



ATIS-0700002

**UTDOA Lbis Interface:
Architecture and Functional Description**

TECHNICAL REPORT



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ATIS-0700002, *UTDOA Lbis Interface: Architecture and Functional Description*

Is an ATIS Standard developed by the **UTDOA Ad Hoc Committee** under the **ATIS Wireless Technologies and Systems Committee (WTSC)**.

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Technical Report on

UTDOA LBIS INTERFACE: ARCHITECTURE AND FUNCTIONAL DESCRIPTION

Secretariat

Alliance for Telecommunications Industry Solutions

Approved August, 2004

Abstract

This Technical Report describes how the UTDOA position determination system for locating mobile stations may be applied to GSM networks in a manner consistent with 3GPP and other relevant standards. UTDOA (uplink time difference of arrival) is one of the location technologies identified in the 3GPP GSM standards. The Lbis interface and Remote PDE Protocol (RPP) enable upgrading earlier proprietary implementations of UTDOA to a standards-based solution with minimal impact to the network infrastructure. This document is the first of a three-part set that describe the Lbis interface and RPP in detail. This document describes the functional architecture and the location procedures using call flow diagrams (stage 2 description). The other two documents will describe, separately, the signaling and OAM protocols (stage 3 description). Informative Annexes to this document cover discussions and concerns raised in the UTDOA technical community during the development of the Lbis interface.

FOREWORD

The Alliance for Telecommunication Industry Solutions (ATIS) serves the public through improved understanding between carriers, customers, and manufacturers. The Wireless Technologies and Systems Committee (WTSC) – formerly T1P1 -- develops and recommends standards and technical reports related to wireless and/or mobile services and systems, including service descriptions and wireless technologies. WTSC develops and recommends positions on related subjects under consideration in other North American, regional and international standards bodies.

This document is entitled *UTDOA Lbis Interface: Architecture and Functional Description*.

This technical report is intended for use in conjunction with standard T1.3GPP.22.071: Location Services (LCS)-Stage 1 and T1.3GPP.23.271: Technical Specification Group Services and System Aspects; Functional stage 2 description of LCS.

Footnotes are not officially part of this document.

Future control of this document will reside with Alliance for Telecommunications Industry Solutions. This control of additions to the specification, such as protocol evolution, new applications, and operational requirements, will permit compatibility among U.S. networks. Such additions will be incorporated in an orderly manner with due consideration to the ITU-T layered model principles, conventions, and functional boundaries.

Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, WTSC Secretariat, 1200 G Street NW, Suite 500, Washington, DC 20005.

Committee WTSC chartered the UTDOA Ad Hoc Committee to provide technical assistance in reviewing this report.

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Technical Report on –

UTDOA Lbis Interface: Architecture and Functional Description

INTRODUCTION/EXECUTIVE SUMMARY

This document describes the GSM architectural enhancements and related functional procedures for realizing a UTDOA positioning method solution using the Lbis interface defined here. Reference ATIS-0700003 August 2004, UTDOA Lbis Interface: Remote PDE Protocol (RPP) describes an implementation of the Lbis signaling protocol, and reference. The other interfaces and procedures supporting the GSM UTDOA solution are part of the 3GPP-defined GSM specifications (see Normative References in Clause 2 below)

This document is published as a Technical Report and not as a Technical Standard. The principal reason for a “TR” rather than a “TS” is that the 3GPP standard identifies the operation of the PDE within the SMLC as being up to the vendors. Nothing in this report is intended to limit, amend, or detract from the published 3GPP and T1 standards relevant to the support of location services within a wireless, digital network. What is offered here, rather, is an approach to implementing a remote PDE such as UTDOA in a digital network such as GSM as defined in 3GPP standards.

Three informative annexes are attached to this report describing, respectively,

- ◆ Annex A: Engineering analysis of UTDOA in the GERAN environment
- ◆ Annex B: Potential security and privacy issues in Lbis implementation
- ◆ Annex C: An overview and historical perspective on the efforts to integrate UTDOA with GSM.

1 SCOPE, PURPOSE, AND APPLICATION

This document addresses integration of an uplink TDOA positioning technology as a remote PDE operating within a GERAN complex as defined in 3GPP Release 6.0. This integration constitutes vendor implementation details of a Location System. 3GPP standards for LCS identify such details as are presented here as being outside the scope of the 3GPP standards. The purpose here, then, is to provide a full description of implementation of a remote PDE such as might be employed in support of an LCS client such as an emergency services (ES) public services access point (PSAP)

The Lbis interface is applicable to North American GSM networks using UTDOA in support of E911 Phase 2 emergency services. The interfaces, protocols, and methods described here are potentially applicable to the integration of other remote PDEs to GERAN and/or UTRAN complexes.

2 NORMATIVE REFERENCES USED IN THIS TECHNICAL REPORT

This technical report is not a standard, and contains no normative references of its own. All standards referred to in the report are subject to revision, and the parties to agreements based on this report are encouraged to investigate the possibility of applying the most recent edition of the standards and reports indicated below.

ATIS-0700003 August 2004, *UTDOA Lbis Interface: Remote PDE Protocol (RPP)*.¹

IETF RFC793, *Transmission Control Protocol*.²

T1.3GPP.49.031 v6.1.0, *Base Station System Application Part; LCS Extension (BSS-LE)*.¹

T1.3GPP.48.071 v.6.3.0, *Serving Mobile Location Center - Base Station System (SMLC-BSS) interface; Layer 3 specification*.¹

T1.3GPP.43.059 v6.1.0, *Functional stage 2 description of Location Services (LCS in GERAN)*.¹

T1.3GPP.22.071, *Location Services (LCS)-Stage 1*.¹

T1.3GPP.23.271, *Technical Specification Group Services and System Aspects; Functional stage 2 description of LCS*.¹

3 DEFINITIONS

3.1 Lbis: An interface between a GERAN-defined SMLC and a remote PDE controller such as may be employed in commercially available UTDOA systems.

4 ABBREVIATIONS, ACRONYMS, AND SYMBOLS

Table 1 provides project-specific terms and acronyms used in this document.

Table 1: Abbreviations & Acronyms

3GPP	Third Generation Partnership Project
A	Interface between MSC and BSS (A-interface)
Abis	Interface between the BSC and BTS (Abis-interface)
AMU	Abis Monitoring Unit, a network monitor used to identify ES calls and call parameters
ARFCN	Absolute Radio Frequency Channel Number
BSC	Base Station Controller
BSS	Base Station Subsystem
BSSAP-LE	Base Station Subsystem Application Part - LCS Extension
BSSLAP	BSS LCS Assistance Protocol
BTS	Base Transceiver Station
CGI	Cell Global Identifier
CI	Cell Identity
CR	Change Request
CS	Circuit Switched
DTM	Dual Transfer Mode
DTX	Discontinuous Transmission

¹ This document is available from the Alliance for Telecommunications Industry Solutions (ATIS), 1200 G Street N.W., Suite 500, Washington, DC 20005. < <https://www.atis.org/docstore/default.aspx> >

² This document is available from the Internet Engineering Task Force (IETF). < <http://www.ietf.org> >

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EOTD	Enhanced Observed Time Difference
ES	Emergency Services
ESME	Emergency Services Messaging Entity
GSM	Global System for Mobile Communications
GPS	Global Positioning System
HSCSD	High Speed Circuit Switched Data
HSN	Hopping Sequence Number
IP	Internet Protocol
LAC	Location Area Code
Lb	Interface between BSC and SMLC (Lb-interface)
Lbis	Interface between SMLC and PDE (Lbis-interface)
LCS	Location Services
LMU	Location Measurement Unit
MAIO	Mobile Allocation Index Offset
MCC	Mobile Country Code
MNC	Mobile Network Code
MS	Mobile Station
MSC	Mobile Switching Center
O&M	Operations & Maintenance
PCF	Position Calculation Function
PDE	Positioning Determination Entity
QoS	Quality of Service
RAN	Radio Access Network
RDSP	RAN Data Synchronization Protocol
RF	Radio Frequency
RP	Remote PDE
RPP	Remote PDE Protocol
RR	Radio Resources
RRFCN	Relative Radio Frequency Channel Number
RT	Response Time
SACCH	Slow Associated Control Channel
SCCP	Signaling Connection Control Part
SDCCH	Stand-Alone Dedicated Control Channel
SID	Silence Descriptor
SMLC	Serving Mobile Location Center
TCH	Traffic Channel
TCH/F	A full rate TCH
TCP	Transmission Control Protocol
TDMA	Time Division Multiple Access
TDOA	Time Difference Of Arrival
TMSI	Temporary Mobile Subscriber Identifier
TN	Timeslot Number
TOA	Time Of Arrival
TSC	Training Sequence Code

UTDOA	Uplink - Time Difference Of Arrival
Um	Interface between MS and BSS (Um-interface)
VBS	Voice Broadcast Service
VGCS	Voice Group Call Service
VLR	Visitor Location Register

5 NETWORK ARCHITECTURE, UTDOA ADDITION TO BSS

5.1 Lbis Functional Architecture

The Lbis architecture consists of three major elements:

1. A GSM network as defined in 3GPP standards, and including an LCS capability implemented in a stand-alone SMLC through the Lb interface.
2. A UTDOA system supporting a controller
3. An interface between the SMLC and the UTDOA controller through which the SMLC is able to task the UTDOA system to perform location requests, and through which the UTDOA controller is able to report status and location results.

Other highlights of this architecture include:

- ◆ The Lbis architecture is designed to have no impact on the installation, operation, or performance of the GSM RAN complex other than uplink antenna sharing for the UTDOA LMUs.
- ◆ The Lb/Lbis interface introduced in the new architecture provides a clear and maintainable separation between the BSS and the UTDOA-specific parts, consistent with the model for RAN/PDE separation expressed in the GERAN standards.
- ◆ The Lbis architecture does not raise UTDOA to the status of a fully supported PDE within the GERAN specification for the SMLC (such as is the case for CID+TA). This is because the SMLC does not perform the PCF for UTDOA. But the Lbis architecture does define how a remote PDE, such as UTDOA, can be operated through the GSM LCS capabilities in a manner consistent with standards. The Lbis interface permits a GSM BSS system to communicate with the remote UTDOA PDE through the SMLC *as if UTDOA were inter-implemented in the SMLC*. Specifically, the new architecture employs the Lg and Lb interfaces for LCS support of UTDOA-obtained position information.

Figure 1 shows the new network architecture to support UTDOA. The UTDOA part consists of the control and positioning unit--the PDE that communicates over a new interface (Lbis) to the GSM-BSS. The PDE also supports dedicated connections to the LMUs under its direct control. The connections between the PDE and its LMUs are physically separated from the BSS complex. If the UTDOA PDE requires service from LMUs controlled by another PDE, a PDE-to-PDE connection is required (not shown in Figure 1). The LMUs are also RF-coupled to the BTS antennas to retrieve uplink bursts from the MSs.

From the BSS side, the PDE is treated as an external (remote) implementation of the UTDOA positioning method. A new interface, Lbis, is introduced to link the external PDE to the BSS complex. This Lbis interface arrangement allows for connection of a remote PDE to a BSS complex without requiring that the UTDOA PDE support full SMLC functionality. The other major benefit of this arrangement is that no new interface is required to the BSC. The BSC communicates to the remote PDE

through the Lb interface to the SMLC, just as it communicates with PDEs supported internally by the SMLC.

