	No	Yes

The information required from UE to UTRAN (PSMF/PCF) is listed in Table 6.2.

Table 9.2: Information required for UE assisted and UE based OTDOA in the UE to UTRAN (PSMF/PCF) direction

Information	UE assisted OTDOA	UE based OTDOA
OTDOA measurement results	Yes	No
OTDOA measurement accuracy	Yes	No
UE geographical location	No	Yes
Location accuracy indicator (based on the signalled and measurement accuracies)	No	Yes

~~8.1.2 Reference Node-Based~~

~~8.1.3 Round Trip Time~~

10~~8.~~2 ~~Network a~~Assisted GPS positioning

10.1 Network Assisted GPS Methods

[NOTE] The following text has been taken from clause 6.2.4.1.2.

These methods make use of UE which are equipped with radio receivers capable of receiving signals from the Global Positioning System (GPS).

The following definitions of "Network-Based", "Mobile-Based" and "Assisted" may be applied :

1. Mobile-Based

   The UE performs signal measurements and computes its own location estimate.

2. Mobile-Assisted (UE-Assisted Network-Based)

   The UE performs and reports signal measurements to the network and the network computes the UE's location estimate. In addition to those we can have following variant:

3. Network-Assisted UE-Based

   The network performs and reports signal measurements to the UE and the UE computes its own location estimate.

Thus, if GPS is utilised with this mechanism (Network-Assisted UE-Based GPS) it means that the location calculation is fulfilled in UE by using the additional measurements from the network to perform a better location estimate. One example of this kind is using of Differential GPS data.

UE-Based GPS can be either independent or dependent on network measurements. If it is dependent on the network measurements (then it can be Network-Assisted, UE-Based GPS). The main point is that where the location estimate is finally calculated and from where the assistance data is originated.

[NOTE] The following text has been taken from clause 4.4.3.

NOTE: the intention is that this description be synergistic with GSM 03.71.

Methods making use of GPS are being standardised for GSM. In order to facilitate efficient implementation, and seamless location service operation between GSM and UTRAN, the support for GPS based methods must be compatible between these systems.

There are four main functions for a stand-alone GPS receiver:

1 Measuring distance from the satellites to the GPS receiver by determining the pseudoranges (code phases);

2 Extracting the TOA of the signal from the contents of the satellite transmitted message;

3 Computing the location of the satellites by evaluating the ephemeris data at the indicated TOA.;

4 Determining the location of the receiving antenna and the clock bias of the receiver by using the above data items.

To reduce the errors contributed from satellite clock and location modelling, ionospheric delay, tropospheric delay, and selective availability (SA), corrections can be done before the fourth step above. The most important technique for error compensation is DGPS.

When GPS is designed to inter-work with the UTRAN, the network assists the UE GPS receiver to improve the performance in several respects. These performance improvements will:

- Reduce the UE GPS start-up and acquisition times; the search window can be limited and the measurements sped up significantly.
- Increase the UE GPS sensitivity; location assistance messages are obtained via UTRAN so the UE GPS can operate also in low SNR situations when it is unable to demodulate UE GPS signals.
- Allow the UE to consume less handset power than with stand-alone GPS ; this is due to rapid start-up times as the GPS can be in idle mode when it is not needed.

The Network assisted GPS methods rely on signalling between reduced complexity UE GPS receivers and a continuously operating GPS reference receiver network which has clear sky visibility of the same GPS constellation as the assisted UEs. Reference GPS receivers may be connected to the UTRAN to enable derivation of UE assistance signals.

NOTE: labels in Figure 10.1 below may need to be aligned with GSM 03.71.

NOTE: charging and billing operations are not illustrated in Figure 10.1 below.

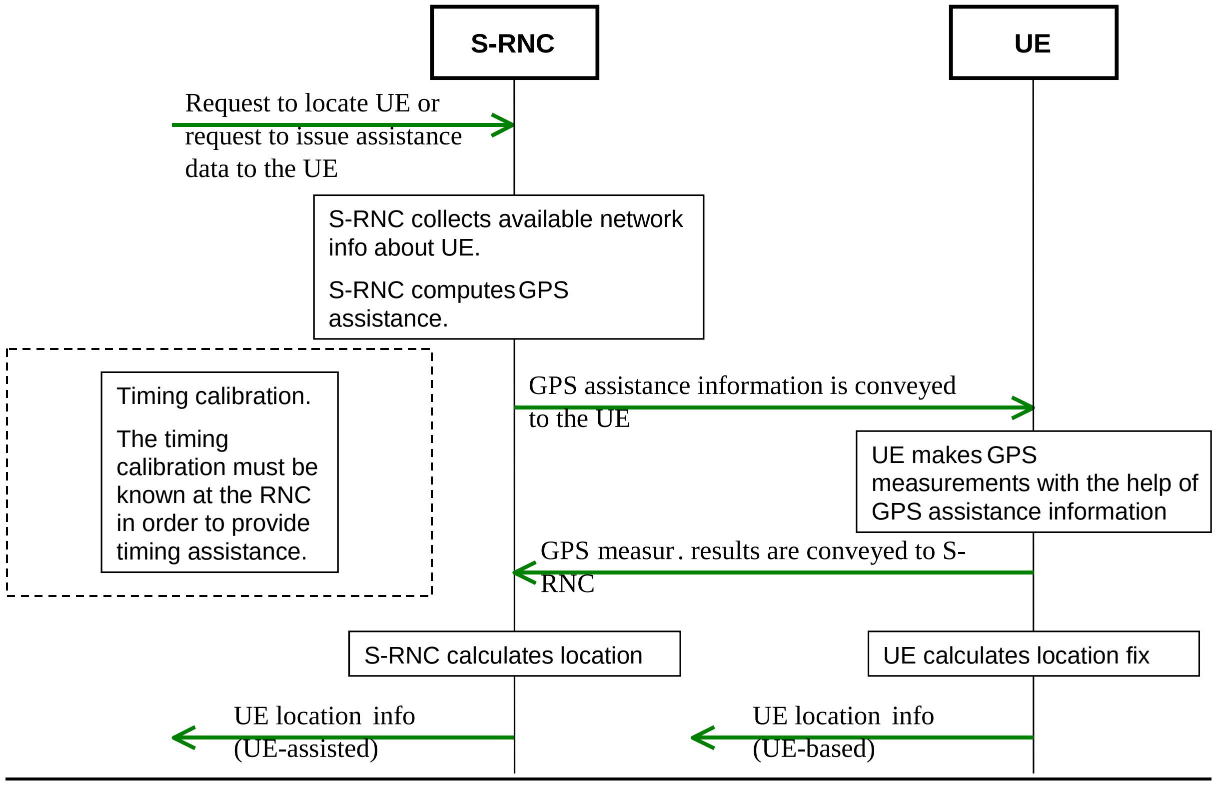


Figure 10.3: Network assisted GPS methods
NOTE: see reference [1] (23.171, section 8.7

10.1.1 Timing calibration

Where timing assistance is needed, the relationship between GPS Time Of Week (see reference: GSM 04.31) and cell-specific UTRAN system timing must be derived.

In the network assisted GPS methods the inter-system measurement may be used to reduce the signal search space and hence reduce the user delay in obtaining a location fix. Typically, a timing assistance accuracy of several microseconds is required for an acceptable location fix user delay. The relationship between GPS time and UTRAN timing is to be defined as GPS-UTRAN-Reference-Time in a similar way as in GSM 04.31 Annex A Section 4.2.4.

The UE or LMU optionally derives the cell specific GPS-UTRAN-Reference-Time through measurement at Layer 1.

