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(GSM 03.22)**

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Foreword

This European Telecommunication Standard (ETS) has been produced by the Special Mobile Group (SMG) Technical Committee (TC) of the European Telecommunications Standards Institute (ETSI) and is now submitted for publication.

This ETS defines the functions related to Mobile Station (MS) in idle mode for the European digital cellular telecommunications system (Phase 2). This ETS corresponds to GSM Technical Specification (GSM-TS) GSM 03.22 version 4.8.1.

The specification from which this ETS has been derived was originally based on CEPT documentation, hence the presentation of this ETS may not be entirely in accordance with the ETSI/PNE rules.

Reference is made within this ETS to GSM-TSs (NOTE).

Reference is also made within this ETS to GSM xx.xx. series. The specifications in the series can be identified, with their full title, within the normative reference Clause of this final draft ETS by the first two digits of their GSM reference number e.g. GSM 09.xx series, refers to GSM 09.01, GSM 09.02, etc.

NOTE: TC-SMG has produced documents which give the technical specifications for the implementation of the European digital cellular telecommunications system. Historically, these documents have been identified as GSM Technical Specifications (GSM-TSs). These TSs may have subsequently become I-ETTs (Phase 1), or ETSS (Phase 2), whilst others may become ETSI Technical Reports (ETRs). GSM-TSs are, for editorial reasons, still referred to in current GSM ETSS.

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1 General

1.1 Scope

This specification gives an overview of the tasks undertaken by a GSM900 or DCS1800 mobile station (MS) when in idle mode, that is, switched on but not having a dedicated channel allocated, e.g., not making or receiving a call. It also describes the corresponding network functions.

This specification outlines how the requirements of the GSM 02 series Technical Specifications (especially TS GSM 02.11) on idle mode operation shall be implemented. Further details are given in Technical Specifications GSM 04.08 and GSM 05.08.

Section 2 of this specification gives a general description of the idle mode process. Section 3 outlines the main requirements and technical solutions of those requirements. Section 4 describes the processes used in idle mode. There is inevitably some overlap between these sections.

1.2 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

- [1] GSM 01.04 (ETR 100): "European digital cellular telecommunications system (Phase 2); Abbreviations and acronyms".
- [2] GSM 02.01 (ETS 300 500): "European digital cellular telecommunications system (Phase 2); Principles of telecommunications services supported by a GSM Public Land Mobile Network (PLMN)".
- [3] GSM 02.02 (ETS 300 501): "European digital cellular telecommunications system (Phase 2); Bearer Services (BS) supported by a GSM Public Land Mobile Network (PLMN)".
- [4] GSM 02.03 (ETS 300 502): "European digital cellular telecommunications system (Phase 2); Teleservices supported by a GSM Public Land Mobile Network (PLMN)".
- [5] GSM 02.04 (ETS 300 503): "European digital cellular telecommunications system (Phase 2); General on supplementary services".
- [6] GSM 02.06 (ETS 300 504): "European digital cellular telecommunications system (Phase 2); Types of Mobile Stations (MS)".
- [7] GSM 02.07 (ETS 300 505): "European digital cellular telecommunications system (Phase 2); Mobile Station (MS) features".
- [8] GSM 02.08 (ETR 101): "European digital cellular telecommunications system (Phase 2); Quality of service".
- [9] GSM 02.09 (ETS 300 506): "European digital cellular telecommunications system (Phase 2); Security aspects".
- [10] GSM 02.11 (ETS 300 507): "European digital cellular telecommunications system (Phase 2); Service accessibility".