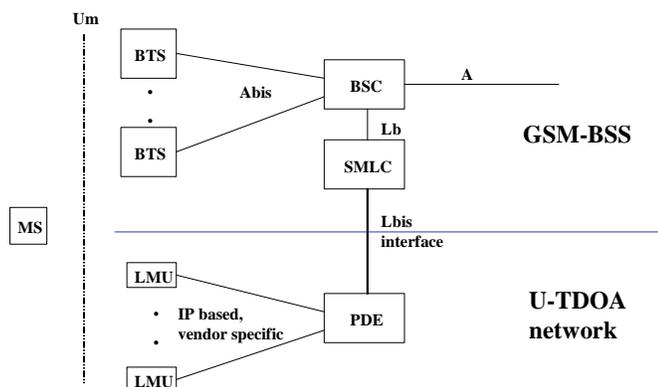


Figure 1: Lbis Network Architecture to support UTDOA

In the architecture depicted in Figure 1, the MSC identifies a call (for example an emergency call) that requires position determination of the MS. Location services activity starts when the MSC generates its PerformLocationRequest message to the GSM BSS. The A interface and Lb interface signaling used are as defined in 3GPP standards. The enhancement is that through the Lbis interface signaling, the BSS and SMLC supply the PDE with the location request and with parameters defining the radio channel used by the mobile station. The BSC ensures a unique association between the mobile station being located and the location request transactions with both the SMLC (over the Lb interface) and PDE (over the Lbis interface). This effectively provides an unambiguous mobile station identity that can be associated with a reported position from the PDE.

From the LCS perspective, other positioning methods could be supported in the same SMLC--methods such as CID+TA or GPS. The SMLC could task any PDE available to it without regard for whether the PDE and corresponding Position Calculation Function (PCF) was internal (in the SMLC) or remote as in the case of UTDOA.

Because the Lbis architecture is consistent with 3GPP GERAN standard, the architecture is adaptable to future standards enhancements in GSM BSS methods or U-TDOA features.

5.1.1 Lbis Interface

The Lbis interface defines two logical links: the RP (Remote PDE) link and optionally the RDS (Remote Database Sharing) link. The RP link carries signaling information for the actual positioning attempts. The RDS link supports administrative functions—specifically the updating of PDE databases from the SMLC. The “Data-Sharing” link is further described in the clause “OA&M architecture” of Clause 5.2 below.

The common characteristics of both links include:

- ◆ Based on TCP/IP
- ◆ Client - Server interface
- ◆ Redundant service. In keeping with general industry good practices, the Lbis interface implementation should support a configuration of at least two hardware-independent TCP/IP ports for the same service. Each client should allow configuration of two hardware-independent

links to the same service. It is not required that more than one link for the same service is actually used at one point in time. It is allowable to have only one TCP/IP port if it is hardware-redundant. In practice, the BSCs, SMLCs, and PDEs are likely to be geographically distributed. Geographical distribution implies wide-area network support for the bearer network. This applies to the RP link and the RDS link.

- ◆ One SMLC can be connected to one or more PDEs. Mapping to the PDE is on a per-BSC basis (see Figure 2)
- ◆ One PDE can be connected to one or more SMLCs (see Figure 2)

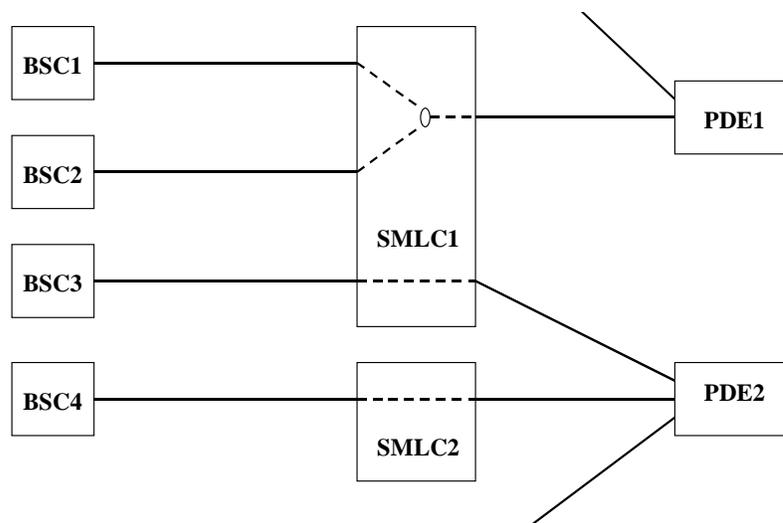


Figure 2: Multiple Lbis Links

5.1.1.1 RP Link Protocol Details

For the RP link, the PDE side is the server and the SMLC side is the client. The RP link protocol is RPP (Remote PDE Protocol). The relationships between the protocols used in the Lb and Lbis links are shown in Figure 3.

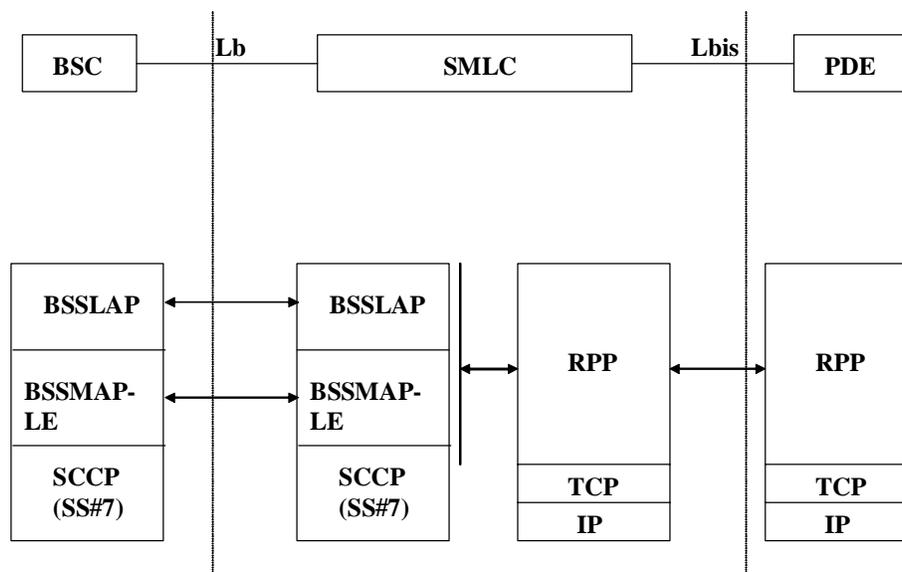


Figure 3: RPP (Remote PDE Protocol) Architecture

When the UTDOA positioning method is used, the RPP bridges relevant information between the SMLC and the PDE. One SCCP connection is established on the Lb for one individual positioning request.

5.1.2 Lb Interface

The Lb interface is defined as part of the LCS complex within the 3GPP standards. The relevant document is 3GPP TS 48.071 Version 6.3.0: *Serving Mobile Location Center – Base Station System (SMLC-BSS) interface; Layer 3 specification*. In order for the BSS to support the operation of a particular PDE, certain specific messages and parameters may need to be passed through the Lb interface. In the case of UTDOA the Lb interface supports call data including channel, frequency, and AMR status that the PDE needs in order to control the LMUs. Version 6.3.0 of 3GPP TS 48.071 supports the messages and parameters required for UTDOA operation in the Lbis architecture.

5.1.3 PDE-LMU interface

This interface is defined within the PDE “black box” model. It is beyond the scope of this document.

5.2 OA&M Architecture

General OA&M of the SMLC and PDE are not addressed in the Lbis architecture. The SMLC is typically supported in the RAN OSS; the PDE is supported in the PDE vendor’s OSS.

The Lbis architecture does address one specific aspect of OA&M. The UTDOA PDE depends on cell site data for its operation. Much of this cell site data exists in the GSM BSS. A Remote Data Sharing link is proposed to support automatic updates of the data in the PDE controller from the data in the BSS.

The abstract model associated with this automatic provisioning employs the principle that the GSM BSS maintains a set of cell records or objects that have specific data associated with them. Data includes the physical and radio description of the cell (latitude, longitude, altitude, number of sectors, power, azimuth, etc.) Each of these cells, in turn, is associated with a particular BSC. The “functional

architecture” for UTDOA in GSM identifies a particular relationship between the BSC and the PDE. The relationship is many to one; a single PDE may support location requests originating within the domain of many BSCs but only one PDE serves a given BSC. Depending on the extent of deployment of UTDOA, there may also be BSCs that are not associated with any PDE. Most important, the BSS data can change.

A key point is that the organization of the data in the BSS (by cell and by BSC) corresponds to the functional architecture for UTDOA. Furthermore, UTDOA needs accurate cell data to be associated with each BSC that it serves. For implementation-specific reasons, a PDE (or other UTDOA subsystem) may require data associated with any arbitrary set of BSCs. (The number of cells supported on a UTDOA controller can be several times larger than the number supported on a typical BSC.) The architecture also assumes support for the transfer of data from the BSS to the UTDOA controller. The benefit of this automatic transfer is to help ensure the accuracy of the data in the UTDOA system (track BSS data changes), while simultaneously reducing the cost of manual data maintenance.

Figure 4 illustrates the logical partitioning of data within the GSM BSS and the relationships between UTDOA subsystems and the BSC. As shown, in normal mode of operation, a PDE is expected to support transfer of data only from the set of BSCs that it serves and not other BSCs. However, the architecture also allows a subsystem to transfer data from an arbitrary set of BSCs, including those not served by it. This may be useful for, for example, in the case of carrier network sharing of the UTDOA infrastructure.

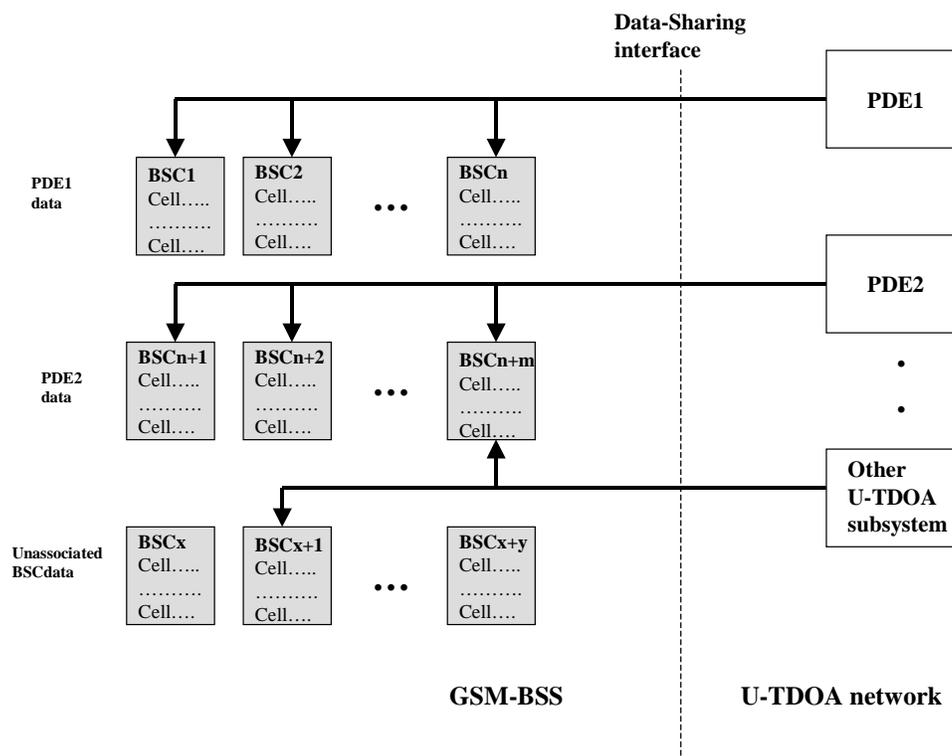


Figure 4: GSM BSS Logical Data and Interested Client Subsystems

5.2.1 Data-Sharing Interface

Cell site data used in UTDOA subsystem is available in the SMLC and BSC. A data sharing interface between the GSM BSS and UTDOA subsystems would facilitate data transfer between these subsystems and thereby simplify operations. This is a capability proposed for a RAN Database Synchronization Program (RDSP). See Figure 5 for an illustration of the relationship between the subsystems. The RDSP is proposed for future development.