10.1.2 Timing assistance

The UTRAN combines the coarse UE location determinations from UTRAN cell-specific information with the GPS-UTRAN-Reference-Time. These coarse determinations can be enhanced through other location methods (e.g. IPDL). Using this information, the UTRAN computes the estimated timing of GPS signals received by the UE and conveys this information to the UE using higher layer signalling. The GPS-UTRAN-Reference-Time is uncertain to a degree depending on the accuracy of the coarse location estimate used. Typically, a window of several microseconds can be attained.

In addition, other GPS parameters, as described in section 4.4.3.3, are conveyed to the UE to further reduce the signal search space.

10.1.3 Data assistance

GPS signals are modulated with low-rate digital information at a rate of 50 bits/sec. This information is necessary for stand-alone GPS receivers to determine their own location (the low rate digital information conveys satellite ephemeris and other GPS data).

The UE receives GPS information (e.g. Doppler shifts) through UTRAN air interface, using higher layer signalling, and modulation 'wipe-off' is applied. Therefore, the space that must be searched by the UE, to derive the GPS signals needed, can be reduced beyond that needed by a stand-alone GPS receiver. Thus, a location fix can be derived with an acceptable sensitivity and delay to the user.

NOTE: "modulation wipe-off" is intended here to mean a removal of the GPS modulation in the UE through the use of the UTRAN assistance information.

The assistance data signalled to the UE may include all information listed below or a selected subset:

Data assisting the measurements; e.g. reference time, visible satellite list, satellite signal Doppler, code phase search window. This data is valid for few hours (2-4 hrs).

Data providing means for location calculation; e.g. reference time, reference location, satellite ephemeris, clock corrections. This data is valid for four hours.

If DGPS is utilised, then differential corrections may also be transmitted. They are valid for about 30 seconds. The DGPS data is valid for a large geographical area, so one centrally located reference receiver can be used to service this large region.

10.1.4 UE search

Application of modulation 'wipe-off' enables the UE to carry out an efficient real-time derivation of the GPS signals needed for a GPS location fix.

10.1.5 Location determination

Computation of the location fix can either be performed in the network infrastructure (UE-assisted) or in the UE (UE-based).

There are two types of network assisted GPS method, namely UE-based and UE-assisted, which differ according to where the actual location calculation is carried out.

10.1.6 Network Assisted, UE Based (GPS)

[NOTE] The following text is taken from clause 4.4.3.5.1.

The UE-based network assisted GPS method maintains a full GPS receiver in the UE, and the location calculation is carried out by the UE.

If the location was requested by an application in the network, then the calculated location is signalled to the proper network element.

[NOTE] The following text is taken from clause 6.2.4.1.2.1.

In this method, the UE includes a GPS receiver which is capable of measuring and calculating the UE location based on the GPS signals. The operation of this receiver is assisted by information supplied by the UTRAN (LSIF). The GPS acquisition and location calculation is assisted by the following information that may be signalled from the UTRAN (LSIF) to the UE:

- Number of satellites for which assistance is provided
- Reference time for GPS
- Reference location
- Ionospheric corrections
- Satellite ID for identifying the satellites for which the assistance is provided
- IODE: sequence number for the ephemeris for the particular satellite
- Ephemeris to accurately model the orbit of the particular satellite and information when this becomes valid
- Clock corrections
- DGPS corrections
- Almanac data

The location information message from UE to the UTRAN (PSMF/PCF) contains the location calculated based on GPS measurements. The message may contain the following information:

- Reference time for which the computed location is valid
- Serving cell information
- Latitude/Longitude/Altitude/Error ellipse
- Velocity estimate of the UE
- Satellite ID for which the measurement data is valid
- Whole/Fractional chips for information about the code-phase measurements
- C/N_0 of the received signal from the particular satellite used in the measurements.
- Doppler frequency measured by the UE for the particular satellite signal
- Pseudorange RMS error
- Multipath indicator

10.2 Network Based, UE Assisted (GPS)

[NOTE] The following text is taken from clause 4.4.3.5.2.

In the UE-assisted network assisted GPS method, the UE employs a reduced complexity GPS receiver.

This carries out the pseudorange (code phase) measurements (item 1 in the list above), and transmits these to the specific network element that estimates the location of the UE and carries out the remaining GPS operations (items 2 – 4 in the list). In this method, accurately timed code phase signalling is required on the downlink. The signalling load in the uplink direction can be larger than in the UE-based method. If DGPS is performed in the UE, then differential corrections must be signalled to it. On the other hand, DGPS corrections can be applied to the final result in the network to improve the location accuracy without extra signalling to the UE.

[NOTE] The following text is taken from clause 6.2.4.1.2.2.

In this method, the UE includes a GPS receiver which is capable of measuring the GPS signals. The operation of this receiver is assisted by information supplied by the UTRAN (LSIF). The GPS measurements are signalled to the UTRAN (PSMF/PCF) where the Position Calculation Function determines the UE location. The GPS acquisition is assisted by the following information that may be signalled from the UTRAN (LSIF) to the UE :

- Number of Satellites
- Reference Time for GPS
- SVID/PRNID
- Doppler (0^{th} order term)
- Doppler (1^{st} order term) (optional)
- Doppler Uncertainty (optional)
- Code Phase
- Integer Code Phase
- GPS Bit Number
- Code Phase Search Window
- Azimuth
- Elevation

The GPS measurement message from UE to the UTRAN (PSMF/PCF) contains the following information measured from the GPS :

- Number of Pseudoranges

- Reference Time for GPS
- SVID/PRNID
- Satellite C/No
- Doppler
- Satellite Code Phase – Whole Chips
- Satellite Code Phase – Fractional Chips
- Multipath Indicator
- Pseudorange RMS Error

11 Other positioning methods

11.1 Reference Node Based

11.2 Round Trip Time (RTT)

[NOTE] The following text is taken from clause 6.2.4.1.3.

This method makes use of measurements by the Node-B or LMU of the round trip time for transmissions to and from the UE. The RTT measurement message from Node-B or LMU to the UTRAN (PSMF/PCF) contains the following information :

- Round trip time (in fractional chips)
- Time of measurement
- Received sector
- Doppler of received signal (Hz)
- Multipath Indicator

12~~9~~ Position calculation functionality

NOTE: The functionality of the PCF is described in more detail in an informative annex FFS.

13~~0~~ Information storage

NOTE This section just outlines the information that may need to be stored in the UTRAN LCS elements (U-LCF, U-PSCF,U-LSCF, UE, etc) that may need to be standardised (if any).

14~~1~~ Operational aspects

3GPP TSG-RAN Meeting #7
Madrid, Spain, 13 - 15 March 2000

Document R2-000171

e.g. for 3GPP use the format TP-00xxxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.305 CR 006 Current Version: 3.0.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to: TSG-RAN #7	for approval	X	strategic		(for SMG use only)
list expected approval meeting # here ↑	for information		non-strategic		

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

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

Source: TSG-RAN WG2 **Date:** 2000-01-17

Subject: Target UE-RNC signalling model

Work item:

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

Reason for change: No specification for the protocol model

Clauses affected: 6.2.4.1

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

Other comments:

help.doc

<---------- double-click here for help and instructions on how to create a CR.

6.2.4.1 Signalling between S-RNC and Target UE

LCS related signaling between an S-RNC and a target UE is supported by the RRC protocol.

3GPP TSG-RAN Meeting #7
Madrid, Spain, 13 - 15 March 2000

Document ***R2-000172***
e.g. for 3GPP use the format TP-00xxxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.305 CR 007 Current Version: 3.0.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to: TSG-RAN #7	for approval	X	strategic		(for SMG use only)
list expected approval meeting # here ↑	for information		non-strategic		

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

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

Source: TSG-RAN WG2 **Date:** 2000-01-17

Subject: LMU description

Work item:

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

Reason for change: Improving alignment with GSM, and clarifications

Clauses affected: 5.5.3

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

Other comments:

help.doc

<--------- double-click here for help and instructions on how to create a CR.