- [11] GSM 02.16 (ETS 300 508): "European digital cellular telecommunications system (Phase 2); International Mobile station Equipment Identities (IMEI)".
- [12] GSM 02.17 (ETS 300 509): "European digital cellular telecommunications system (Phase 2); Subscriber identity modules Functional characteristics".
- [13] GSM 02.24 (ETS 300 510): "European digital cellular telecommunications system (Phase 2); Description of Charge Advice Information (CAI)".
- [14] GSM 02.30 (ETS 300 511): "European digital cellular telecommunications system (Phase 2); Man-Machine Interface (MMI) of the Mobile Station (MS)".
- [15] GSM 02.40 (ETS 300 512): "European digital cellular telecommunications system (Phase 2); Procedures for call progress indications".
- [16] GSM 02.41 (ETS 300 513): "European digital cellular telecommunications system (Phase 2); Operator determined barring".
- [17] GSM 02.81 (ETS 300 514): "European digital cellular telecommunications system (Phase 2); Line identification supplementary services - Stage 1".
- [18] GSM 02.82 (ETS 300 515): "European digital cellular telecommunications system (Phase 2); Call Forwarding (CF) supplementary services - Stage 1".
- [19] GSM 02.83 (ETS 300 516): "European digital cellular telecommunications system (Phase 2); Call Waiting (CW) and Call Hold (HOLD) supplementary services - Stage 1".
- [20] GSM 02.84 (ETS 300 517): "European digital cellular telecommunications system (Phase 2); MultiParty (MPTY) supplementary services - Stage 1".
- [21] GSM 02.85 (ETS 300 518): "European digital cellular telecommunications system (Phase 2); Closed User Group (CUG) supplementary services - Stage 1".
- [22] GSM 02.86 (ETS 300 519): "European digital cellular telecommunications system (Phase 2); Advice of charge (AoC) supplementary services - Stage 1".
- [23] GSM 02.88 (ETS 300 520): "European digital cellular telecommunications system (Phase 2); Call Barring (CB) supplementary services - Stage 1".
- [24] GSM 04.08 (ETS 300 557): "European digital cellular telecommunications system (Phase 2); Mobile radio interface layer 3 specification".
- [25] GSM 05.02 (ETS 300 574): "European digital cellular telecommunications system (Phase 2); Multiplexing and multiple access on the radio path".
- [26] GSM 05.08 (ETS 300 578): "European digital cellular telecommunications system (Phase 2); Radio subsystem link control".

1.3 Definitons and abbreviations

Abbreviations used in this specification are listed in GSM 01.04.

Selected PLMN	This is the PLMN that has been selected according to Section 3.1, either manually or automatically.
Available PLMN	This is a PLMN where the MS has found a cell that satisfies conditions (ii) and (iv) of Section 3.2.1.
Registered PLMN (RPLMN)	This is the PLMN on which certain LU outcomes have occurred (see table 1).
Allowable PLMN	This is a PLMN which is not in the list of forbidden PLMNs in the SIM.
Registration	This is the process of camping on a cell of the PLMN and doing any necessary LUs.
Camped on a cell	The MS (ME if there is no SIM) has completed the cell selection/reselection process and has chosen a cell from which it plans to receive all available services. Note that the services may be limited, and that the PLMN may not be aware of the existence of the MS (ME) within the chosen cell.
Current serving cell	This is the cell on which the MS is camped.
Suitable Cell	This is a cell on which an MS may camp. It must satisfy criteria (i) to (iv) of Section 3.2.1
Acceptable Cell	This is a cell that the MS may camp on to make emergency calls. It must satisfy criteria (ii) and (iv) of Section 3.2.1

The PLMN to which a cell belongs (PLMN identity) is given in the system information transmitted on the BCCH (MCC + MNC part of LAI).

2 General description of idle mode

When an MS is switched on, it attempts to make contact with a GSM public land mobile network (PLMN). The particular PLMN to be contacted may be selected either automatically or manually. The MS looks for a suitable cell of the chosen PLMN and chooses that cell to provide available services, and tunes to its control channel (BCCH plus CCCH). This choosing is known as "camping on the cell". The MS will then register its presence in the location area (LA) of the chosen cell if necessary, by means of a location updating (LU) or IMSI attach procedure. If the MS loses coverage of a cell, it reselects onto the most suitable alternative cell of the selected PLMN and camps on that cell. If the new cell is in a different LA, an LU request is performed. If the MS loses coverage of a PLMN, either a new PLMN is selected automatically, or an indication of which PLMNs are available is given to the user, so that a manual selection can be made.

The purpose of camping on a cell in idle mode is threefold:

- a) It enables the MS to receive system information from the PLMN.
- b) If the MS wishes to initiate a call, it can do this by initially accessing the network on the CCCH of the cell on which it is camped (with the exceptions defined in sections 3.5.3 and 3.5.4).
- c) If the PLMN receives a call for the MS, it knows (in most cases) the LA of the cell in which the MS is camped. It can then send a "paging" message for the MS on CCCHs of all the cells in the LA. The MS will then receive the paging message because it is tuned to the CCCH of a cell in that LA, and the MS can respond on that CCCH.

If the MS is unable to find a suitable cell to camp on, or the SIM is not inserted, or if it receives certain responses to an LU request (e.g., "illegal MS"), it attempts to camp on a cell irrespective of the PLMN identity, and enters a "limited service" state in which it can only attempt to make emergency calls.

The idle mode tasks can be subdivided into 3 processes:

- PLMN selection;
- Cell selection and reselection;
- Location updating.

The relationship between these processes is illustrated in Figure 1. The states and state transitions within each process are shown in figures 2 to 4.

3 Requirements and technical solutions

The following sections list the main requirements of idle mode operation and give an outline of the technical solution.