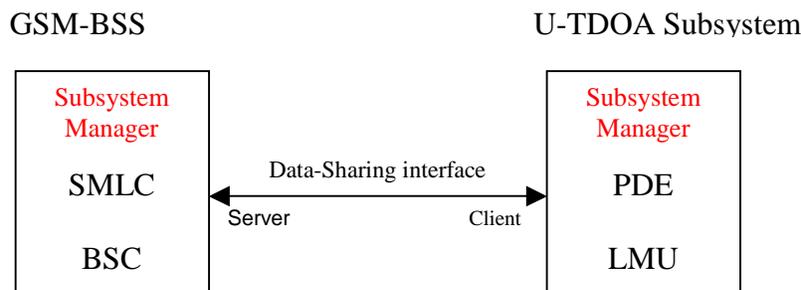


Figure 5: GSM BSS UTDOA Subsystem Interface

The GSM BSS UTDOA subsystem interface does not assume which network entities support the protocols for data sharing *within* those subsystems. For example, the data source in the BSS could be the BSC, the SMLC, or combinations of those and other network entities.

The architecture makes a clear and maintainable separation between the GSM BSS and UTDOA subsystems. These subsystems could support sharing of the GSM RAN configuration data via a defined protocol--RDSP (RAN Data Synchronization Protocol). In this architecture, the GSM BSS subsystem would be the server providing the configuration data and the UTDOA subsystem would be the client.

Using the Data-Sharing interface, a node within the UTDOA network can establish a data-sharing session with a node within the GSM BSS to collect cell site configuration data. The BSS and UTDOA vendors will define which node in the respective subsystems may be used for a Data-Sharing interface. RDSP or some other protocol could be used by the remote PDE subsystem to share operations data with the RAN or other systems. Similarly, the BSS may allow clients other than the UTDOA subsystems to access and retrieve data using a protocol set up for database administration and maintenance.

6 UTDOA POSITIONING PROCEDURE

Prerequisites: The MS has initiated a call (for example, emergency call) and is connected over the BSS to the serving MSC/VLR. In the radio interface, the MS is allocated to an SDCCH or a TCH. The MS connection is associated with an SCCP connection in the A-interface. The MSC initiates a PerformLocationRequest to determine the position of the MS.

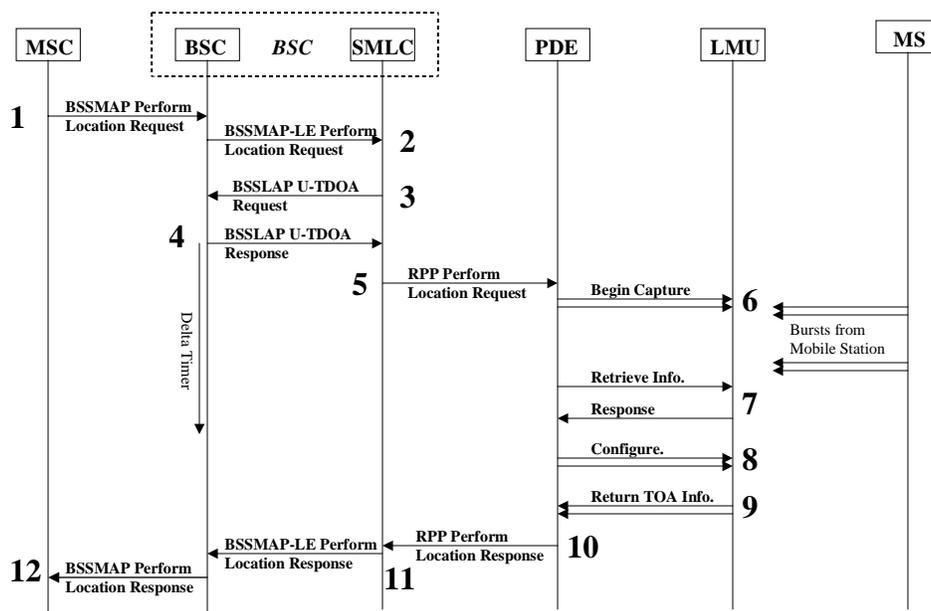


Figure 6: UTDOA Positioning Message Flow

The steps listed in Figure 6 are described as follows:

1. The message “BSSMAP PerformLocationRequest” is sent from the MSC to the BSC over the previously established SCCP connection in the A-interface (SCCPa). The MSC requests positioning of the MS associated with SCCPa.
2. The BSC forwards the message content received in 1, in the message “BSSMAP-LE PerformLocationRequest” to the SMLC. This is made with an SCCP setup request in the Lb interface (SCCPb). The SCCPa is the reference for the mobile connection in the A-interface. The SCCPb is the identification for the positioning transaction in the Lb interface. The BSC maintains an association between SCCPa and SCCPb during the whole positioning transaction over the Lb interface (2-11 in Figure 6).
3. The SMLC now determines which PDE to task to satisfy the location request (picks which method to use in determining the geographic position of the MS.) The logic used to select the particular positioning method is discussed in Clause 6.1 below. The case of interest here is selection of UTDOA. The SMLC requests radio channel information for the MS (SCCPb) from the BSC with the message “BSSLAP UTDOA Request”. An optional “Delta Timer” parameter may be included in this message. The value assigned to the “Delta Timer” is provisioned in the SMLC through the O&M control interface.
4. The BSC collects relevant information about the radio connection for the MS (see ATIS-0700003). The main parameters are serving cell identifier, radio channel description, and ciphering key. The BSC inserts the parameters in a reply message “BSSLAP UTDOA Response” to the SMLC, on the same SCCP connection as message 3 was received on (SCCPb). If the MS is not in a “steady state”, some RR procedures ongoing, the BSC awaits a “steady state” before the parameters are collected. From the point in time when the BSC has sent “BSSLAP UTDOA Response”, the BSC is responsible for supervising the MS connection for changes affecting UTDOA measurements in the radio interface.

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This supervision is controlled by a state in the BSC called UTDOA_supervision in this document. The state UTDOA_supervision has two values: ON or OFF, (default value is OFF). The supervision in the BSC starts when the BSC sends message "BSSLAP UTDOA Response" and sets the UTDOA_supervision state to ON. The supervision in the BSC ends when the first of the following events occurs.

- a. Optionally the BSC can start one timer with value "Delta Timer", when the BSC sends message "BSSLAP UTDOA Response". When this timer expires, the UTDOA_supervision state is set to OFF.
 - b. When message 11 (BSSLAP-LE PerformLocationResponse) in the sequence above is received in the BSC, the UTDOA_supervision state is set to OFF and the "Delta Timer" is stopped (if used).
 - c. If any BSSLAP message is received over the actual SCCP connection (SCCPb), the UTDOA_supervision state is set to OFF and the "Delta Timer" is stopped (if used).
 - d. If a "BSSLAP Reject" or "BSSLAP Abort" is sent to the SMLC, the UTDOA_supervision state is set to OFF and the "Delta Timer" is stopped (if used).
 - e. If BSSMAP-LE PerformLocationAbort is sent to the SMLC, the U-TDOA_supervision state is set to OFF and the "Delta Timer" is stopped (if used).
5. The SMLC uses information received in "BSSMAP_LE PerformLocationRequest" (message 2) and information received in "BSSLAP UTDOA Response" to assemble the message content for "RPP PerformLocationRequest". The SMLC also defines the Transaction_ID for use in the "RPP PerformLocationRequest", defined as Transaction_IDc in this clause of the document. The SMLC sends the complete "RPP PerformLocationRequest" to the PDE. Transaction_IDc and SCCPb from now serves as a routing key in the SMLC for messages exchange between Lb and Lbis. There is one option for parameter selection in the message "RPP PerformLocationRequest". Some parameters can be substituted with geographic position, see ATIS-0700003.
 6. The PDE, based on CGI and accuracy requirements, defines a list (positioning list) of which LMUs within its control are to be tasked for location processing. The PDE sends a message to all LMUs in the positioning list with information based on information received in the message "RPP PerformLocationRequest". The main parameters are cell definition, radio channel parameters, and capturing time. The PDE sends, in parallel, the configuration information to up to 40 individual LMUs (around 100 bytes). The selected LMUs then begin capturing, decoding, and storing the information contained in the received RF bursts on the specified radio channel.
 7. The PDE interrogates the LMU at (or closest to) the serving cell for information contained in sufficient RF bursts to meet the accuracy requirements (20 - 100 bursts). This LMU responds to the PDE with decoded burst information including time stamps (normally around 50 bursts or 4 KB).
 8. The PDE sends the information received in step 7 to the other LMUs in the positioning list (around 4 KB).
 9. The LMUs encode and modulate the captured data. A TOA value is determined and returned to the PDE.
 10. The PDE uses the received TOA values to calculate a geographic position. Standard coded positioning is transferred to the SMLC with earlier defined Transaction_ID (Transaction_IDc).
 11. The SMLC sends standard message "BSSMAP-LE Perform Location Response" to the BSC on actual SCCP connection (SCCPb).

12. The BSC relays the message contents to the MSC over SCCPa. The BSC also releases the associated SCCP connection to the SMLC (SCCPb), resets the UTDOA Supervision flag to “OFF”, and clears the Delta timer.

6.1 Selection of Positioning Method

The Lbis interface supports a model in which the SMLC manages multiple positioning methods (for example UTDOA, AGPS, CID+TA). The rules regarding which method or methods the SMLC tasks in response to a particular request for service are defined and implemented in the SMLC.

Figure 7 is the same as Figure 6, but the emphasis is on selection of the positioning method by the SMLC (shown as step 2).

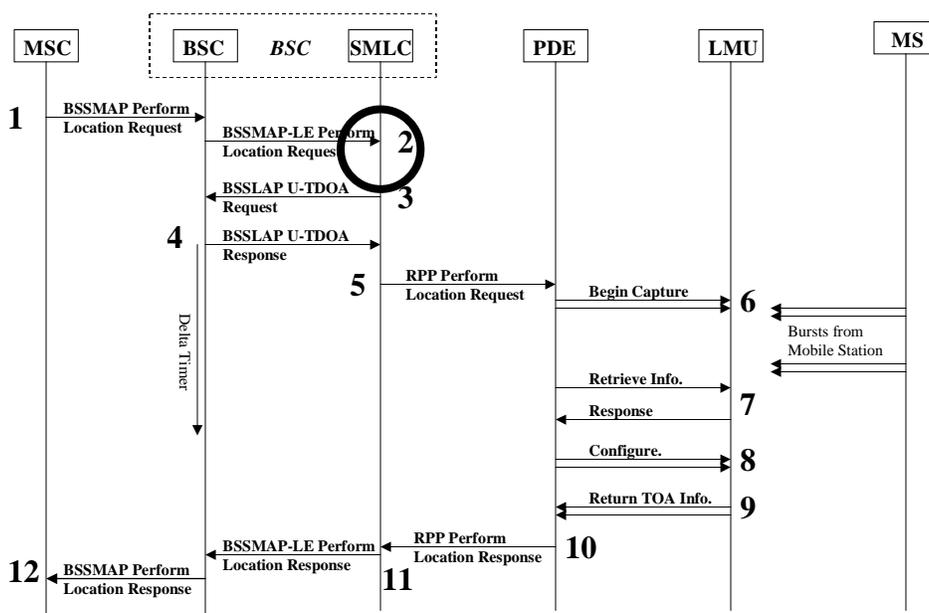


Figure 7: Selection of Positioning Method

In step 2, the SMLC is requested to make a positioning attempt when the message “BSSMAP-LE PerformLocationRequest” is received from the BSC. Parameters of interest for making a decision about what position method to select are all optional in the LCS standards. For practical system implementation, coordination with the MSC is required to ensure proper functionality. Parameters of interest are:

- ◆ **LCS_Client_Type**—Defines the originating LCS Client. LCS Client is specified as Client_Category and Client_Subtype. Client_Category = Emergency_services is of prime interest in the implementation of UTDOA.
- ◆ **LCS_Priority**—Defines the priority of the location request. Values presently defined are Highest_priority or Normal_priority.
- ◆ **LCS_QoS**—Defines the required Quality of Service for the LCS Request. Quality of Service may include horizontal accuracy, vertical accuracy and allowed response time. The accuracy can be specified in a range from 0 m to 1800 km in 128 steps. The allowed response time (RT) is specified as “Response Time is not specified”, “Low Delay”, “Delay Tolerant” or

reserved/spare code points. The actual value in seconds is provisioned by O&M in the SMLC and also in the PDE.