5.5.3 LCS measurement unit (LMU)

The LCS Measurement Unit (LMU) entity makes measurements (e.g. of radio signals) and communicates these measurements to the S-RNC (e.g. the PRCF). The LMU contains a PSMF and may also perform calculations associated with the measurements.

The LMU may make its measurements in response to requests (e.g. from the S-RNC (e.g. the PRCF)), or it may autonomously measure and report regularly (e.g. timing of Node-B transmissions) or when there are significant changes in radio conditions (e.g. changes in the RTD).

There may be one or more LMU associated with the UTRAN and an LCS request may involve measurements by one or more LMU. The LMU may be of several types and the S-RNC will select the appropriate LMUs depending on the LCS method being used.

The LMU may be used, for example, to measure UTRA transmissions either uplink or downlink. These measurements may be made either, for example, to locate the UE or to measure a system parameter needed by the LCS system such as the timing offset (RTD) of transmissions of two or more base stations. The LMU may also measure other transmissions, such as those of satellite navigation systems (i.e. the Global Position System (GPS)) and either report the measurements for use by the S-RNC (e.g. the PCF), or report the location results as determined by internal calculations of the LMU). The details of the measurements to be made by the LMU will be defined by the chosen LCS method.

An LMU makes radio measurements to support one or more location methods. These measurements fall into one of two categories:

(a) Location measurements specific to one UE and used to compute its location;

(b) Assistance measurements specific to all UEs in a certain geographic area.

All location and assistance measurements obtained by an LMU are supplied to a particular S-RNC associated with the LMU. Instructions concerning the timing, the nature and any periodicity of these measurements are either provided by the S-RNC or are pre-administered in the S-RNC (e.g. using O&M).

There are two classes of LMU :

Stand-Alone LMU: accessed over the UTRAN air interface

Associated LMU: accessed over the Iub interface

Stand-Alone LMU

A stand-alone LMU is accessed exclusively over the UTRAN air interface (Uu interface). There is no other connection from the stand-alone LMU to any other UTRAN network element.

NOTE: This does not preclude a stand-alone LMU from also communicating with other networks (e.g. GSM) through interfaces that are not part of this specification.

A stand-alone LMU has a serving-Node-B that provides signaling access to a controlling S-RNC. A stand-alone LMU also has a serving 3G-MSC, VLR and a subscription profile in an HLR. A stand-alone LMU always has a unique IMSI and supports all radio resource and mobility management functions of the UTRAN air interface that are necessary to support signaling. A stand-alone LMU shall support those connection management functions necessary to support LCS signaling transactions with the S-RNC and may support certain call control functions of to support signaling to an S-RNC using a circuit switched data connection.

NOTE: A network operator may assign specific ranges of IMSI for its LMUs and may assign certain digits within the IMSI to indicate the associated S-RNC. Certain digits in the IMSI may also be used as a local identifier for an LMU within an S-RNC.

To ensure that a Stand-alone LMU and its associated S-RNC can always access one another, an LMU may be homed (camped) on a particular cell site or group of cell sites belonging to one 3G-MSC. For any Stand-alone LMU with a subscription profile in an HLR, a special profile may be used to indicate the assigned supplementary services (e.g. the SMS-PP MT for data download via the SIM application toolkit, and barring of all incoming and possibly outgoing calls). An identifier in the HLR profile also distinguishes an LMU from a normal UE. All other data specific to an LMU is administered in the LMU and in its associated S-RNC.

Associated LMU

An associated LMU is accessed over the Iub interface from an RNC. An associated LMU may make use of the radio apparatus and antennas of its associated Node-B. The LMU may be either a logically separate network element addressed using some pseudo-cell ID, or connected to or integrated in a Node-B. Signaling to an associated LMU is by means of messages routed through the controlling Node-B.

An associated LMU may be separated from the Node-B, but still communicate with the S-RNC via the Node-B Iub interface. The interface between the associated LMU and its Node-B is not part of this specification.

NOTE: An associated LMU is not precluded from also communicating with other networks (e.g. GSM) through interfaces that are not part of this specification.

Measurements

The assistance measurements obtained by an LMU have are generic and are usable by more than one location method. These include :

- Radio Interface Timing measurements – include Absolute Time Differences (ATDs) or Relative Time Differences (RTDs) of the signals transmitted by Node-B, where timing differences are measured relative to either some Absolute Time Difference (ATD) or the signals of another Node-B (RTD).

- Inter-System Timing measurements – include the Absolute Time Difference (ATD) or Relative Time Difference between the UTRAN radio signals transmitted by a Node-B and an external system such as the GPS satellite navigation system or GSM.

3GPP TSG RAN WG2 Meeting #10
San Diego, US, Jan 17-21, 2000

Document* *R2-000553
e.g. for 3GPP use the format TP-00xxxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.305 CR 008r2 Current Version: 3.0.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to:	TSG-RAN #7	for approval	X	strategic		(for SMG use only)
list expected approval meeting # here ↑		for information		non-strategic		

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

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

Source: TSG-RAN WG2 **Date:** 2000-03-01

Subject: LMU signalling description

Work item:

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

Reason for change: No specification yet for LMU signalling model. R2 changes the signalling for associated LMU to NBAP signalling according to agreement in R2 plenary discussion about R2-000403.

Clauses affected: New clause 6.2.3.1

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

Other comments: The changes from r1 is shown in yellow

help.doc

<--------- double-click here for help and instructions on how to create a CR.

6.2.3.1 Signalling Between RNC and LMU

Signalling exchanges between an RNC and a LMU under the control of that RNC will be specified in the NBAP protocol for associated LMUs.

The use of stand-alone LMUs is FFS. If it is decided to have stand-alone LMUs in the standard, the signaling will be performed with the new protocol LLP. If no need is seen for the stand-alone LMUs the LLP protocol will not be defined and it will be remove from 25.305.

6.2.3.1.1 RNC signaling to an associated LMU

The protocol layers employed to enable signaling between the RNC and an associated LMU are defined in 25.430. The LMU signaling information elements are included directly in the NBAP protocol, defined in 25.433.

6.2.3.1.2 RNC Signaling to an Stand-alone LMU

The following figures illustrate the protocol layers used to support signaling between an RNC and a Stand-Alone LMU over the Uu interface.

6.2.3.1.2.1 Signaling using a signalling bearer

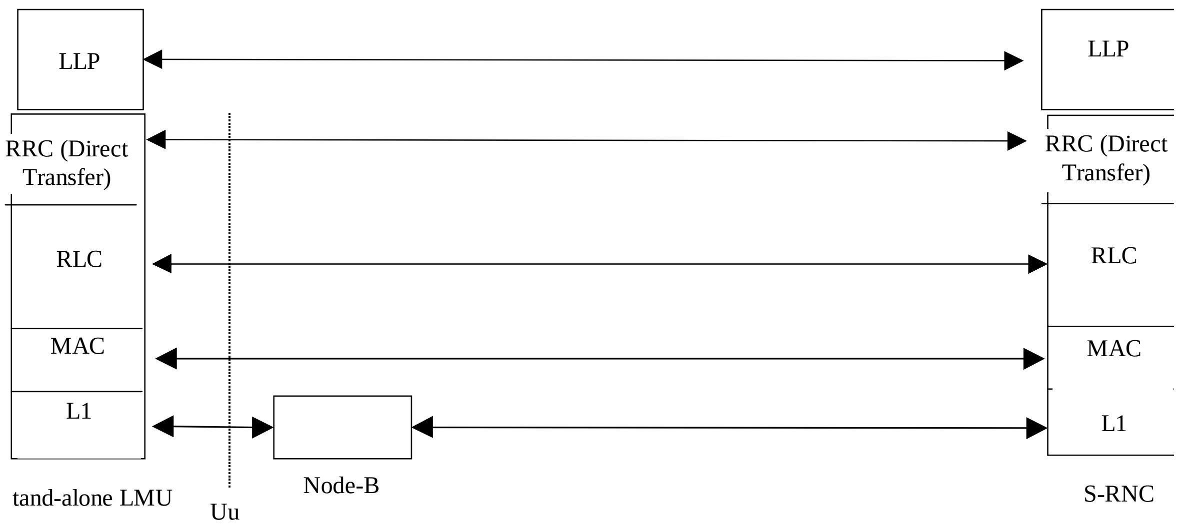


Figure nn – Signalling between an RNC and a Stand-Alone LMU using a signalling bearer