3.1 PLMN selection and roaming

The MS normally operates on its home PLMN (HPLMN). However a visited PLMN (VPLMN) may be selected, e.g., if the MS loses coverage. There are two modes for PLMN selection:

- i) Automatic mode - This mode utilises a list of PLMNs in priority order. The highest priority PLMN which is available and allowable is selected.
- ii) Manual mode - Here the MS indicates to the user which PLMNs are available. Only when the user makes a manual selection does the MS try to obtain normal service on the VPLMN.

There are two cases:

- International Roaming - This is where the MS receives service on a PLMN of a different country than that of the HPLMN.
- National Roaming - This is where the MS receives service from a PLMN of the same country as that of the HPLMN, either anywhere or on a regional basis. The MS makes a periodic search for the HPLMN while national roaming.

To prevent repeated attempts to have national roaming service on a not allowed LA, when the MS is informed that an LA is forbidden, the LA is added to a list of "forbidden LAs for national roaming" which is stored in the MS. This list is deleted when the MS is switched off or when the SIM is removed.

If a "PLMN not allowed" message is received by an MS in response to an LU request from a VPLMN, that VPLMN is added to a list of "forbidden PLMNs" in the SIM and thereafter that VPLMN will not be accessed by the MS when in automatic mode. A PLMN is removed from the "forbidden" list if, after a subsequent manual selection of that PLMN, there is a successful LU. This list is retained when the MS is switched off or the SIM is removed. The HPLMN shall not be stored on the list of "forbidden PLMNs".

3.2 Camping on a cell

3.2.1 Normal camping

For normal service, the MS has to camp on a suitable cell, tune to that cell's BCCH + CCCH, and possibly register within the PLMN so that the MS can:

- a) Receive system information from the PLMN (on the BCCH), e.g., the cell options;
- b) Receive paging messages from the PLMN, e.g., when there is an incoming call for the MS;
- c) Initiate call setup for outgoing calls or other actions from the MS (where possible, see Sections 3.5.3 and 3.5.4).

The choice of such a suitable cell for the purpose of receiving normal service is referred to as "normal camping". There are various requirements that a cell must satisfy before an MS can perform normal camping on it:

- i) It should be a cell of the selected PLMN;
- ii) It should not be "barred" (see Section 3.5.1);
- iii) It should not be in an LA which is in the list of "forbidden LAs for national roaming";
- iv) The radio path loss between MS and BTS must be below a threshold set by the PLMN operator. This is estimated as shown in Section 3.6.

Initially the MS looks for a cell which satisfies these 4 constraints ("suitable cell") by checking cells in descending order of received signal strength. If a suitable cell is found, the MS camps on it and performs any registration necessary. Cells can have two levels of priority, suitable cells which are of low priority are only camped on if there are no other suitable cells of normal priority. (This is called "cell selection").

When camped on a cell the MS regularly looks to see if there is a better cell in terms of a cell re-selection criterion, and if there is, the better cell is selected. Also if one of the other criteria changes, (e.g., the current serving cell becomes barred), or there is a downlink signalling failure (see Section 3.6), a new cell is selected. (This is called "cell reselection").

In order to speed up these processes, a list of the RF channels containing BCCH carriers of the same PLMN is broadcast on the BCCH, see Section 4.8. Also, the MS does not need to search all possible RF channels to find a suitable cell. If, after searching the 30 (GSM900) or 40 (DCS1800) RF channels with strongest received signal level, a BCCH carrier has been found but no suitable cell of the selected PLMN has been found, the MS can stop the attempt to find a suitable cell of the selected PLMN.

3.2.2 "Camp on any cell"

If the MS cannot find a suitable cell, it attempts to camp on any acceptable cell and enter a "limited service state", as defined in Section 3.7.

3.3 Regional provision of service

An MS may have a "regionally restricted service" where it can only obtain service on certain LAs. If such an MS attempts to camp on a cell of an LA for which it does not have service entitlement, when it does an LU request, it will receive an "LA not allowed" message. In this case:

- The MS stores the forbidden LA identity (LAI) in a list of "forbidden LAIs for regional provision of service", to prevent repeated access attempts on a cell of the forbidden LA. This list is deleted when the MS is switched off or the SIM is removed. If the MS cannot find a suitable cell, the MS performs the PLMN selection procedure starting at Section 4.4.3.1 A or B.

3.4 Borders between location areas

If the MS is moving in a border area between LAs, it might repeatedly change between cells of different LAs. Each change of LA would require an LU, which would cause a heavy signalling load and increase the risk of a paging message being lost. To prevent this, a "CELL_RESELECT_HYSTERESIS" (CRH) parameter is used. A cell in a different LA is only selected if it is "better", in terms of the path loss criterion (see section 3.6), than all the cells in the current LA by at least the value of CRH. The CRH parameter is broadcast on the BCCH. As the value of CRH broadcast may be different on different cells, the CRH parameter to be used is that broadcast on the current serving cell. There is also a lower limit on the time interval between reselection of cells on different LAs.