- ◆ **LCS_Capability or Classmark_Information_Type_3**—Provides information about the LCS capabilities of the target MS. The presently defined capabilities are EOTD (MS-assisted and MS-based) and GPS (conventional, MS-assisted, and MS-based).

The requirement for selection logic is high accuracy but also a first quick positioning to be able to route the emergency call. The selection logic then can be defined for a particular customer and the available positioning methods. A representative example is shown in Figure 8.

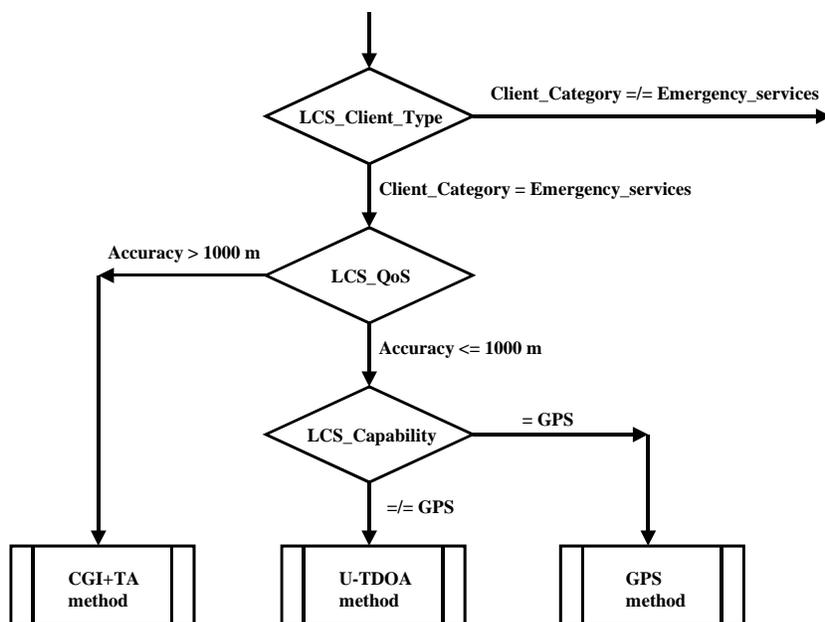


Figure 8: Example of Selection Logic

Economic or practical engineering considerations may influence this model. The diagram above does not, for example, consider XY routing or issues related to initial, vs. update position requests. Since the cost of calculating the estimated location using the CID+TA method is very low, it may be desirable to calculate and cache that value even when UTDOA or a GPS method are also invoked.

Determination of actual logic and accuracy values used for selection of position method is left for further study. From the SMLC vendor perspective, the goal is one general specification for all carriers and markets.

6.2 Timing

6.2.1 Call Timing, Mobile Originating

A circuit switched call to the network from the MS is first set up on a signaling channel (SDCCH). This phase contains a number of procedures between the network and the MS (for example, authentication, ciphering) and ends with setup of the call. After initial call setup, the MS is assigned to a new channel in the cell (TCH) and the phone on the other end starts ringing. The call is then answered and voice conversation can begin. Figure 9 shows the mobile origination call timing.

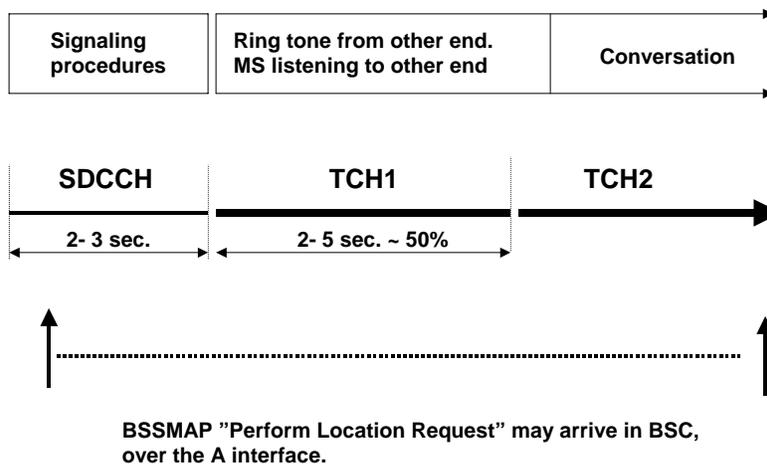


Figure 9: Mobile Origination Call Timing

The time the MS is allocated on the SDCCH channel depends on what procedures are executed before call setup and are vendor-dependent. Two or three seconds is estimated to help ascertain the magnitude. This phase may be prolonged in congestion cases (waiting for TCH). Also, if specific features are used in the BSS, the MS can be assigned to a TCH directly (instead of an SDCCH) and during the signaling phase of the call the TCH can be used for signaling only. In effect, the TCH performs the role of the SDCCH initially and thereafter assumes its normal function of carrying speech traffic. In this case, changing the TCH from signaling only to full traffic use will not disturb the UTDOA measurements.

In approximately 50% of the cases, the MS will change channels in the first part of the "speech" phase (TCH1 to TCH2 in Figure 9). The best channel in the cell may not have been selected when the mobile is first connected to the network. Then, the location function in the BSS requires a number of measurement reports from the MS to be able to select a "better" channel.

Another cause of early handovers depends on characteristics of the MS in Idle mode. The MS tends to be slow in changing cells, and because of this, it is set up in one cell and moved to a better cell when measurement reports have been evaluated.

From the UTDOA measurement point of view, it is important to know the uplink TDMA burst frequency of the call.

During the time the MS is assigned to an SDCCH channel, the burst rate is 25 Hz. If fully used in the uplink, the SDCCH channel is defined on a 102-multiframe cycle (470 ms). If no uplink signaling is required, the MS sends filling frames. This gives 12 bursts per 102-multiframe cycle.

During the time MS is assigned to a TCH channel (full channel mode), the burst frequency varies between 25 and 208 Hz. The TCH channel is defined on a 26-multiframe cycle (120 ms). Minimum burst rate is when there is no speech activity and the MS is "silent" (assuming DTX is activated). One measurement report and one SID frame is sent per measurement period (104 multi-frame is equal to 480 ms). One measurement report is 4 bursts and one SID frame is interleaved over 8 bursts. This gives a minimum of 4+8=12 bursts per 480ms. Maximum burst rate is when there is speech activity and the MS is actively transmitting. Assuming TCH/F channel, the maximum burst rate is 25 bursts on a 26-multiframe cycle (120 ms).

6.2.2 Main Procedure Timing

Figure 10 shows the message flow for the positioning procedure timing.

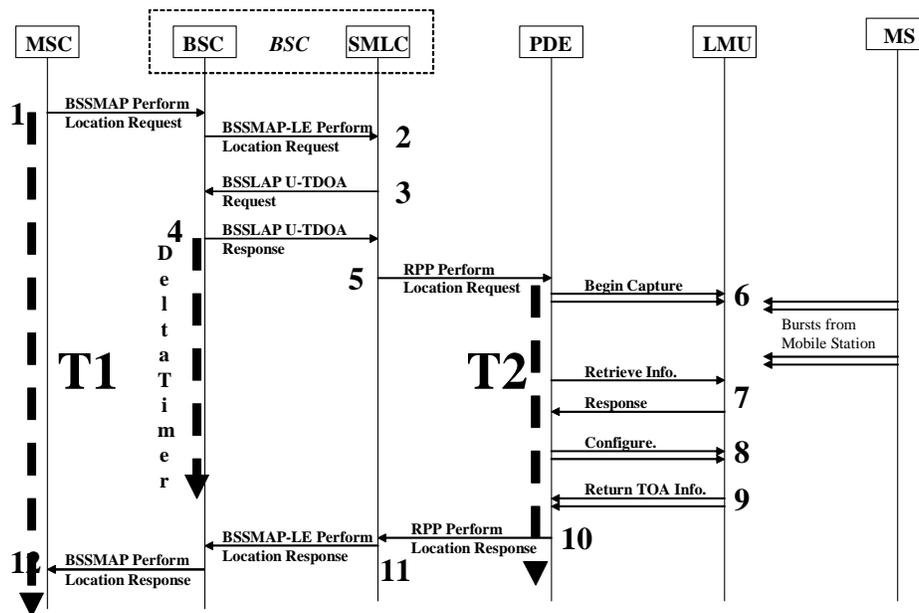


Figure 10: Positioning Procedure Timing

6.2.2.1 T1 Positioning Request Timer

The positioning *request* from the MSC is guarded with one timer (T1) in the MSC. If the result for the positioning request (Perform Location Response) is not returned before T1 times out, the MSC considers the positioning request unsuccessful.

6.2.2.2 T2 Positioning Method Timer

The positioning *method* is also required to have one timer (T2). This timer determines the maximum time allowed for the method to produce a positioning result for the SMLC. This result may be unsuccessful, but a result should be returned by T2 at the latest.

According to the positioning architecture for GSM, the SMLC is required to have timers matching the different quality of services supported. Present timer definitions are “Low Delay” and “Delay Tolerant”, see LCS_QoS in Clause 6.1. Actual time values for “Low Delay” and “Delay Tolerant” are normally commissioned in the SMLC by O&M functions.

To comply with the timing requirements, the PDE must have timer T2 defined. Two alternatives to supply the PDE with time values for T2 are defined:

1. Time values for “Low Delay” and “Delay Tolerant” are provisioned in the PDE by O&M.
2. The SMLC provides the actual timer value to the PDE as an additional parameter in the “RPP PerformLocationRequest” message.

For flexibility, the Lbis interface identifies the timer value in the “RPP PerformLocationRequest” message as optional. Selection of an alternative to use can be made later. If the PDE receives the timer value in the “PerformLocationRequest” message, the PDE would use this value in T2. If the PDE does

not receive the timer value in the “RPP PerformLocationRequest” message, the PDE would use a locally provisioned or default-defined value corresponding to “Low Delay” and “Delay Tolerant”.

Timing considerations for the A-interface and the Lb interface are not affected by the introduction of the UTDOA method.

Timing considerations for the RPP are described in ATIS-0700003.

Other timers related to the UTDOA method should be stated by each vendor in a “Network Impact Report”. The “Network Impact Report” is a vendor-specific report.

6.2.2.3 Delta Timer

The Delta Timer was introduced in the notes for Figure 6 earlier in this clause

6.2.3 Critical Delays

Positioning for ES is time-critical. For the UTDOA method it is essential that as much processing time (6 to 30 seconds) is allowed as possible. The longer the processing time, the better accuracy in positioning will be. Figure 11 shows the call flow for critical delays in the positioning procedure.

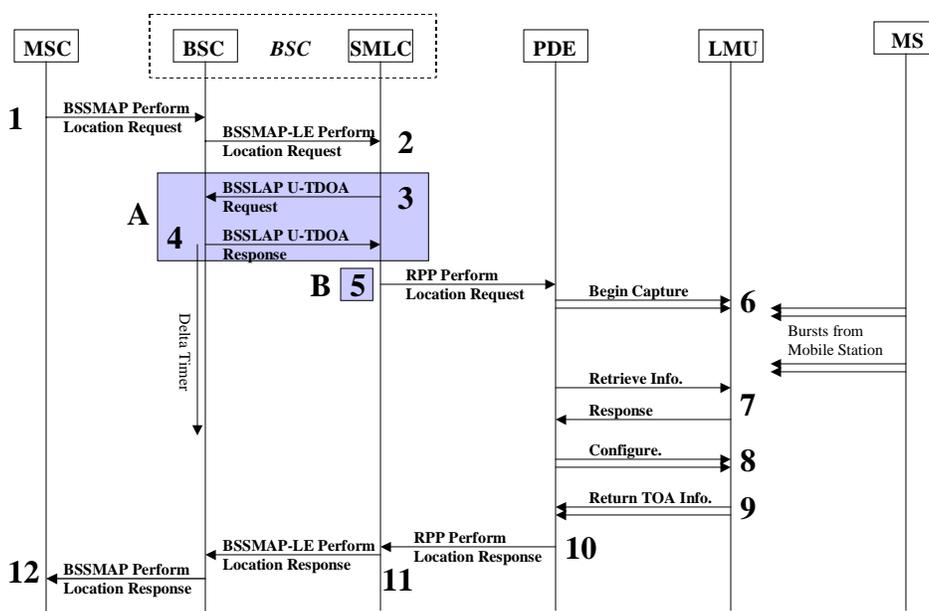


Figure 11: Critical Delays in Positioning Procedure

Some guiding values are provided for sequence delay A and B in Figure 11 above.