6.2.3.1.2.2 Signaling using a radio bearer

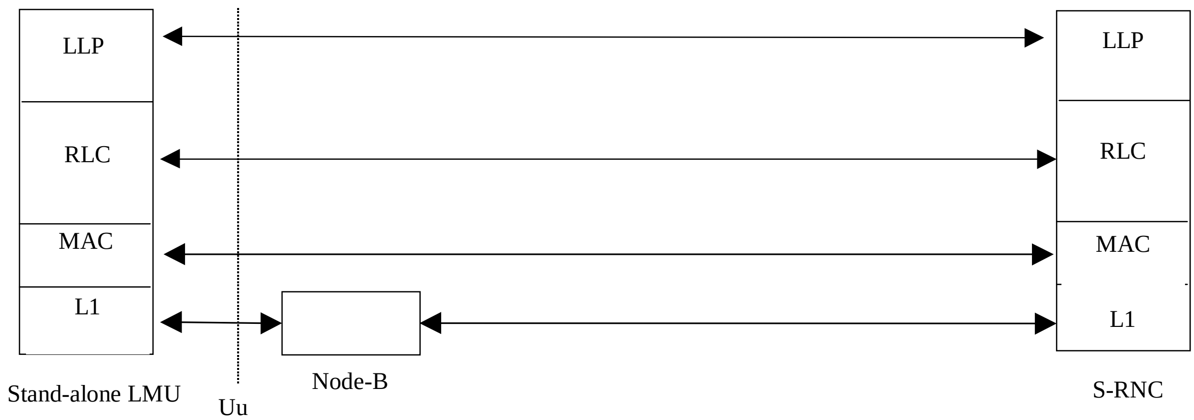


Figure bb – Signalling between an RNC and a Stand-Alone LMU using a radio bearer

3GPP TSG-RAN Meeting #7
Madrid, Spain, 13 - 15 March 2000

Document R2-000210
e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.305 CR 009 Current Version: 3.0.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to: TSG-RAN #7	for approval	X	strategic		(for SMG use only)
list expected approval meeting # here ↑	for information		non-strategic		

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

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

Source: TSG-RAN WG2 **Date:** 2000-01-19

Subject: Incorporation of R1 Liaisons R2-000022 and R2-000023

Work item:

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

Reason for change: This CR aligns the R1 and R2 specifications according to the Liaisons R2-000022 and R2-000023 (from R1).

Clauses affected: 4.4.2.1.1, 4.4.2.1.2, 4.4.2.2

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

Other comments:

help.doc

<--------- double-click here for help and instructions on how to create a CR.

4.4.2.1.1 Operation and specification of idle periods

To support time difference measurements that need to be made for location services there needs to be Idle Periods created in the DownLink (IPDL) during which time all channels from a node B are temporally seized. During these Idle Periods the visibility of neighbour basestations from the UE is improved thus allowing the measurements to be performed.

The Idle Periods are arranged in a predetermined pseudo random fashion according to higher layer parameters, these parameters are used by layer 1 to arrange and use these Idle Periods. Idle Periods differ from compressed mode in that they are shorter in duration, all channels are silent simultaneously, and no attempt is made to prevent data loss.

In general there are two modes for these Idle Periods:

- Continuous mode, and
- Burst mode

In continuous mode the Idle Periods are active all the time. In burst mode the Idle Periods are arranged in bursts where each burst contains enough Idle Periods to allow a UE to make sufficient measurements for its location to be calculated. The bursts are separated by a period where no Idle Periods occur.

~~There are several requirements on the provisioning of idle periods, listed in the following:~~

~~System requirements:~~

- ~~Many idle period pseudo random patterns~~
- ~~Co-located sectors shall have the same idle period timing~~

~~Operator flexibility:~~

- ~~Continuous operation or activated on demand~~
  ~~Variable average frequency of idle periods~~
- ~~Variable idle period length~~
  ~~Burst mode for regular updating of location~~

~~Implementation restrictions:~~

- ~~Minimum spacing between idle periods~~
- ~~Maximum spacing between idle periods~~

The following are the parameters for the idle periods (IP) :

Parameter	Min value	Max value	Bits Required	Units (see note 1)	Description
IP_spacing	2^2+1	2^6	4	frames	Number of frames between Idle Periods.
IP_status	0	1	1	Logic Value	0 = Idle Periods active in continuous mode 1 = Idle Periods active in burst mode
IP_length	5	10	1	symbols	Length of Idle Periods
IP_offset	0	15	4	Symbols	A cell specific offset (can be used to synchronise Idle Periods from different sectors within a node B).
Max_dev	140	145	0 (depends on IP length)	Symbols	Maximum deviation in time from beginning of frame
Seed	0 - 63			(no units)	Seed for random function "rand(x)"
rand(x)	= (106.rand(x-1) + 1283)%6075, rand(0)=seed				Random function used in the calculation of the Idle Periods. Note: rand(0) = Seed.
IP_position(x)	= x*~~.~~IP_spacing*150 + rand(xmod64)mod~~%~~Max_dev+IP_offset			Symbols	Function for generating the exact positions of the x^{th} Idle Period. (see notes 2 & 4 below)
Extra parameters used in the case of burst mode operation (i.e. IP_status = 1)					
Burst_Start	[0]	$[2^4-1]*256$	[4]	SFN (in steps of 256 frames)	The frame number where the 1^{st} Idle Period Burst occurs within an SFN cycle.
Burst_Length	[10]	$[10+2^4-1]$	[4]	Ips	Number of Idle Periods in a 'burst' of Idle Periods
Burst_freq	$[2^8]$	$[2^{12}]$	[4]	Frames	Number of 10ms frames between consecutive Idle Period bursts.

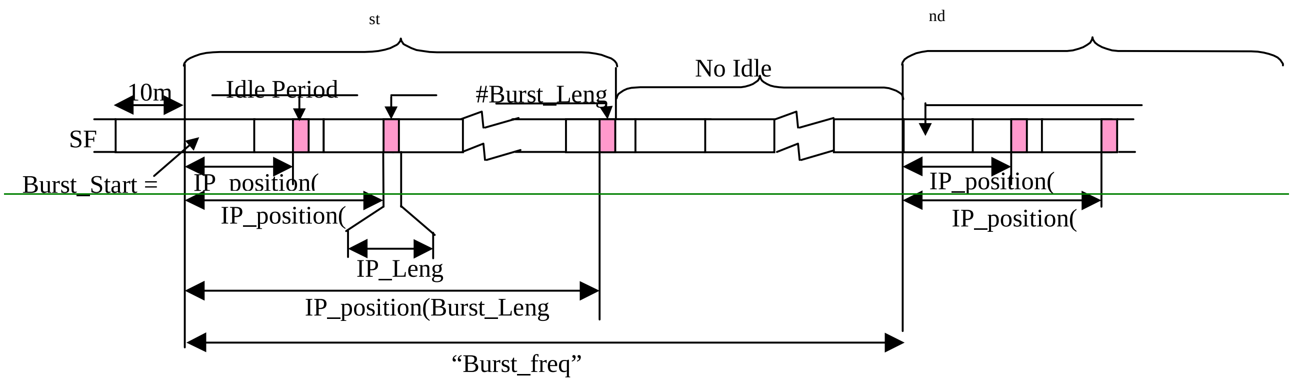
NOTE 1: The unit 'symbol' refers to symbols on the CPiCH channel.