3.5 Barred cells and access control

3.5.1 Barred cells

The PLMN operator may decide not to allow MSs to camp on certain cells. (These cells may, for example, only be used for handover traffic, i.e. calls which need to be handed over to other cells). Barred cell information is broadcast on the BCCH to instruct MSs not to camp on these cells. The barred cell status may in fact change dynamically; hence the MS needs to regularly check the BCCH system information for this parameter.

The barred status of a cell depends both on CELL_BAR_ACCESS and on the cell's priority indicated by CELL_BAR_QUALIFY. The effect of these two parameters is further described in TS GSM 05.08.

If a cell is barred this applies both for cell selection and reselection.

3.5.2 Prioritising cells

In general, cell prioritisation is a means of encouraging MSs to select some suitable cells in preference to others. Since the priority comparison is only between suitable cells, prioritisation does not affect coverage. Operators may prefer a certain type of cell not to be selected unless it is the only suitable type. For example, umbrella cells due to their large frequency reuse distance, or microcells because the MS could be travelling too fast for them.

3.5.2.1 For cell selection

During cell selection (see section 3.2.1), a cell with low priority indication will only be selected if a suitable cell of normal priority cannot be found.

3.5.2.2 For cell reselection

Cell prioritisation can also be achieved during cell reselection by the use of the reselection parameters optionally broadcast. Cells are reselected on the basis of a parameter called C2 and the C2 value for each cell is given a positive or negative offset to encourage or discourage MSs to reselect that cell. A full range of positive and negative offsets is provided to allow the incorporation of this feature into already operational networks.

3.5.3 Access control

Due to problems in certain areas, Network Operators may decide to restrict access from some MSs (e.g., in case of congestion on the AGCH), and for this reason the access control mechanism is provided.

At subscription one or more access control classes are allocated to the subscriber and stored in the SIM. The information providing all authorised classes is broadcast on the BCCH (together with a bit indicating whether emergency calls may be made). This information is modified dynamically and therefore the MS has to check the BCCH before each attempt to access.

The MS ignores the Access Control information when selecting a cell to camp on, i.e. it shall not reject a cell for camping on because access on that cell is not allowed.

3.5.4 Forbidden LA for regional provision of service

When the MS is camped on a cell, the LA of which belongs to the list of forbidden LA for regional provision of service, the MS is not allowed to initiate establishment of a CM connection except for an emergency call; it may respond to paging.

If the MS has received the cause 'LA not allowed', it shall ignore this fact when selecting a cell to camp on, i.e. it shall not reject a cell for camping on because that cell is part of a LA where this cause has been received.

3.6 Radio constraints

The MS uses a "path loss criterion" parameter C1 to determine whether a cell is suitable to camp on. C1 depends on 4 parameters:

- i) The received signal level (suitably averaged);
- ii) The parameter RXLEV_ACCESS_MIN, which is broadcast on the BCCH, and is related to the minimum signal that the operator wants the network to receive when being initially accessed by an MS;
- iii) The parameter MS_TXPWR_MAX_CCH, which is also broadcast on the BCCH, and is the maximum power that an MS may use when initially accessing the network;
- iv) The maximum power of the MS.

The formula for determining C1 is given in GSM Rec 05.08.

Use of the parameter C1 enables the MS to determine whether communication is possible with the network in the absence of interference. However because of the possibility of interference degrading the communications, an additional safeguard is used. This is to monitor the success rate of the MS in decoding signalling blocks of the paging subchannel. If there is a downlink signalling failure, i.e. the success rate drops too low, this indicates probable interference on the downlink, and the MS attempts to find another suitable cell. Downlink signalling failure monitoring is specified in GSM 05.08.

In order to optimise cell reselection, additional cell reselection parameters can be broadcast on the BCCH of each cell. The cell reselection process employs a parameter C2 which depends on these parameters.

The parameters used to calculate C2 are as follows:

- i) CELL_RESELECT_OFFSET (see section 3.5.2.2);
- ii) PENALTY_TIME;

When the MS places the cell on the list of the strongest carriers as specified in GSM 05.08, it starts a timer which expires after the PENALTY_TIME. This timer will be reset when the cell is taken off the list. For the duration of this timer, C2 is given a negative offset. This will tend to prevent fast moving MSs from selecting the cell.

- iii) TEMPORARY_OFFSET;

This is the amount of the negative offset described in (ii) above. An infinite value can be applied, but a number of finite values are also possible.

The permitted values of these parameters and the way in which they are combined to calculate C2 are defined in GSM 05.08.