- A <= 200 ms.
- B <= 50 ms.

A is defined from the time the SMLC has selected to use the UTDOA method, to the point in time when all data is available to the SMLC application to start assembly of the “RPP PerformLocationRequest” message. While the 200 ms target is expressed as a “guiding value”, it is essential that the UTDOA Request/Response pair sequence delay (“A”) be kept as short as possible.

B is defined as, if option “Geographic Location” in “RPP PerformLocationRequest” message can be computed in B, the option can be used.

6.3 Error Cases

The following are the expected cause cases of a “BSSLAP Abort” message (from 3GPP TS.48.071):

- ◆ Failure for other radio-related events
- ◆ Inter-BSS handover
- ◆ Loss of signaling connection to MS
- ◆ Incorrect serving cell identity; (not applicable for UTDOA)
- ◆ Supervision timer expired; (not applicable for UTDOA)

The following are the expected cause cases of a “BSSLAP Reject” message (from 3GPP TS.48.071):

- ◆ Congestion
- ◆ Channel mode not supported
- ◆ Positioning procedure not supported
- ◆ Failure for other radio-related events
- ◆ Incorrect serving cell identity; (not applicable for UTDOA)
- ◆ BSSAP-LE segmentation error; (not applicable for UTDOA)

Some examples of error situations are as follows:

1. After receiving message 3, the BSC waits for stable conditions for the radio connection to the MS. If handover to another BSC occurs, then the BSC will send Abort as message 4 with cause = (inter-BSS handover).
2. A “PerformLocationRequest” can arrive in the BSC over the Gb interface. In the message 2 to the SMLC, it is not indicated that the connection to the MS is not a CS connection over A-interface. In this case the BSC will send Reject as message 4 with cause = (channel mode not supported). In this case, the SMLC may invoke another positioning method instead of UTDOA.

The UTDOA method expects the BSC to indicate changes in the radio channel to the MS that affect measurement on the uplink bursts. The relevant RR procedures will be specified in 3GPP TS.43.059 v6.1.0. For the UTDOA method the “BSSLAP Reset” message indicates that changes may be needed in the measurement of uplink bursts. One cause value is needed, but two are allowed within the 3GPP standard.

6.3.1 BSC error cases for UTDOA method

The UTDOA_supervision state in the BSC was introduced in the call flow notes for Figure 6 at the beginning of this clause. UTDOA_supervision state has two values: ON or OFF. The figures below describe procedures for BSSLAP Reset and for BSSLAP Abort/Reject in each of the two supervisory states. Error cause values for BSSLAP messages defined in the standard 3GPP TS.48.071 are shown for reference in Table 2.

Table 2: BSSLAP BSC Error Cause Values

Cause Value	Description
0000 0000	Congestion
0000 0001	Channel mode not supported
0000 0010	Positioning procedure not supported
0000 0011	Failure for other radio-related events
0000 0100	Intra-BSS handover
0000 0101	Supervision timer expired
0000 0110	Inter-BSS handover
0000 0111	Loss of signaling connection to MS
0000 1000	Incorrect serving cell identity
0000 1001	BSSAP-LE segmentation error
All unassigned codes are spare.	

6.3.1.1 UTDOA_Abort/Reject when UTDOA_supervision is OFF

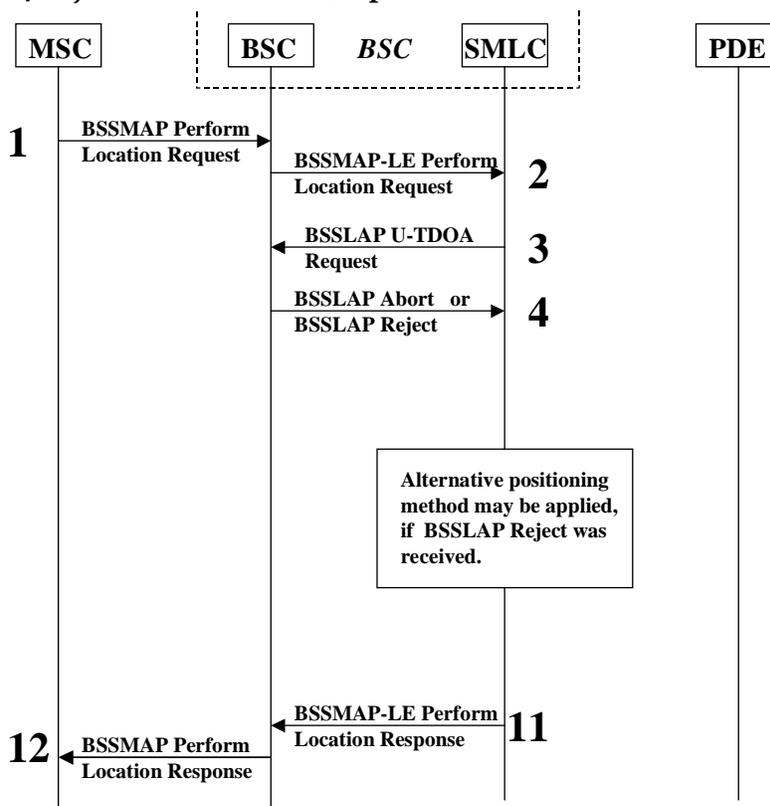


Figure 12: BSSLAP Abort/Reject Procedures (UTDOA_supervision OFF)

Steps 1-3 in Figure 12: The same actions are performed as in steps 1-3 of Figure 6 (Normal Positioning Method).

Step 4 in Figure 12: The BSC identifies one of the error conditions defined above in Clause 6.3. Then the BSC sends the message “BSSLAP Abort” or “BSSLAP Reject” to the SMLC.

Steps 11-12 in Figure 12: The same actions are performed as in positions 11-12 of Figure 6.

6.3.1.2 Reset Case When UTDOA supervision is ON

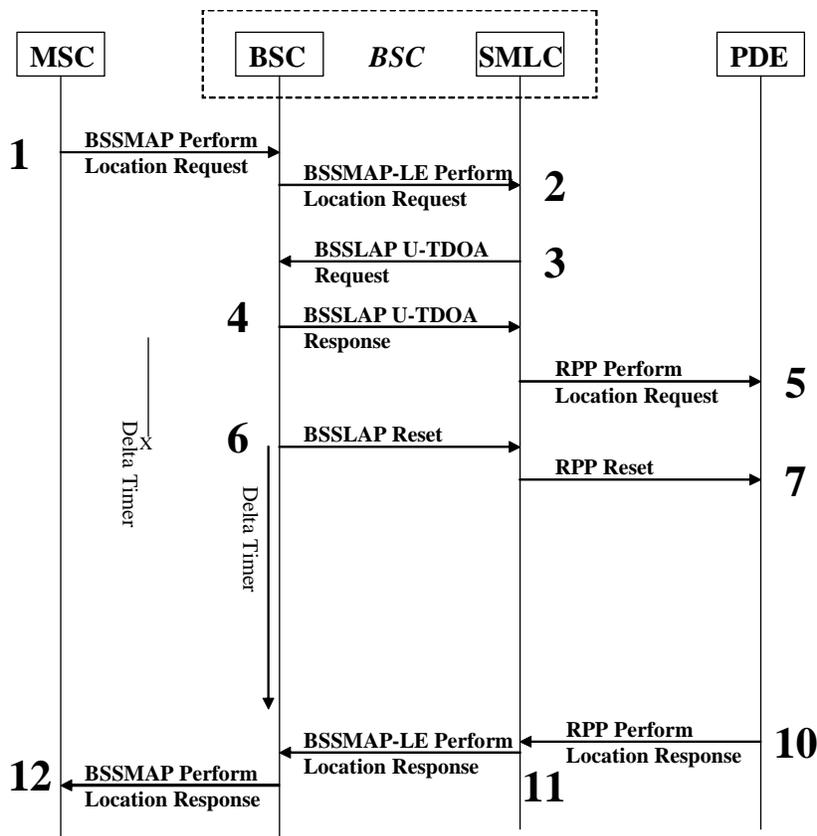


Figure 13: BSSLAP Reset Procedure (UTDOA_supervision ON)

Steps 1-5 in Figure 13: The same actions are performed as in steps 1-5 of Figure 6 (Normal Positioning Method).

Step 6 in Figure 13: The BSC UTDOA_supervision = ON and relevant RR procedure start. The BSC waits until the MS radio connection is in a "stable state" and still served by the BSC.

Then the BSC sends the message "BSSLAP Reset" to the SMLC. The BSC will keep the "UTDOA supervision state in the ON state. If the BSC uses the "Delta timer" to control the UTDOA supervision state, the timer is restarted.

Step 7 in Figure 13: The SMLC gives new radio channel information to the PDE in the RPP Reset message.

Steps 10-12 in Figure 13: The same actions are performed as in positions 10-12 of Figure 6.

6.3.1.3 Abort and Reject cases when UTDOA_supervision is ON

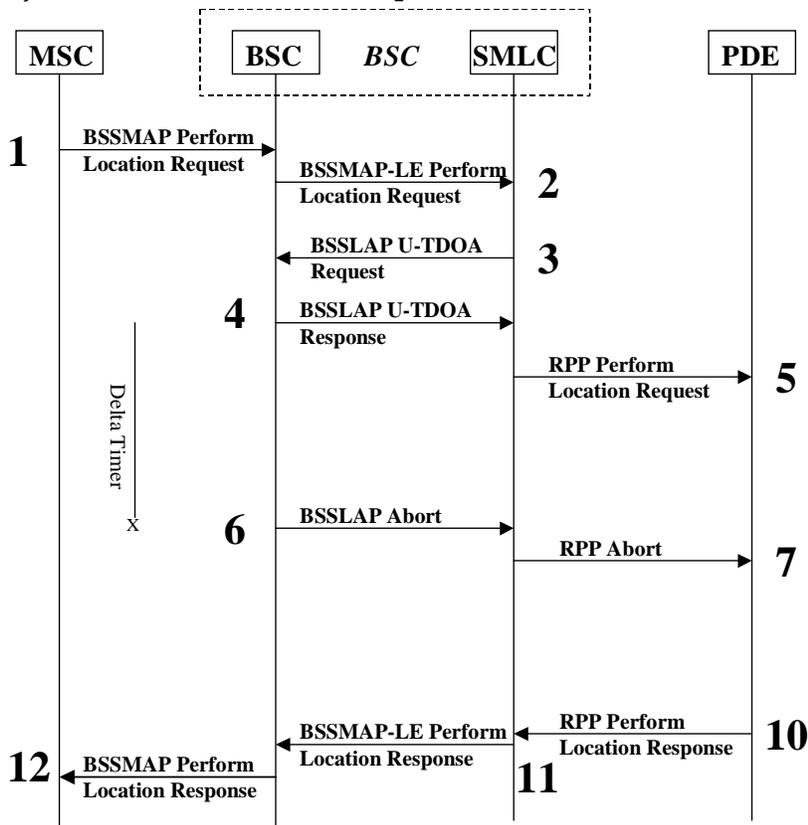


Figure 14: BSSLAP Abort Procedures (UTDOA_supervision ON)

Steps 1-5 in Figure 14: The same actions are performed as in step 1-5 of Figure 6 (Normal Positioning Method).