NOTE 2: The function IP_position(x) yields the position of the x^{th} Idle Period relative to a) the start of the SFN cycle when in continuous mode or b) the start of a burst when in burst mode.

NOTE 3: The operator "%" denotes the modulo operator

NOTE 4: Regardless of mode of operation, the Idle Period pattern is reset at the start of every SFN cycle.

NOTE 5: Continuous mode can be considered as a specific case of the burst mode with just one burst spanning the whole SFN cycle. Note also that x will be reset to x=1 for the first idle period in a SFN cycle for both continuous and burst modes and will also, in the case of burst mode, be reset for the first Idle Period in every burst.



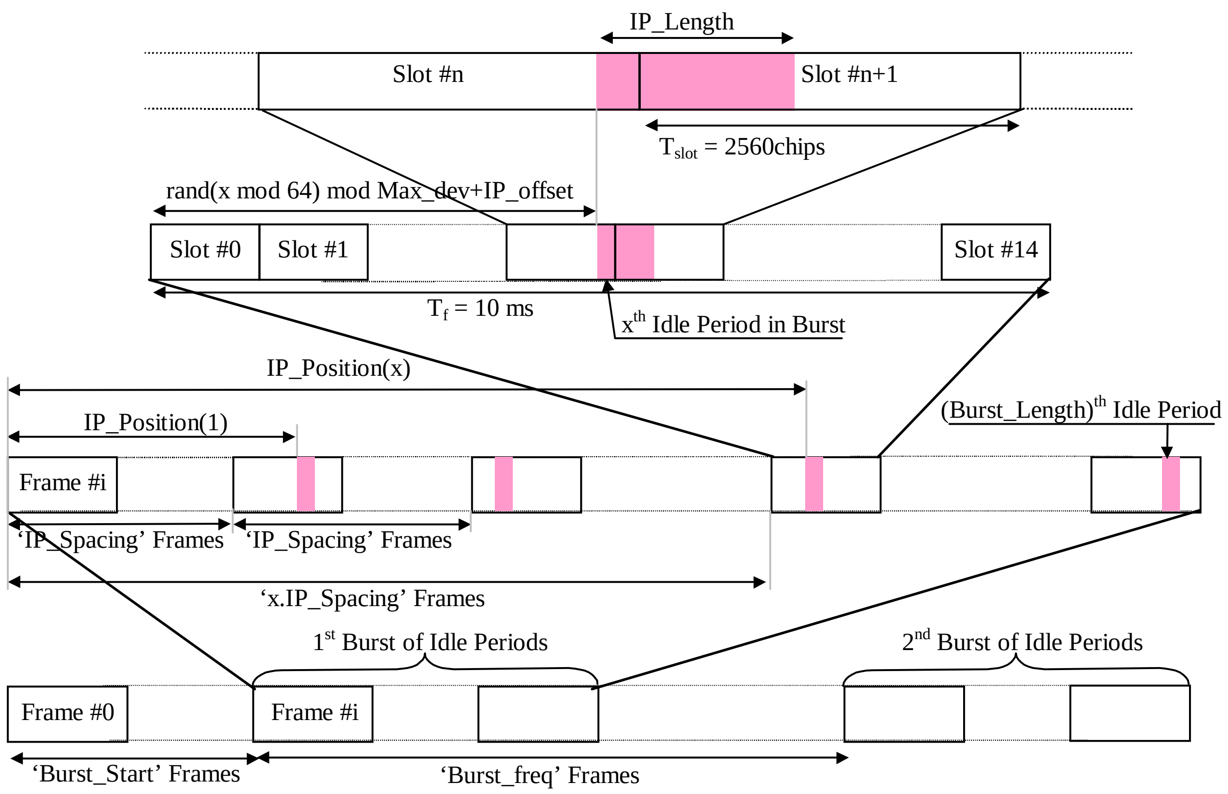


Figure 4.2: IPDL Timing

~~4.4.2.1.2 Time Aligned IPDL~~

~~Use of the Time Aligned method is dependent upon there being a demonstrated benefit at layer 1 and limited signalling overhead at layer 3.~~

~~In areas where traffic is high or pilot visibility is low (due for example to irregular site topology or low pilot levels), it is possible to configure IPDL in order to further increase the probability of accurate TDOA measurements. This can be achieved by approximately time aligning the occurrences of idle periods, and enabling CPICH transmission during some of these periods. The alignment can typically be to within half a CPICH symbol.~~

~~During the 'common' idle period, the node B transmits the CPICH randomly, pseudo-randomly or periodically. Thus in each idle period, the only radio activity will be due to the CPICH and in addition, only a fraction of node B's are active (and this set will change for different idle periods). Finally, it is also possible to increase the CPICH power during the idle period in order to increase range for location purposes.~~

~~In this configuration, location performance is not dependent on the traffic load. Additionally, it is possible to increase the range of pilots in rural areas or for indoor coverage purposes .~~

~~Idle period alignment requires that the offsets between the transmission times of each node B be known, ideally to a resolution better than half a symbol period i.e. 33.33 µs or less. Due to drift between different node Bs the idle period timing will need to be updated at regular intervals. The update rate is a function of network clock stability.~~

~~Measurement of time offsets can be achieved in a number of ways. A possible option is for these to be estimated by the LMUs (Location Measurement Units) which may be employed to measure the node B transmission time offsets so as to enable TOA based location as discussed in section 4.4.2.~~

~~In comparison with standard IPDL, the UE requires similar information regarding the occurrences of idle periods. Since each node B is active during a fraction of the idle periods only, complexity reduction at the UE can be obtained if knowledge of the actual activity of node Bs in the idle periods is provided, via additional signalling. In the RAN, the additional requirements to standard IPDL are:~~

~~(a) the node B should be able to leave the CPICH on in some of the periods, possibly ramping up the power if requested to do so~~

~~(b) signalling from the UTRAN Position Radio Resource Management (U-PRRM) to the node B is required to maintain partial synchronisation.~~

~~The following table provides a set of parameters which may be used to configure idle periods for both time aligned and non-time aligned operation.~~

Parameter	Min value	Max value	Bits Required	Units (see note 1)	Description
IP_spacing	2	72	4	frames	Number of frames between Idle Periods (4 bit represent exponents in $2^i x2^j x3^k x3^l$)
IP_status	0	1	1	Logic Value	0 = Idle Periods active in continuous mode 1 = Idle Periods active in burst mode)
TA_status	0	1	1	Logic value	0 = Time Alignment not enabled 1 = Time Alignment enabled
IP_length	3	10	2	symbols	Length of Idle Periods
Max_dev (S)	140	145	0 (depends on IP length)	symbols	Maximum deviation in time from beginning of frame
Seed (S)	0-63			no units	Seed for random function "rand(x)"
rand(x) (S)	= (106.rand(x-1) + 1283)%6075				Random function used in the calculation of the Idle Periods. Note: rand(0) = Seed.
IP_position(x)	= x.IP_spacing *10 + rand(x)%Max_dev +(IP_offset/2)			symbols	Function for generating the exact positions of the x^{th} Idle Period. (see notes 2 & 4 below) For standard IPDL, IP_offset=0 For TA IPDL, Max_dev=0
Extra parameters used in the case of the time aligned configuration					
IP_offset (T)	0	2^{15}-1	15	Half symbol	Offset giving start of idle period with respect to reference point
IP-CPICH_up (T)	0	15	4	dB	CPICH power step up relative to current level
IP_TA_prob (T)	0.2	0.5	4	-	Probability of CPICH being on during idle period
IP_TA_seed (T)	0	63	6	-	Number used to point to CPICH power on pattern in TA mode, actual pattern is for FFS (same pattern must be provided to co-located cells)
Extra parameters used in the case of burst mode operation (i.e. IP_status = 1)					
Burst_Start	[0]	[2^4-1]*256	[4]	SFN (in steps of 256 frames)	The frame number where the 1st Idle Period Burst occurs within an SFN cycle.
Burst_Length	[10]	[10+2^4]	[4]	IPs	Number of Idle Periods in a 'burst' of Idle Periods
Burst_freq	[2^8]	[2^{12}]	[4]	frames	Number of 10ms frames between consecutive Idle Period bursts.