3.7 No suitable cell (limited service state)

There are a number of situations in which the MS is unable to obtain normal service from a PLMN. These include:

- a) Failure to find a suitable cell of the selected PLMN;
- b) No SIM in the MS;
- c) A "PLMN not allowed" response to an LU;
- d) An "illegal MS", "illegal ME" or "IMSI unknown in HLR" response to an LU. (Any SIM in the ME is then considered 'invalid'.)

(In automatic PLMN selection mode, events (a) and (c) would normally cause a new PLMN selection, but even here, the situation may arise when no PLMNs are available and allowable for use).

Under any of these conditions, the MS attempts to camp on an acceptable cell, irrespective of its PLMN identity, so that emergency calls can be made if necessary. When in the limited service state with a valid SIM, the MS shall search for available and allowable PLMNs in the manner described in section 4.4.3.1. To minimise the time taken to find new available PLMNs while maintaining battery life, discontinuous search schemes may be used, see TS GSM 02.11. No LU requests are made until a valid SIM is present and either a suitable cell is found or a manual network reselection is performed. In the limited service state the presence of the MS need not be known to the PLMN on whose cell it has camped. Cell reselection takes place as normal, except that a zero dB value of CRH will be used.

There are also other conditions under which only emergency calls may be made. These are shown in table 2.

4 Overall process structure

4.1 Process goal

The aim of the idle mode processes is to achieve the following conditions ("normal service state"):

- a) The registered PLMN is the selected PLMN;
- b) The MS is camped on a suitable cell of the LA on which the last successful LU was performed, and that cell has the highest value of C2 for any unbarred cell in that LA;
- c) The value of C2 for the MS is not lower than the value of C2 for any suitable cell in another LA of the selected PLMN by more than the hysteresis value CRH.

There may be temporary conditions under which not all these are fully satisfied, e.g., during cell selection on a PLMN or while in the process of reselecting another cell. However if the above cannot be satisfied for a certain period of time, the MS will normally enter a "limited service state" in which it will try to camp on an acceptable cell. In this state, only emergency calls are possible.

4.2 States description

Each of the processes of PLMN selection, cell selection and location updating can be described by a set of states. The overall state of the mobile is thus a composite of the states of the three processes. In some cases, an event which causes a change of state in one process may trigger a change of state in another process, e.g., camping on a cell in a new LA triggers an LU request. The relationship between the processes is illustrated in figure 1.

The states in which the MS may be, for each of the processes, are described below and illustrated in figures 2 to 4. For many of the states, a fuller description can be found in other GSM Technical Specifications, and a reference to the GSM Technical Specification and the relevant section within it, are given after the state description.

In the event of any conflict between the diagrams and the text in this specification, the text takes precedence.

4.3 List of states

4.3.1 List of states for the PLMN selection process

4.3.1.1 List of states for automatic mode (Figure 2a)

- A1 Trying RPLMN - The MS is trying to perform a Location Update on the registered PLMN.
- A2 On PLMN - The MS has successfully registered on a PLMN.
- A3 Trying PLMN - The MS is trying to register on a PLMN in the ordered list of PLMNs.
- A4 Wait for PLMNs to appear - There are no allowable and available PLMNs at present and the MS is waiting for one to appear.
- A5 HPLMN search in progress - The MS is trying to find if the HPLMN is available.
- A6 No SIM - There is no SIM in the MS, or certain LU responses have been received.

4.3.1.2 List of states for manual mode (Figure 2b)

- M1 Trying registered PLMN - The MS is trying to perform a Location Update on the registered PLMN.
- M2 On PLMN - The MS has successfully registered on a PLMN.
- M3 Not on PLMN - The MS has failed to register on the selected PLMN.
- M4 Trying PLMN - The MS is trying to register on a user selected PLMN.
- M5 No SIM - There is no SIM in the MS, or certain LU responses have been received.

4.3.2 List of States for the cell selection process (Figure 3)

- C1 Normal Cell Selection - This is the process of initial cell selection, searching all GSM or DCS RF channels.
- C2 Stored List Cell Selection - This is the process of initial cell selection where BCCH carrier information (e.g. a BA list) for the selected PLMN is stored in the MS.
- C3 Camped Normally - This is where the MS is camped on a cell of the selected PLMN and may be able to make and receive calls. (Whether or not the MS can make and receive calls depends on the state within the location updating process). The MS monitors received level and BCCH data and checks whether cell reselection is needed.
- C4 Normal Cell Reselection - This is where the MS has determined that cell reselection is needed and an attempt is being made to reselect a new cell.
- C5 Choose Cell - This is where the MS has returned to idle mode from "connected mode" and is choosing a suitable cell to camp on.
- C6 Any Cell Selection - This is where the MS is unable to camp normally on any cell of the selected PLMN, or cannot obtain service because of certain responses to a location updating (LU) attempt. It is searching for a cell of any PLMN to camp on (so that emergency calls can be made).
- C7 Camped on any Cell - This is where the MS has camped on a cell irrespective of its PLMN identity, so that emergency calls can be made.
- C8 Any Cell Reselection - This is where the MS is attempting to reselect a cell, irrespective of PLMN identity.