Step 6 in Figure 14: The BSC UTDOA_supervision is ON and an error condition (shown in Clause 6.3.1 above) is detected by the BSC. The BSC sends the message “BSSLAP Abort” to the SMLC. The BSC sets UTDOA_supervision = OFF and stops the “Delta Timer” (if used). Note: There are no cases yet known when to use the “BSSLAP Reject” message when the BSC state UTDOA_supervision = ON.

Step 7 in Figure 14: The SMLC indicates the error condition with the message “RPP Abort” to the PDE.

Step 10 in Figure 14: The PDE responds immediately with the message “RPP Perform Location Response” to the SMLC.

Steps 10-12 in Figure 14: The same actions are performed as in steps 10-12 of Figure 6.

6.4 Special Cases

6.4.1 High Speed Circuit Switched Data

If the MS uses the HSCSD service in the network, it can be connected to up to and including four TCH/Fs. The number of TCH/Fs allocated to the MS is, among other things, dependent on the traffic level in the cell. Individual TCH/Fs can be allocated or de-allocated during the call. One of these channels is defined as “HSCSD main channel”. Network signaling, MS signaling and measurement reports from the MS are carried on the “HSCSD main channel”. The radio parameters for the “HSCSD

main channel" are reported from the BSC in the "BSSLAP UTDOA Response" message if the MS is using HSCSD service.

6.4.2 DTM

The MS in DTM mode uses both one dedicated circuit switched channel and packet switched channel(s). In the case of "UTDOA request" for one MS in DTM mode, the BSC will report the radio parameters for the dedicated channel (dedicated circuit switched channel) in the "BSSLAP UTDOA Response" message.

ANNEX A ENGINEERING ANALYSIS OF UTDOA IN THE GERAN ENVIRONMENT: POSSIBLE UTDOA RADIO AND FEATURE INTERACTIONS

In addition to developing the Lbis interface, the carriers and vendors working on UTDOA integration with GSM undertook an engineering analysis of UTDOA. The purpose of the analysis was to identify possible interactions between UTDOA and GSM that would limit or even prevent use of UTDOA as a PDE for GSM. As an example of the questions raised, the carriers wanted to know if their plans for high reuse patterns and reduced power operation in North America would still provide the MS signal to the LMUs with enough strength to allow the UTDOA LMUs to operate correctly.

A.1 Introduction

When introducing UTDOA, some considerations and possible new functions in BSS may enhance or, conceivably, interfere with the overall performance of UTDOA. These issues need further investigation on a carrier-to-vendor level and possible standardization in 3GPP. The areas suggested for further actions are listed in tables in this document. Some of the conclusions are intended for UTDOA emergency calls implementations, and not for volumes associated with commercial purposes.

For example, one assumption has been that there is one ES call per one-thousand, and that the mean holding time of any call is 90 seconds. Those assumptions are used for estimating some of the benefits/costs in terms of C/I in the radio network.

Most of the actions have such an impact that they should be standardized before implementation, which will ensure a more consistent handling between BSS vendors versus UTDOA vendors.

No cost estimates are included, since they might reveal sensitive aspects of BSS implementation among vendors.

A.2 UTDOA versus Frequency Planning

The general assumption is that the carrier networks will consist of cells equipped with 1 TRX carrying a non-hopping BCCH, with additional TRXs that are synthesizer-hopping, normally in a so-called 1/1 reuse pattern. Comparing a 1/1-reuse pattern with CDMA is reasonable; in a 1/1 reuse pattern all cells will have all frequencies, with the exception of BCCH.

ATIS-0700002

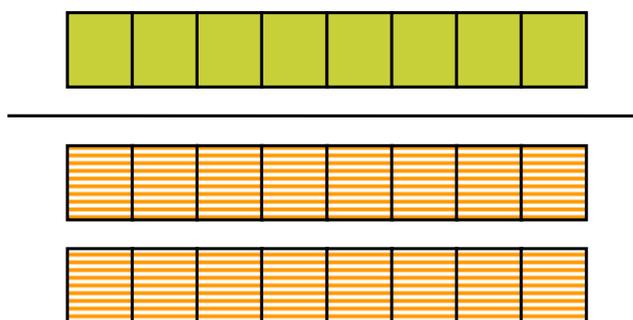


Figure 15: A cell with 3 TRX.

Figure 15 represents three TRX channels. Typically the first TRX (shown in green) is configured for BCCH (non-hop) while the remaining channels (two shown here) are configured for traffic and support hopping. For the cell configuration shown in Figure 15, the ES calls will be placed on either the BCCH non-hopping or a TCH 1/1-hopping TRX at an unknown distribution, depending on most of the preferences set in the BSS for channel allocation. These BSS preferences vary among vendors.

In order to have a high frequency load while maintaining good quality, antenna down-tilt is normally used in order to reduce interference levels in the network. Antenna downtilt leads to less network coverage, but also the possibility to increase the frequency load and thus utilize the radio spectrum better. For example, if new sites are deployed in dense areas, the surrounding sites should be considered for increased antenna downtilt in order to reduce interference from the old sites already covering the area of the new site, otherwise the capacity increase from the new site may be reduced. The carriers need to balance network capacity against the possibility of reduce radio coverage when introducing new sites. However, if sites use antenna downtilt, the LMU coverage will also be reduced in one way or another.

Here is an illustrative example: Suppose that a RAN vendor recommends antenna downtilt in a 1/1 reuse pattern system. The vendor may instruct the carrier to aim the antenna so that it points at the cell border (arctangent of Antenna Height above Average Terrain divided by cell radius), and to then add a "half lobe" more downtilt. For example, a 15-dBi antenna with a 12 degree vertical lobe should be tilted down first to the cell border (for example by -1.5 degrees) and then by another 6 degrees, for a total downtilt of -7.5 degrees. A reasonable antenna downtilt is then typically in the half-lobe range of -6 degrees to -12 degrees depending on the surrounding topography.

A.2.1 BCCH Frequency

The level of frequency reuse ranges from about the same as for TDMA to approximately twice the pattern density used in TDMA. Any call on a non-hopping BCCH will have a C/I on uplink in the range of approximately 9 dB. This assumption is based on a reuse of 12 for the BCCH frequency, normally referred to as a 4/12 cell plan. Denser reuse patterns will yield poorer C/I.

A.2.2 Non-BCCH Frequency

For the non-BCCH-frequencies, it is assumed that 1/1 hopping will be used. It is believed by BSS vendors that a reasonable limit is 4-7.5 dB C/I on average. The 4-dB limit is related to the fact that it seems like SACCH is actually limiting the C/I-performance of GSM rather than speech bursts, and 7.5

dB corresponds to a FER of 2.5%. The C/I Estimates are summarized in Table 3. Note that the base station may have features making it more resistant for uplink interference. For example, a deployed site at a high position may experience a worse C/I situation on uplink compared to the MS on downlink, but the software in the base station may be more sophisticated. For example, IRC may be used.

Table 3: Estimates for C/I for Different Cell Configurations

	# TS on BCCH (9 dB) 4/12 [dB]	# TS 1/1 (4- 7.5 dB) [dB]	# Total TS in cell [dB]	C/I average in cell (linear assumption) [dB]
1 TRX	7	0	7	9.0
2	6	8	14	6.1 - 8.1
3	6	16	22	5.4 - 7.9
4	6	24	30	5.0 - 7.8

The C/I environment for an ES call may be improved significantly if the call is placed on the non-hopping BCCH frequency. Note that the values above are average values; the deviations from this can be substantial from second to second.

A.2.3 Further Development

Due to C/I limits for signaling channels (SACCH), it is not expected to be a too dramatic increase in frequency load. However, concepts like CHAT (Channel Allocation Tearing) may increase the load in the future.

Currently, a reasonable frequency load in existing 1/1 reuse pattern-networks is about 10 percent. The top value today is about 20% frequency load. There seems to be an upper limit of 50% frequency load in 1/1-systems - this load level is the same or slightly above the theoretical levels of CDMA. It is reasonable to see this as an upper implementation limit for GSM.

The correlation between C/I and frequency load exists, but is rather weak. For example, a cell with no neighbors can be loaded up to 100% Fractional load if no internal cell interference exists, but the C/I is indefinite - the correlation is determined by how the cells overlap each other - heights, selection of antennas, and antenna downtilt.

A.2.4 Conclusion

Based on statements that the LMU sensitivity and the LMU C/I robustness exceed the BTS corresponding performance, it is assumed that UTDOA will not limit the implementation of 1/1 reuse pattern networks known today.

If C/I is a concern, the option of placing 911 on BCCH may improve the situation. However, this may interact with carrier preferences for allocating channels for CS and PS and needs further study that are both carrier- and Infrastructure-dependent.

In order to have a transparent implementation between vendors, the activities as suggested in Table 4 should be standardized in 3GPP before implementing them in the different BSSs. Therefore, none of the actions below are currently recommended.

Table 4: E911 on a BCCH carrier - Recommendations

#	Action	Description	Advantages	Disadvantages	C/I change.	Recommendation
1.	911 on BCCH if resources are available	At 911, check for and use idle TCH on BCCH	Possible rather limited implementation cost	BSS implementation	0-4 dB better for LMU No network C/I increase, only moved from 1/1 to BCCH	Not recommended
2.	911 on BCCH even at congestion	If 1. fails, make place by moving another user from BCCH or pack to HR	911 will be on BCCH to the most possible extent.	Complex BSS implementation, prioritization mechanisms.	>0-4 dB better for LMU No network C/I raise, only moved from 1/1 to BCCH	Not recommended, too complex in BSS. LMUs would be able to handle the expected C/I.

A.3 UTDOA versus Power Control Uplink

Among the tradeoffs to be considered in the engineering of a UTDOA implementation for GSM is the cost and benefit of power control on the uplink early in the call. The basic nature of the tradeoff is between reduce power operation (yielding reduced MS power consumption and lower levels of adjacent channel interference), and full power operation during the first few seconds of the call (yielding a higher likelihood of successful position determination and improved location accuracy).

In general, it is desirable to reduce the potential impact from MS Power Control especially close to the base stations; the power control might be in the range of up to 30 dB. In addition, the surrounding base stations are not likely to have their antennas directed toward an MS that is close to another base station, making the signal strength at adjacent sites even lower. On the other hand, an MS operating near a cell border may have little or possibly no power control and can be seen from several base stations, so in such cases the problem is more limited. This problem has been observed in actual practice, with position accuracy decreasing in areas immediately around the BTS antennas.

If acceptable UTDOA accuracy can be achieved within a given signal collection/ correlation time at full MS transmit power, it may be necessary to increase collection time if power control is active. To achieve the same level of accuracy in an MS transmitting at a power lowered by a factor of X , the UTDOA system may have to increase the signal collection time by a corresponding factor of X or more to achieve the same location performance. For example, if 100m accuracy is achieved with an integration time of 4 bursts at full MS transmit power, the following TruePosition supplied table (see Table 5) shows the estimated number of bursts required to achieve the same accuracy with the MS powered down:

Table 5: Correlation of MS Power Control down Regulation and Required Number of Bursts

MS Transmit Power level decrease	Required number of Bursts
0 dB	4
10 dB	40
20 dB	400
30 dB	4000

The actual location accuracy is a function of many parameters beyond integration time, such as cell spacing, interference level, propagation environment, antenna gain, but the general trend of required signal collection and processing applies to all scenarios.

The increase in required signal collection and processing time for MSs powered down by greater than 10 to 20 dB could dramatically impact the utilization of UTDOA resources, as well as increase the latency of producing a location. Each 10 dB of power control may increase the UTDOA system resource utilization by an order of magnitude.