~~NOTE 1: The unit 'symbol' refers to symbols on the CPiCH channel.~~

~~NOTE 2: For standard IPDL, the function IP_position(x) yields the position if the x^{th} Idle Period relative to a) the start of the SFN cycle when in continuous mode or b) the start of a burst when in burst mode. For the TA configuration the function IP_position(x) always yields the position of the x^{th} Idle Period relative to the start of the SFN cycle (in this case, the burst parameters in burst mode define the frames when IPs are enabled).~~

~~NOTE 3: The operator "%" denotes the modulo operator~~

~~NOTE 4: Regardless of mode of operation (except TA), the Idle Periods pattern is reset at the start of every SFN cycle. For TA, the IP spacing must be kept across SFN boundaries, hence the first IP_position after a new SFN cycle should be calculated modulo (no of symbols in SFN cycle).~~

~~NOTE 5: (S) refers to parameter required only in standard IPDL, (T) refers to parameter required only in time aligned configuration~~

~~4.4.2.2 Accuracy~~

~~In the OTDOA technique, generally, the location is being determined by means of an estimate of the transit time (time-of-flight) of the radio signals. The radio path and the geographical path are assumed to be the same with unobstructed line-of-sight. The radio signals travel about 0,3 metres per nanosecond. To achieve an uncertainty of less than 50 metres in the location estimate requires an uncertainty in timing of less than 166 nanoseconds. With a 4 Mchip/s rate, the chip duration is 250 nanoseconds and ultimately, LCS requires timing measurements of the radio signals to the sub-chip level. Many current receivers are capable of combining multipath signal components to the sub-chip level of timing (often to better than 1/4 chip), and so such timing accuracy is already available, although in a different form.~~

~~The radio signal path is, unfortunately, not always equal to the geographic separation. The effects of multipath and obstructions combine to make the radio path typically longer (but never shorter) than the geographic path. A distance estimate derived from radio signal timing will generally be longer than the true distance. The techniques to mitigate the effects of multipath in the LCS are beyond the scope of this specification and are, in any case, subjects of current active technology research. These can be expected to improve with experience in system operation and the measurement function and calculation function designs can be expected to evolve to give better performance over the lifetime of deployed UTRAN LCS.~~

~~The accuracy of the location estimate may thus vary from area to area within an operator's territory due to the effects of multipath propagation. Some operators may choose to add extra base stations or extra transmissions to provide better location service accuracy in areas they deem critical for their service. Other operators may choose to have fewer base stations and consequently a lower accuracy service in some areas.~~

~~The objective is to provide the best estimate available with the equipment, measurements and propagation conditions prevailing at the time and place of the UE. Not all results will be of the same precision and there is a cost associated with increased precision. Making use of a downlink based measurement technique minimises the network traffic and provides a system that scales with increased usage by UE. In some jurisdictions, the equipment must meet some minimum requirements to satisfy regulatory requirements for accuracy of the location service (e.g. the FCC in the United States) and this must be taken into consideration in the design of equipment for operation in these areas.~~

~~Generally the measurement of location is a statistical process and not all measurements of the same location will yield the same result. The overall system accuracy of its reports (e.g. less than 50 metres error in 80% of measurements) will involve a statistical measure of many operations at may times and at many locations through the UTRAN coverage area. The accuracy reported together with an individual report must take into account the individual measurements, environmental conditions and the time of the measurement. The accuracy reported for an individual measurement may vary considerably from the overall system performance statistic.~~

3GPP/SMG Meeting RAN WG2 #11
Turin, Italy, 28th Feb - 3rd Mar 2000

Document ***R2-000536***

e.g. for 3GPP use the format TP-00xxxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.305 **CR** **010r3** Current Version: 3.0.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to: TSG-RAN #7	for approval	X	Strategic		*(for SMG use only)*
list expected approval meeting # here ↑	For information		non-strategic		

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

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

Source: TSG-RAN WG2 **Date:** 25th Feb 2000

Subject: OTDOA – GPS Location Procedures

Work item:

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

Reason for change: Inclusion of the signalling flows for UE to S-RNC signalling

Clauses affected: New section 6.2.4.2

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

Other comments:

help.doc

<--------- double-click here for help and instructions on how to create a CR.

6.2.4.2 Signalling between RNC and Target UE

The location Request to UE signaling flow is generic for all UE based or assisted location methods (OTDOA and Network Assisted GPS).

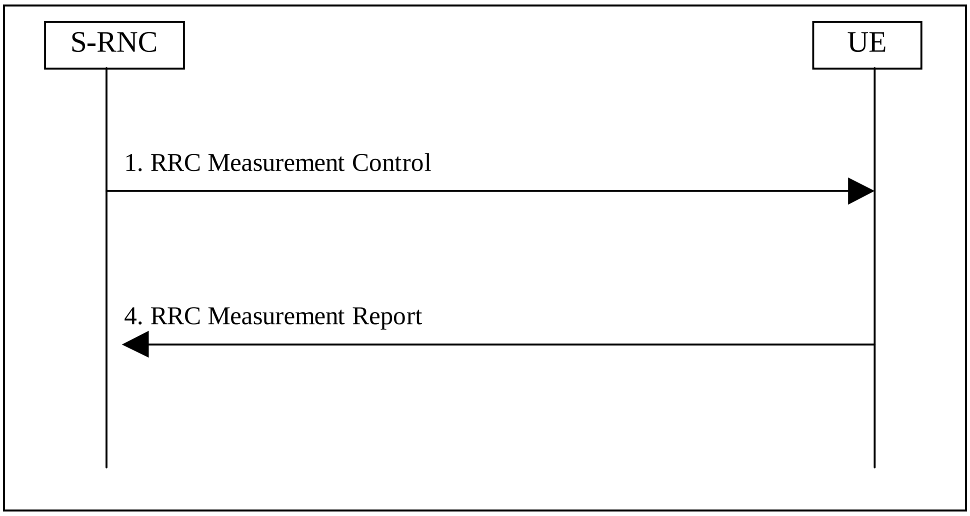


Figure aa OTDOA /GPS Location Message Flow

1. The S-RNC determines possible assistance data and sends a MEASUREMENT CONTROL request to theUE.

2. Provided that location request meets the privacy criteria, the UE performs the requested measurements. If the UE is able to calculate its own location, and this is requested, the UE computes a location estimate based on measurements. Any assistance data necessary to perform these operations will either be provided in the MEASUREMENT CONTROL request or be available from broadcast sources. The resulting measurements or location estimate are returned to UTRAN in a MEASUREMENT REPORT response. If the UE cannot fulfil the request, a MEASUREMENT CONTROL FAILURE message is returned.

6.2.4.2.1 Assistance Data Delivery to UE

The assistance data signaling flow illustrated here is generic for UE based location methods, including OTDOA and Network Assisted GPS. Note that if the assistance data is sent as part of a broadcast message, then no assistance data acknowledgement is required.