- C9 Choose Any Cell - This is where the MS is returning to idle mode, after having entered "connected mode" from the "camped on any cell" state to make an emergency call. It is attempting to find an acceptable cell to camp on.

For detailed description of the behaviour in the above states see GSM 05.08.

4.3.3 List of states for location updating (Figure 4)

The states are entered depending on responses to location update (LU) requests.

- L1 Updated - The MS enters this state if an LU request is accepted. The update status on the SIM is set to "updated".

- L2 Idle, No IMSI - The MS enters this state if an LU request is rejected with cause:

- a) IMSI unknown in HLR;
- b) illegal ME;
- c) illegal MS;

or if there is no SIM.

If a SIM is present, the update status of the SIM is set to "Roaming not allowed".

- L3 Roaming not allowed - The MS enters this state if it receives an LU reject message with the cause:

- a) PLMN not allowed;
- b) Location area not allowed;
- c) National Roaming not allowed in this location area.

The update status on the SIM is set to "Roaming not allowed".

The behaviour of the MS in the roaming not allowed state is dependent on the LU reject cause as shown in Table 2. Additionally:

- in automatic mode, "PLMN not allowed" and "national roaming not allowed in this location area" cause the Automatic Network Selection procedure of section 4.4.3.1A to be started
- in manual mode, "PLMN not allowed" and "national roaming not allowed" cause the Manual Network Selection procedure of section 4.4.3.1B to be started.

- L4 Not updated - The MS enters this state if any LU failure not specified for states L2 or L3 occurs, in which cases the MS is not certain whether or not the network has received and accepted the LU attempt. The update status on the SIM is set to "not updated".

4.4 PLMN selection process

4.4.1 Introduction

There are two modes for PLMN selection, automatic and manual. These are described in Sections 4.4.3 below and illustrated in figures 2a to 2b.

4.4.2 Registration on a PLMN

In both automatic and manual modes, the concept of registration on a PLMN is used. An MS successfully registers on a PLMN if:

- a) The MS has found a suitable cell of the PLMN to camp on; and
- b) An LU request from the MS has been accepted in the LA of the cell on which the MS is camped (see table 1).

It should be noted that if registration is unsuccessful because no suitable cell could be found, the MS will have had to search at least the 30 (GSM) or 40 (DCS) strongest RF channels (see Section 3.2) and therefore all the available PLMNs will potentially have been detected. If registration is unsuccessful because of an LU failure or an LU rejection, the MS need not necessarily have already searched the 30 or 40 strongest RF channels, and would need to do so before being in a position to display to the user all available PLMNs (see below).

4.4.3 PLMN selection

4.4.3.1 At switch-on or recovery from lack of coverage

At switch on, the MS selects and attempts to perform a Location Update on the registered PLMN, if it exists. On recovery from lack of coverage, the MS selects the registered PLMN (if it exists) and, if necessary (see section 4.6.2) attempts to perform a Location Update.

If successful registration is achieved, the MS indicates the selected PLMN.

If there is no registered PLMN, or if registration is not possible due to the PLMN being unavailable or registration failure, the MS follows one of the following two procedures depending on its operating mode.

A) Automatic Network Selection Mode Procedure

The MS selects and attempts registration on other PLMNs, if available and allowable, in the following order:

- i) HPLMN (if not previously selected);
- ii) each PLMN in the "PLMN Selector" data field in the SIM (in priority order);
- iii) other PLMNs with received signal level above -85 dBm in random order;
- iv) all other PLMNs in order of decreasing signal strength.

If successful registration is achieved, the MS indicates the selected PLMN.

If registration cannot be achieved because no PLMNs are available and allowable, the MS indicates "no service" to the user, waits until a new PLMN is available and allowable and then repeats the procedure. If there were one or more PLMNs which were available and allowable, but an LU failure made registration on those PLMNs unsuccessful or an entry in a forbidden LAI list prevented a registration attempt, the MS selects the first such PLMN again and enters a limited service state.

B) Manual Network Selection Mode Procedure

The MS indicates whether there are any PLMNs which are available. This includes "Forbidden PLMNs"

If displayed, PLMNs meeting the criteria above are presented in the following order:

- i) HPLMN;
- ii) PLMNs contained in the "PLMN Selector" data field in the SIM (in priority order);
- iii) other PLMNs with received signal level above -85 dBm in random order;
- iv) all other PLMNs in order of decreasing signal strength.