A.3.1 Power Control during Early Phases

Before down regulation starts, a few measurement results have to be received by the algorithm. It is assumed that this will take about 2 seconds, and after that the down regulation will start. At a change of channel, power control is likely reinitiated. The result is that there will be no or very little down regulation during the first 4-5 seconds after the call is initiated.

The assumption is based on "Immediate Assignment on TCH" is not activated. In such case, the Immediate Assignment will direct the MS to a TCH instead of an SDCCH.

The Infrastructure vendors have a common view that this is the case. However, since the algorithms may vary between Infrastructure vendors and is partially dependent on parameter settings, some minor difference exists.

To have consistent environment that doesn't depend on individual BSS vendors, it is recommended that the UTDOA community work to put standards around the power control issue. Until a decision is made to put forward new standards for power control, no implementation is recommended.

Changed settings of power control parameters require no BSS modifications, but increase the interference somewhat and will be used for all calls. It is not recommended for further consideration.

If initial power control is not used with DFCA in the Nokia System, the lost of capacity gain can be significant. The 5-7 seconds is a big percent of average call duration. So there is significant likelihood of increased call interference. This problem can lead to situation where power control is not an acceptable option. But if this initial power control is out of use only in the kind of areas where there are enough frequencies available, low traffic areas or for ES calls, then the effect may be lessened.

The initial power control is a very important part of DFCA. With the DFCA, all Carrier-to-Interference directions are examined (uplink, downlink, for new and existing connections), as better frequency (less interference) there is available as more the power of a new call can be reduced and hence this new call causes less interference for the existing connections. So with DFCA all calls can all the time use the most optimum power level and the interference level of the network can be kept low.

A.3.2 The “Mid-911” Scenario

If there is a need to perform another positioning, the worst case is a down regulation of 30 dB, which can occur if the MS is close to the base station. At the same time, the geographical distance to other base stations is probably unfavorable. The combination of a highly powered-down MS with use of DTX could cause data collection/correlation times exceeding the expectation of PSAPs in some mid-call update (that is, re-bid) E911 scenarios.

Three options are identified:

1. Disable MS power control for the whole duration of the call
2. Do not allow full down regulation during the call
3. Temporarily disable MS power control during positioning procedure

For option 1, it may be a manageable function to support in BSS, even if the BSC normally does not relate a power control algorithm to a certain user. Potential drawbacks are the increased interference caused by this, and the reduction of talk time per battery that may be a rather significant disadvantage in emergency situations.

For option 2, it has about the same complexity as for 1, but increases the interference somewhat and reduces the talk time per-battery somewhat.

For option 3, the complexity is increased even further, both within BSS but also when it comes to synchronization of the measurements by the LMU. Both up and down regulation are taken in steps.

From TDOA-vendors, measures that address power control are of interest, since power control may substantially increase the needed integration times and latencies for a UTDOA positioning procedure. The availability of a mechanism to temporarily increase the transmit power of a powered-down MS for only the duration of the location process could have a substantial positive impact on the capacity and latency of the UTDOA location system.

The interest is particularly biggest for option #3 above which has a minor impact on the interference levels in the network. It is recommended for further considerations even though the implementation in the different BSS may be complicated and standardization in 3GPP might be required.

A.3.3 Further Development

For power control, GSM specifications have a suggested algorithm, but due to performance issues it may be or already has been replaced by enhanced versions that are proprietary. It is believed that importance will actually become even more significant in the future as power control has desired properties with respect to performance improvements versus the cost for running power control in the networks.

A.3.4 Conclusion

If the positioning takes place the first 5 seconds, no or minor down regulation will take place. Power Control issues are summarized in Table 6.

Table 6: Power Control Issue Summary

#	Action	Description	Advantages	Disadvantages	C/I change	Recommendation
1.	MS PC slow down for all calls.	From (for example) 5 to 7 seconds before down regulation	No implementation cost (parameter tuning) – fast implementation, but BSS vendor dependent parameters	Increases C/I in networks for all calls in early phase. Assume 90 s call and $2 \text{ s} * 2 \text{ dB}$ increase in C/I Leads to $2*2/90=0.04 \text{ dB C/I}$ increase	0.04	Not recommended.
2.	MS PC	Not down regulated as many dB as other calls	Maybe smaller BSS impact than 4.	Increases C/I. assume 5 dB less down reg. Leads to $5*1/1000=0.005 \text{ dB C/I}$ increase	0.005	Not recommended, complex implementation
3.	Disable MS PC during the full call for ES calls.	When accessing the system, down regulation is disabled during the full call	Best possible C/I and coverage on UL.	BSS Implementation, short talks time per battery, C/I small but not negligible. Assume down regulation Average is 10 dB, $10 * 1/1000 = 0.01 \text{ dB}$ increase.	0.01	Not recommended, increases interference and reduces talk time per battery.
4.	Disable MS PC during Positioning Procedure	At any time, the power is maximized for 3-5 seconds for the ES call, after that down regulation reinitiates.	Negligible C/I impact in networks.	Complex implementation in BSS, “synch” with LMU. Assume 5 s out of 90 s and ramping (+50% C/I) $5/90*10*1/1000=0.006 \text{ dB} + 50\%$	0.0008	Candidate for Further Study; No Specific Recommendation

The assumptions are that there is one ES call per 1000 calls, and that the duration of all calls are on average 90 seconds and that power down regulation turns out to be 10 dB on average – all of the traffic evenly spread over the cells, that is, no shopping mall fire where hundreds of ES calls are made from the same cell.

A.4 DTX Switched Off For Emergency Calls

The general assumption is that the LMUs will handle 1/1-reuse with DTX in all cases and therefore no action is needed.

If activated, the mobile will transmit speech bursts on UL only when speech is detected in the MS. This prolongs the talk time per-battery and also reduces the interference on UL. It is assumed that the reduction in C/I corresponds to almost 3 dB based on 50% talk time and 50% listening.

It is believed that the DTX will be rather active in the start, before PSAP answers. DTX may reduce signal to 1/26, which is in the range of 12-15 dB reduction of signal strength on UL if the subscriber is completely silent during positioning procedure, and DTX is activated. DTX results in fewer bursts, not less power from MS per burst. So the gain is likely smaller than 12-15 dB.

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In addition, experiences (TP) have shown that the MS seems to be rather “quick” in not using DTX – even background noise seems to deactivate DTX reducing the issue for UTDOA.

On the SDCCH and on the half rate traffic channel TCH/H in signaling only mode, DTX is not allowed. System Information 6, supports a DTX-flag that can be used to switch off/on DTX on UL for a call in progress. Assuming one ES call per thousand calls, the C/I network increase would correspond 3/1000 dB on average if DTX is disabled for the whole duration of the call.

The benefits are twofold:

1. More bursts during the call – especially early in a “911-call”
2. A better C/I-environment on average for a 911-call in comparison

One disadvantage, as for power control, is that the talk time per battery will decrease if the DTX is disabled through the call.

A.4.1 Further development

No further development is required.

A.4.2 Conclusion

Generally, there seems to be an option to disable DTX during at least the positioning procedure itself as a precaution. Even though the LMUs are designed to handle the radio environment without disabling DTX, it appears that the total “C/I-cost” is small compared to a possible increase in, for example yield.

Since the implementation in respective to the BSS varies and is proprietary, it is recommended that the carriers request this to be investigated “per vendor” if a need occurs. It is unlikely that any Infrastructure vendor has already implemented a support for switching on/off DTX on a subscriber basis. The recommendation is to standardize this before further actions are taken. DTX Issues are summarized in Table 7.

Table 7: DTX Issue Summary

#	Action	Description	Advantages	Disadvantages	C/I change	Recommendation
1.	DTX Off	At 911, disable DTX UL during the call	Better C/I for the ES call by “3dB” and more bursts to measure on	BSS implementations, shorter talk time per ES call/battery. C/I raises with 45 sec/90 sec $3*1/1000 = 0.0015$	0.0015 network increase, 0-15 dB C/I improvement for LMU.	Not recommended
2.	DTX On/Off	Disable DTX for the duration of the procedure	As 1. but with very marginal C/I impact, C/I $5/90*3*1/1000 = 0.0002$ dB	More complex BSS implementation than 1.	0.0002 network increase, 0-15 dB C/I improvement for LMU	Candidate for Further Study; No Specific Recommendation.

A.5 *UTDOA versus AMR*

The impacts are covered already – for AMR FR, the call will handle even more interference; a C/I down to 4 dB is expected.

For (AMR) HR, it will be more of an issue that only every second burst will belong to an ES call, and the other bursts must be discarded by the UTDOA system and cannot be handled or controlled by the BSS.

Furthermore, the AMR encoding pattern needs to be known by the UTDOA controller. But if AMR causes C/I to worsen, and if recognition of the encoding pattern uses PDE resources, latency will increase for the time it takes the PDE to task the LMUs and for the time it will take to return an initial position estimate. Of particular concern is that AMR processing required of the PDE would use time during the full-power uplink phase. Any reduction in the time available for position determination during that “power-up” equates to a decrease in successful location calculations. The UTDOA vendors and carriers are understandably interested in having the BSC communicate AMR parameters including FR/HR and encoding scheme across the open interface as part of the call information provided to the UTDOA system.

A.6 *UTDOA versus Smart Antennas*

The concept of fixed lobe antennas (antenna arrays) where the subscriber is allocated to the “best” lobe is more problematic than the version where the antenna is actively tracking the subscriber. This is not further studied here.

A.7 *UTDOA versus Cell Plans*

The deployment of UTDOA in existing cell plans is not covered here.

A.8 *Interaction with Other Features*

This clause identifies topics that were identified in the engineering analysis, but which are either not covered or recommended for further study.

HSCSD – Is not an issue, as it is no traffic case.

GPRS – Not in the scope. As of the time of writing, there is no North American requirement for GPRS location on ES.

Extended Range – Unexpected traffic case, is not an issue. The implementation may vary between BSS vendors.

DTX – The “alien bursts” are taken care of by LMU. The issue of switching DTX off during an ES call and the C/I improvement if DTX is switched off for ES calls is FFS.

HR – HR will result in alternate bursts belonging to different calls; also to the creation of “alien bursts” on UL, as for DTX. Standards changes introduced to the Lb interface (GERAN T1.3GPP.48.071) include transmission of the AMR information to the SMLC. Lbis extends these parameters out to the UTDOA server. So the PDE is able to listen for the correct call in an AMR-enabled network.

Dual Band – In order to be future safe, all LMUs must be capable of both 800 and 1900. In North America it is standard practice for carriers to install dual band TDOA LMUs today.

Ciphering break – Not radio, covered by infrastructure.

Call setup scenario – RA > SDCCH > TCH and the corresponding changes of resources on ABIS (difficult to follow). It is not a radio issue.

ANNEX B SECURITY AND PRIVACY CONSIDERATIONS RELATED TO Lbis IMPLEMENTATION

This annex highlights some of the security and privacy issues to be considered in Lbis interface implementations. The annex does not address the full range of security concerns related to LCS or PDEs employed in GSM. The annex provides a perspective on Lbis specific issues, but is by no means a complete analysis. Because some of the concerns relate to the network architecture of the carrier, each item needs to be reconsidered in the context of a particular implementation.

1. IP network attacks on the SMLC or the PDE
2. Key (Kc) transmission in plain text between the SMLC and the PDE
3. Cipher Mode parameter passed from the SMLC to the PDE
4. Privacy of MS positioning Information

B 1 IP Network Attacks

Consideration needs to be given to the possibility of IP Network Attacks – especially from a “spoofer”.

In the RPP’s client-server model, the PDE is the server. The server is the potential target of attacks from an intruder “spoofing” the IP characteristics of an SMLC. Even if the attacker were unable to access the PDE server, he or she could mount a denial of service or port attack.

A low cost defense against a “spoofer” attack on the PDE could be had if the PDE were to support a lockout period following a failed handshake on the RPP. That capability is not specifically required to support the RP link, and so is not discussed in the RPP technical report.