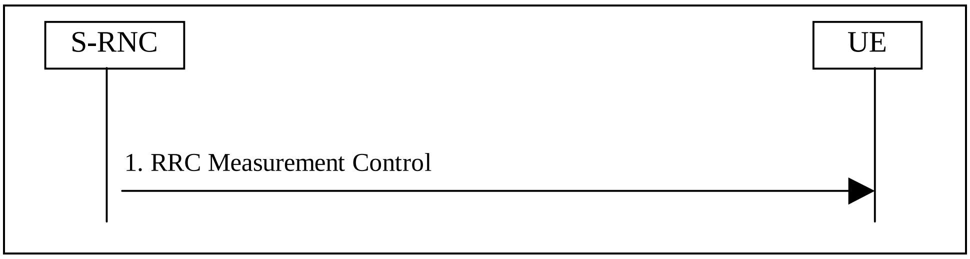


Figure bb OTDOA or GPS Assistance Data Delivery Flow

(1) The S-RNC determines assistance data and sends it in the RRC MEASUREMENT CONTROL message to the UE.

6.2.4.2.2 Error Handling

6.2.4.2.3 Broadcast of Assistance Data

In the UE Based OTDOA or Network Assisted GPS methods, where the measurements and/or location calculation is done in the UE, assistance data may be broadcast to the UE.

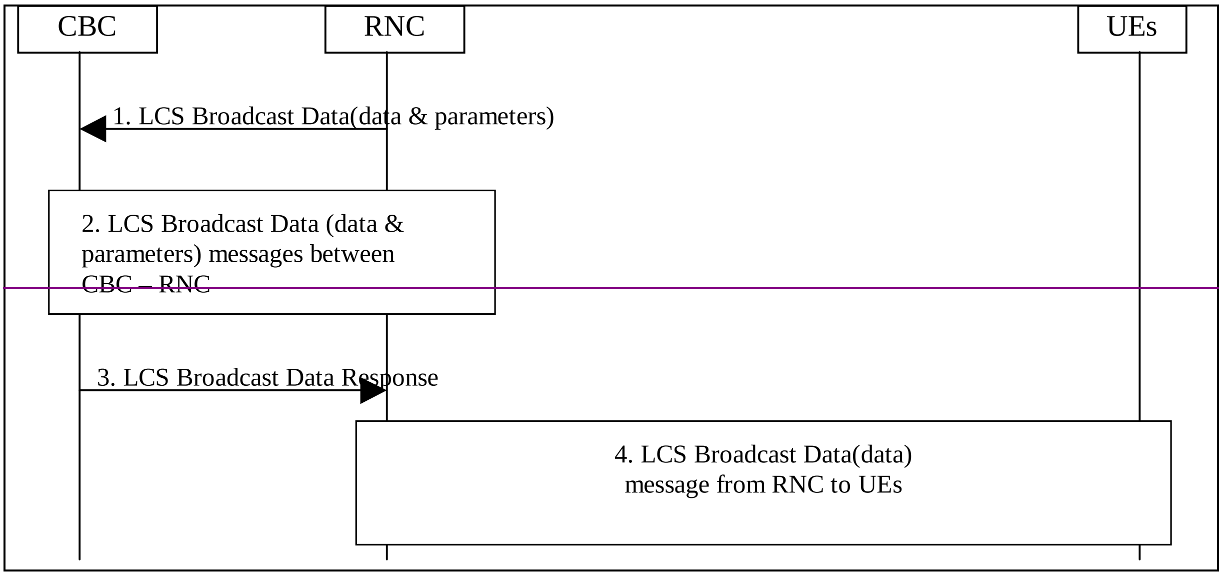
The assistance data to be broadcast for UE Based OTDOA contains the Relative Time Difference (RTD) values (e.g. in case of a non-synchronized network) and base station coordinates. In addition, the broadcast data may contain other information to simplify the OTDOA measurements.The length of the message depends on how many neighbours are included in the assistance data. Part of the broadcast message (e.g. the serving and neighbour base station geographic coordinates) may be ciphered.

Part of the broadcast message (e.g. the GPS differential corrections) may be ciphered.

The broadcast channel that is used for the OTDOA and GPS assistance data makes use of the common UTRAN broadcast service~~ or of the Cell Broadcast Service~~.

~~6.2.4.2.4~~ 3.1 ~~Point-To-Multipoint~~ Signalling Flow for ~~Assistance Data Broadcast Flow~~Using CBS

~~This signaling flow is generic for UE based location methods (OTDOA or Network Assisted GPS). The Assistance Data Broadcast Message is created in the RNC and the message (including the ciphered parts and parameters to control the broadcast) is transferred from the RNC to the CBC. The cell broadcast service is used for the LCS assistance data broadcast. Prior to receiving the first scheduled broadcast message, the UE should read the first block of each message lot to be able to receive the LCS Broadcast Data or the schedule message. After receiving the schedule message, the UE should receive the LCS Broadcast Data messages according the schedule information.~~



~~**Figure dd - Broadcast Data Flow**~~

~~1.The RNC sends the complete broadcast message to CBC with LCS Broadcast Data message. This LCS Broadcast Data message contains the data to be broadcast as well as parameters which indicate to which Node-B the broadcast message is targeted and when the broadcast should happen. The LCS~~

~~Broadcast Data message may also contain the scheduling information which is broadcast to the UEs in order that they can utilize a discontinuous reception technique.~~

~~2.The CBC transfers the broadcast message to the RNC.~~

~~3.The LCS Broadcast Data Response message from the CBC to RNC is used to indicate that the LCS Broadcast Data request has been fulfilled. This response message is optional.~~

~~4.The RNC starts the broadcast message transfer to UEs.~~

~~Note : Implementations that have the CBC integrated into RNC may use other message signalling.~~

6.2.4.2.4~~3.2~~ Signalling Flow for Assistance Data Broadcast Using the Common UTRAN Broadcast Service

The assistance data broadcast to UEs can be signalled via the RRC Measurement Control meassage as shown in section 6.2.4.2 or it can be broadcast by the UTRAN within the system information.

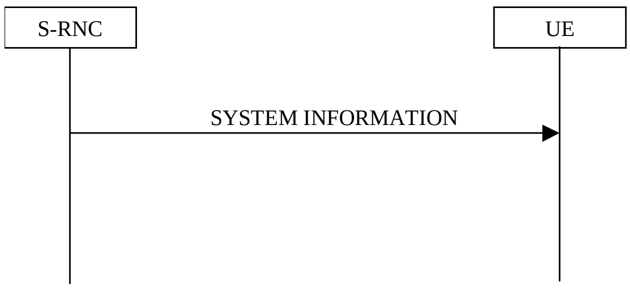


Figure xx: Broadcast of system information

6.2.4.2.5 LCS Assistance Data Ciphering

To allow control of access to the assistance data, parts of the broadcast assistance data may be ciphered. Ciphering is done with a specific ciphering key delivered by the core network for this purpose. The management of the key is described in the System Aspects Stage 2 ([xx] = 23.171).

6.2.4.2.6 LCS Assistance Data Ciphering Algorithm

Editor's note : The text below is inherited from GSM. The choice of the algorithm should be discussed in 3GPP/SA. It can also be chosen to put this text in the System Aspect Stage 2.

The algorithm used for ciphering the LCS assistance data is the standard 56-bit Data Encryption Standard (DES) algorithm.

The deciphering of broadcast assistance messages is done in the UEs. The deciphering will utilize the deciphering keys delivered during the location update request.

The RNC ciphers the parts of the LCS Broadcast Data message to be protected using the 56-bit DES algorithm and a ciphering keys (56 bits) and Ciphering Serial Number (16 bits) for the broadcast location area.