The user may select his desired PLMN and the MS then initiates registration on this PLMN. (This may take place at any time during the presentation of PLMNs). For such a registration, the MS shall ignore the contents of the forbidden LAI and PLMN lists.

If the user does not select a PLMN, the selected PLMN shall be the one that was selected before the PLMN selection procedure started. If no such PLMN was selected or that PLMN is no longer available, then the MS shall attempt to camp on any acceptable cell and enter the limited service state.

4.4.3.2 User reselection

At any time the user may request the MS to initiate reselection and registration onto an alternative available PLMN, according to the following procedures, dependent upon the operating mode.

A) Automatic Network Selection Mode

The MS selects and attempts registration on PLMNs, if available and allowable, in accordance with the following order:

- i) HPLMN;
- ii) PLMNs contained in the "PLMN Selector" data field in the SIM (in priority order);
- iii) Other PLMNs with the received signal level above -85 dBm in random order;
- iv) All other PLMNs in order of decreasing signal strength.

The PLMN which the MS had selected prior to the start of this reselection procedure is not reselected, unless no other PLMNs are available, allowable and have higher received signal level, in which case it is reselected at the end of the procedure.

B) Manual Network Selection Mode

The Manual Network Selection Mode Procedure of section 4.4.3.1 is followed.

4.4.3.3 In VPLMN of home country

The MS shall periodically attempt to obtain service on its HPLMN. For this purpose, a value T minutes may be stored in the SIM, T is either in the range 6 minutes to 8 hours in 6 minute steps or it indicates that no periodic attempts shall be made. If no value is stored in the SIM, a default value of 30 minutes is used.

The attempts to access the HPLMN shall be as specified below:

- a) The periodic attempts shall only be performed in automatic mode when the MS is roaming in its home country;
- b) After switch on, a period of at least 2 minutes and at most T minutes shall elapse before the first attempt is made;
- c) The MS shall make an attempt if the MS is on the VPLMN at time T after the last attempt;
- d) Periodic attempts shall only be performed by the MS while in idle mode;
- e) If the HPLMN is not found, the MS shall remain on the VPLMN.

4.4.4 Abnormal cases

If there is no SIM in the MS, if there is an authentication failure, or if the MS receives an "IMSI unknown in HLR", "illegal ME" or "illegal MS" response to an LU request, then effectively there is no selected PLMN ("No SIM" state). In these cases the states of the cell selection process are such that no PLMN selection information is used. No further attempts at registration on any PLMN are made until the MS is switched off and on again, or a SIM is inserted.

When in Automatic Network Selection mode and the MS is in the 'not updated' state with one or more suitable cells to camp on; then after 3 minutes or 6 unsuccessful LU requests the MS may continue (or start if it is not running) the user reselection procedure of 4.4.3.2 A.

4.4.5 National roaming not allowed in this LA

If in either PLMN selection mode the LU response "National roaming not allowed in this LA" is received:

The PLMN Automatic or Manual Mode Selection Procedure of section 4.4.3.1 are followed, depending on whether the MS is in automatic or manual mode. (This requirement applies to DCS 1800 and GSM 900 MSs.)

4.5 Cell selection process

Whenever a PLMN is selected, the MS attempts to find a suitable cell of that PLMN to camp on. Two methods of searching for a suitable cell are possible:

- a) Normal cell selection ("Normal cell selection" state) - Here the MS has no prior knowledge of which GSM 900 or DCS 1800 RF channels are BCCH carriers. It searches at least the strongest 30 (GSM) or 40 (DCS) RF channels in descending order of received signal level to see which are BCCH carriers. (If no BCCH carriers have yet been found, searching will continue until at least one BCCH carrier is found.) The first BCCH carrier found which is from a suitable cell and on which there is a normal priority indication is taken and that cell is camped on. If at least the 30 strongest GSM or 40 strongest DCS1800 RF channels have been tried and the only suitable cells found have low priority indication the MS shall camp on the strongest of these cells.
- b) Stored list cell selection (optional) ("Stored list cell selection" state)- Here the MS has a list of the BCCH carriers used by the PLMN. (This list may be derived by the MS from information gathered during previous selections of the PLMN). The BCCH carriers in the list are searched in descending order of received signal level, and the first BCCH carrier found which is from a suitable cell and on which there is a normal priority indication is taken, and that cell is camped on. If an MS decodes BCCH data from a cell of the selected PLMN but is unable to camp on that cell, the BA of that cell shall be examined and any BCCH carriers in the BA which are not in the list of BCCH carriers to be searched shall be added to the list. If all these BCCH carriers have been tried and the only suitable cells found have low priority indication, the MS shall camp on the strongest of these cells.