B 2 Key Transmission

Key (Kc) transmission in plain text has been identified as a potential security threat for some implementations. Many variables contribute to the magnitude of this threat, so the problem must be analyzed for each new application.

Kc is the cipher key used to encrypt the call’s voice channel. An attacker could use the Kc to perform an unauthorized intercept of the voice channel. The Kc is generated at the start of a call and may be re-generated at any one of many events that could occur during the call. The Kc is transmitted as plain text over the Abis and Lb interfaces (SS7 links). The security issue is whether the Kc should be encrypted when it is transmitted over the Lbis interface.

The RPP doesn’t link the Kc to an IMSI or MSISDN. To use the Kc, an attacker would need additional information from the RAN or Core networks, or would need to try all calls active on a particular BTS, looking for one it could decode. To mount such an attack the attacker needs access to the BSS network. But the Kc can be intercepted in the BSS network on the Abis interface.

Note: The Kc inclusion in the Lb interface as part of TS.48.071 Rel 6.3.0 was reviewed in the SA3 committee of GERAN.

B 3 Cipher Mode

Cipher mode is sent as plain text in the Lbis interface. The cipher mode is part of the communication between the MS and the RAN complex to qualify the handset and to identify which of the several

cipher modes is to be employed. Cipher Mode can be intercepted at several points. It is displayed, for example, on the standard field test interface that many MS manufacturers include with their handsets.

B 4 Privacy of Positioning Information

The PDE controller uses the Lbis interface to send the XY location information to the SMLC. This transmission is in plain text. This transmission may need to be examined as a potential subscriber privacy issue.

The XY position is referenced to a Transaction ID (6.2.1.1 of the RPP technical report). But the RPP messages do not contain the IMEI or the MSISDN. The association between the Transaction ID in the RPP and the ESRN in the PerformLocationRequest is known to the SMLC, and not to the Remote PDE. The RPP messages by themselves are not sufficient to enable an attacker to associate a specific Lat/Long with a particular MS or a particular call.

ANNEX C BACKGROUND OF THE Lbis INTERFACE AND THIS TECHNICAL REPORT

The work that produced the Lbis architecture took place over approximately a year. To provide a perspective on the Lbis architecture and its features, this Annex provides a description of the previous architecture - the initial implementation of a UTDOA overlay architecture for GSM. The principal feature of the earlier architecture is the use of Abis Monitor Units (AMUs) to obtain ES call parameters from the communication between the BTS and the BSC.

Radio Access network

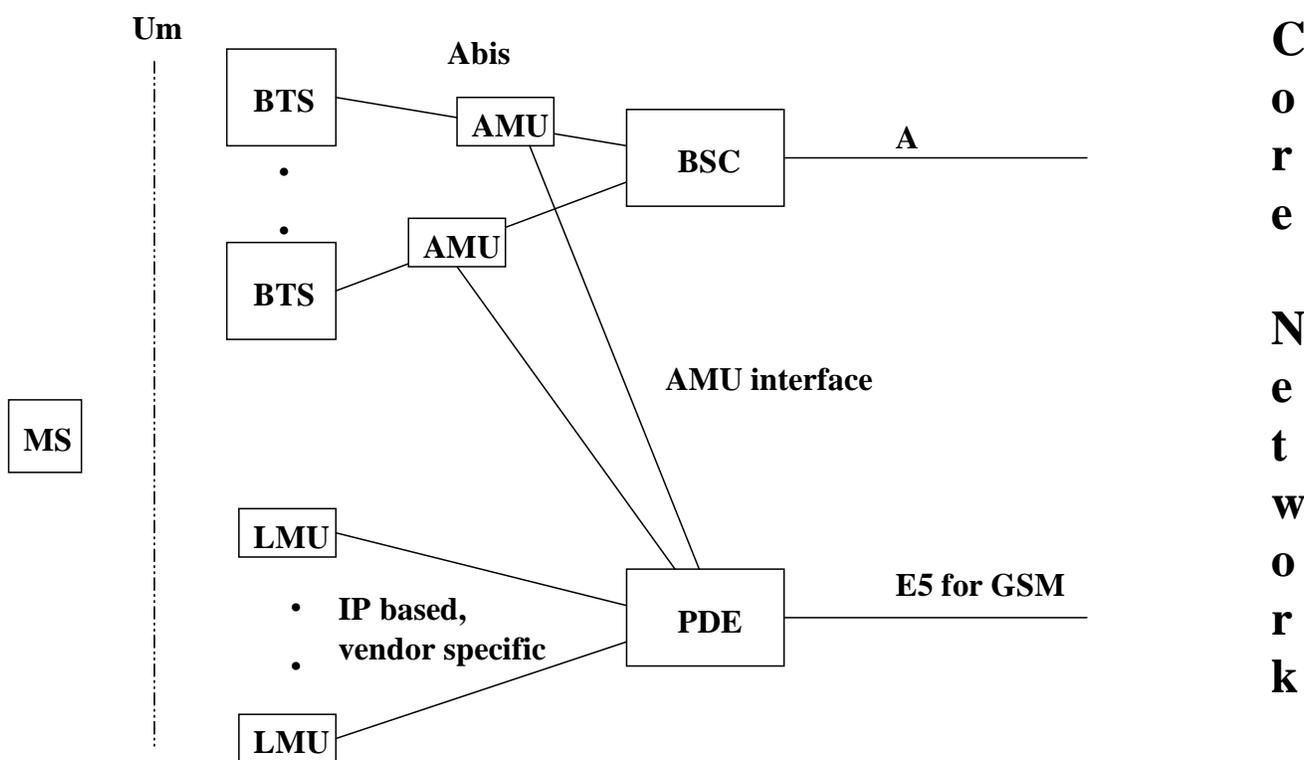


Figure 16: Original Network Architecture

The initial effort to implement TDOA as a GSM overlay network sought an architecture consistent with both 3GPP and J-STD-036. The carriers approached their UTDOA system vendors with the request to adapt UTDOA so that it would provide the location information for GSM MSs. This effort was successful. Figure 16 above shows the essential elements of this initial UTDOA integration with GSM:

- ◆ UTDOA had been previously been deployed as a position technology in support of TDMA and other wireless networks.
- ◆ The UTDOA system for GSM initially operated as an overlay network, using as much of the equipment the carriers had already deployed in support of TDMA as possible.
- ◆ The call information needed in the UTDOA PDE was obtained from a monitor on the Abis interface between the BTS and the BSC – the AMU.

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- ◆ Communication between the PDE and the Emergency Services Messaging Entity was through a modified E5 interface adapted from ANSI J-STD-036
- ◆ The LCS interfaces specified in 3GPP standards (Lg, Lb, etc.) were not used.
- ◆ The SMLC was not used.
- ◆ Note that the only interface between the GSM BSS system and the UTDOA system in the original architecture is the Abis monitor unit that “sniffs” the messages sent between the BTS and the BSC.

Even though this architecture helped the carriers meet the FCC requirements, it was clear from the first efforts to adapt TDOA to GSM that the carriers would benefit from a tighter integration of UTDOA into the BSS network—particularly one that more closely adhered to the LCS concepts in 3GPP. This hope for an improved architecture was the impetus for formation of a team of vendor and carrier representatives to engineer such architecture. This team became known as the TDOA System Study team. The resulting architecture is generally known as “Lbis”. The name is a play on words based on a contraction of Lb and Abis.

The TDOA System Study team’s effort was shaped by these two tenets:

- ◆ The team sought to define a way to support a *Remote* PDE within the GSM BSS complex. This new architecture needed to be consistent with both 3GPP and J-STD-036. The team was not developing a 3GPP standard, because existing 3GPP standards identified the PDE implementation and its integration into the SMLC as outside the scope of GERAN. In theory, this new architecture could be applied to any remote PDE – not just UTDOA.
- ◆ The team sought to develop and publish a UTDOA architecture that would help control costs and business risk for both carriers and vendors. The Lbis interface and the two protocols supported in that interface are the products of the TDOA System Study team’s efforts.

C 1 Objectives of the Improved Architecture

The main objectives of the architecture are to:

- ◆ Use 3GPP standard methods for the PerformLocationRequest function.
- ◆ No impact to support of UTDOA in 3GPP or J-STD-036.
- ◆ Identify an MS using explicit messaging through the Lb interface (unambiguous MS identification).
- ◆ Implement UTDOA as a remote PDE that the SMLC tasks.
- ◆ Maximize alignment between UTDOA systems and 3GPP standards.

Only the circuit switched domain and the A-interface mode are included in the study. The study is also limited to the impacts on the GSM BSS. The GSM core network functionality is independent of the positioning method selected. Some specific configurations in the core network may be required for emergency services calls

C 1.1 Use 3GPP standard methods for the PerformLocationRequest function.

In the original marriage of GSM and UTDOA, the tasking of the PDE came from either from the AMU as it identified an emergency services call in progress, or as an update request communicated across the E5 interface from the E911 GMLC as was done in the TDMA system. This method completely eliminated the MSC and the SMLC from the location services methods used in support of emergency calls. The disadvantage of that architecture was that the LCS methods defined in GERAN could not be

used. In the new architecture the SMLC is returned to the RAN complex, and PerformLocationRequests for ES are launched over the A and Lb interfaces from the MSC to the SMLC.

C 1.2 Unambiguous MS Identification

The methods used to identify the MS in the original AMU-based UTDOA architecture may rely on correlations or inference. Here is a brief description of the problem with such a method. At the start of the call, the handset is identified over the Abis interface using the TMSI. The problem for the UTDOA system, then, is to identify the mobile without knowing the IMEI or IMSI. To determine which handset is transmitting, the UTDOA controller uses algorithms based on timing windows, correlations, or other stochastic methods. In the open interface architecture, the information to identify the MS to the PDE comes over the Lb interface. The MSC provides unambiguous MS identification using information from the VLR.

C 1.3 Implement UTDOA as a PDE that the SMLC Tasks.

UTDOA implementations, based as they are on J-STD-036, do not require an SMLC. Coordination of UTDOA methods through an SMLC was not defined in GERAN. As mentioned in C 1.1 above, the Lbis architecture re-introduces the SMLC. The UTDOA system is a PDE that the SMLC can task. In the real world environment of a GSM RAN system, multiple PDEs are available, and each has its own features and limitations. The LCS system for Emergency Systems is made more robust by allowing the SMLC to task whichever PDEs are available to locate a handset as the situation demands.

C 1.4 Maximize alignment between UTDOA and 3GPP GERAN standards

The open interface architecture resolves all critical issues related to the integration of UTDOA into the GSM network model as defined in 3GPP. Most important among these resolved issues are:

- ◆ The integration of the SMLC together with the use of the Lb interface to communicate between the SMLC and the BSC, and
- ◆ The use of the Lg interface to communicate between the GSM network and the GMLC.

Historically, UTDOA has found wide deployment in 2G networks such as TDMA. Those 2G networks use PDE interfaces defined in J-STD-036—specifically the E5 interface. Adapted to GSM use through the inclusion of additional parameters, the extended “E5+” interface permits an overlay UTDOA network for TDMA to support mobile positioning on the GSM network. But the E5+ interface is not defined in 3GPP. The open interface architecture dispenses with the E5+ interface and supports Lg and Lb communication to the UTDOA interface, and thus largely restores the standard functionality of the SMLC and GMLC defined in the 3GPP standards.

C 2 High Level Perspective of the Lbis Interface

The Lbis interface represents a shift in the concept of the SMLC from the server that supports location methods (such as EOTD and CID+TA), to the center that manages all LCS methods available to the network. This is true whether the SMLC supports the position calculation function (PCF) internally or communicates with a specialized, remote PDE that supports a location method as in the case of UTDOA. This is a significant advance. The Lbis interface allows GERAN-defined nodes to function as defined in 3GPP standards, and yet allows carriers to employ remote PDEs that may not be defined in GERAN in support of specialized services such as North American E911 Phase 2.