The ciphered part is variable in length with one bit resolution. By using the LCS Broadcast Data message header, the UEs can determine what part of message is ciphered.

Inputs to the 56-bit DES algorithm are the following:

- 56-bit key K (deciphering key)
- 16-bit Ciphering Serial Number from broadcast message which is denoted here by IV (Initialization Vector)
- plain-text bits (the ciphered part of broadcast message)

The ciphering process is illustrated in the following diagram. Ciphering is done by producing a mask bit stream which is then "XORed" bit-by-bit to the plain-text data to obtain the cipher-text data. First, the Initialization Vector (IV) is concatenated with 0-bits in order to achieve a 64-bit block I_1. This block is then encrypted by the DES algorithm using the key K. Output is a 64-bit block I_2. This constitutes the first 64 bits of the mask bit stream. If the message is longer than 64 bits, then more bits are needed. These are produced by encrypting I_2 again by the DES algorithm using the key K. The output is a 64-bit block I_3. This is the next 64 bits of the mask bit stream. This iteration is continued until enough bits are produced. The unnecessary bits from the last 64-bit block I_j are discarded. The figure below illustrates the first two mask bit generations and the two ciphered 64-bit blocks.

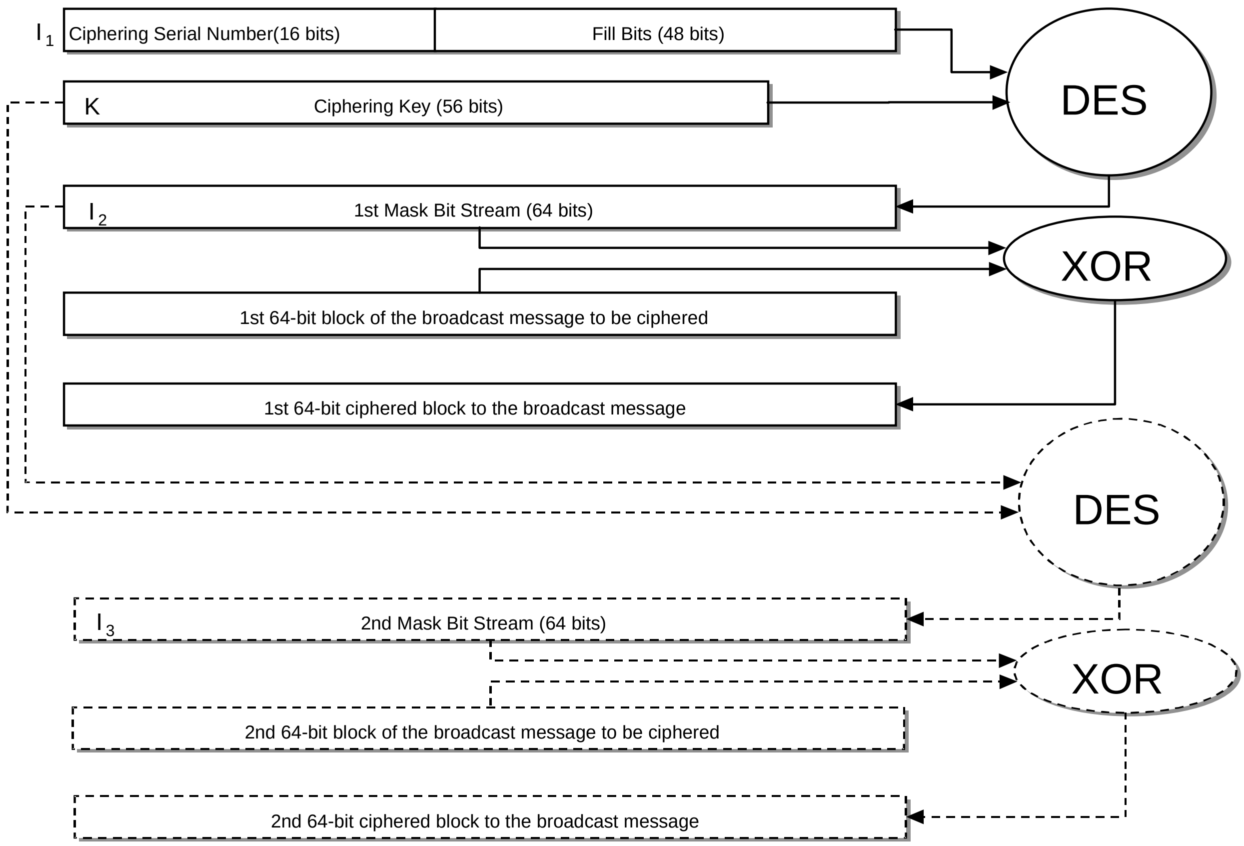


Figure ee: Data Assistance Ciphering Algorithm

Deciphering is done similarly. The same mask bit stream is produced and these are XORed, bit-by-bit, to the cipher-text data bits. The result will be the plain-text data.

3GPP TSG RAN WG2 #11
Turin, Italy, 28 Feb – 3 Mar 2000

Document R2-000530
e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.305	**CR**	**011r1**	Current Version:	3.0.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to:	TSG-RAN #7	for approval	X	strategic		*(for SMG use only)*
list expected approval meeting # here ↑		for information		non-strategic		

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

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

Source: TSG-RAN WG2 **Date:** 29.02.2000

Subject: Clarification of the different LMU types

Work item:

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

Reason for change:

In the current version of TS 25.305 the signalling aspects related to Location Measurement Units (LMUs) are unclear. This CR attempts to clarify these issues by stating that for LMUs associated with Node B:s use NBAP. For standalone LMUs the signalling is done over the Uu interface, but the actual protocol used for signalling is not yet defined.

Clauses affected: 5.5.3

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

Other comments:

help.doc

<--------- double-click here for help and instructions on how to create a CR.

5.5.3 Location measurement unit (LMU)

There are two types of LMU, the LMU associated with the Node-B and a "stand-alone LMU". The associated LMU signalling is associated with a Node-B, and the "stand-alone LMU" signalling passes over the Uu interface. The associated LMU signalling protocol is the NBAP. The protocol for stand-alone LMU signalling has not been defined yet.

[NOTE: The stand-alone LMU signalling protocol could be e.g. RRC or LLP, but this is still for further study.]

The Location Measurement Unit LMU entity makes measurements (e.g. of radio signals) and communicates these measurements to the PRCF. The LMU contains a PSMF and also may also perform calculations associated with the measurements.

The LMU may be associated with the Node-B and make use of its radio apparatus and antennas. Alternatively, the LMU may be separated from the Node-B, but communicate with the PRCF via the Node-B Iub interface. These "Independent LMU" may communicate to the PRCF via the Uu interface or may otherwise communicate to the PRCF (through an interface yet to be defined).

The LMU may make its measurements in response to requests (e.g. from the PRCF), or it may autonomously measure and report regularly (e.g. timing of Node-B transmissions) or when there are significant changes in radio conditions (e.g. changes in the RTD).

There may be one or more LMU associated with the UTRAN and an LCS request may involve measurements by one or more LMU. The LMU may be of several types and the PRCF will select the appropriate LMUs depending on the LCS method being used.

The LMU may be used, for example, to measure UTRA radio transmissions either uplink or downlink. These measurements may be made either, for example, to locate the UE or to measure a system parameter needed by the LCS system such as the timing offset (RTD) of transmissions of two or more base stations. The LMU may also measure other transmissions, such as those of satellite navigation systems (i.e. the Global Positioning System (GPS)) and either report the measurements for use by the PCF of the LCS system, or report the location results as determined by internal calculations of the LMU.) The details of the measurements to be made by the LMU will be set by the chosen LCS method.