If no suitable cell is found using method b), method a) is then tried.

While camped on a cell of the selected PLMN ("camped normally"), the MS may need to select a different cell ("normal cell reselection" state). The following events trigger a cell reselection:

- i) The path loss criterion parameter C1 (see Section 3.6) indicates that the path loss to the cell has become too high;
- ii) There is a downlink signalling failure (Section 3.6);
- iii) The cell camped on (current serving cell) has become barred;
- iv) There is a better cell (in terms of the path loss criterion C2) in the same LA, or a much better cell in another LA of the selected PLMN (using the CRH parameter, section 3.4);
- v) A random access attempt is still unsuccessful after "Max retrans" repetitions; "Max retrans" being a parameter broadcast on BCCH.

The MS will then reselect a new cell in order to fulfil the process goal (see section 4.1).

Before camping on the cell after re-selection, the MS shall attempt to decode the full set of data of the BCCH. The MS shall check that the parameters affecting cell re-selection are unchanged. If a change is detected the MS shall check if the cell re-selection criterion is still valid using the changed parameters. If the cell selection criteria are still valid, the MS shall camp on the cell. If they are not still valid, the MS shall repeat this process for the cell with the next highest value of C2.

Once the MS has re-tuned to the chosen cell, it shall monitor its paging subgroup (if known) for that cell. If the MS receives a page before having decoded the full BCCH data for the new cell, the MS shall store the page and respond, if permitted, once the full BCCH data has been decoded. If not permitted, no page response shall be made.

When the MS leaves idle mode and enters "connected mode" (e.g., to make a call), on return to idle mode at the end of the call, a cell must be chosen ("choose cell" state) as soon as possible e.g., to allow a new call to be made as soon as possible. The chosen cell will not necessarily be the same cell as the MS was camped on when the call started e.g., if the MS moved a significant distance while the call was in progress. Two cases are distinguished in GSM 05.08, for which the algorithm is slightly different:

- a) Normal case - The call is terminated, either because the user (or network) has terminated the call, or because a radio link failure has occurred and call re-establishment is not being attempted.
- b) Call re-establishment - A radio link failure has occurred and a call re-establishment is being attempted. (The MS returns to idle mode to start the call re-establishment attempt and needs to select a new cell on which to make the attempt as soon as possible in order to minimise the interruption to the call).

If no suitable cell is found by either the stored list cell selection, normal cell reselection, or choose cell tasks (all of which use a limited search), the normal cell selection task (which searches all RF channels for a suitable cell) is entered.

If no suitable cell is found by the normal cell selection task, or if there is no SIM in the MS, the MS attempts to find an "acceptable cell" on which it may camp so that emergency calls may be made ("any cell selection" state). The MS ignores the PLMN information when selecting an acceptable cell, and no attempt at location updating is made. This task is also entered if an LU reject is received with one of the following cause values:

- "IMSI unknown in HLR";
- "Illegal MS";
- "illegal ME";
- "PLMN not allowed". (However, this will trigger a new PLMN selection if the MS is in automatic mode).

If an acceptable cell is found, the MS camps on it ("Camped on any cell" state). If one of the cell reselection trigger events (i) to (v) above occurs, the MS attempts to find a new acceptable cell to camp on ("any cell reselection" state) but using a zero dB value of CRH. If no acceptable cell can be found, the "any cell selection" task is re-entered.

If while camped on an acceptable cell, an emergency call origination is made, the MS enters a connected mode and at the end of the call, chooses an acceptable cell ("choose any cell" state) so that it is ready for the next emergency call origination.

In all cases, if a new PLMN is selected, the MS searches for a suitable cell of that PLMN. However, if the MS has recently searched the strongest RF channels while a previous PLMN was selected, it may already have information about other PLMNs.

The user may request a search of RF channels to determine which PLMNs are available. This search shall be done in such a way as to minimise interruptions to the MS's monitoring of its paging subchannel.

4.6 Location updating process

4.6.1 General

When the MS is switched on, the action taken by the location updating process is as follows:

- a) SIM present and no LU needed (because of the status of the stored LAI and "attach" flag): The MS is in the update state UPDATED;
- b) SIM present and LU needed: A LU request is made;
- c) No SIM present: The MS enters the update state Idle, NO IMSI.

In case (b) above, and subsequently whenever a LU request is made, the MS enters a state depending on the outcome of the LU request, as listed in Section 4.3.3 above.

Whenever the MS goes to connected mode and then returns to idle mode again, the MS selects the appropriate state.

4.6.2 Initiation of Location Updating

An LU request indicating Normal Location Updating is made when, in idle mode,

- the MS changes cell while being in the update state NOT UPDATED.
- the MS detects that it has entered a new location area, i.e., when the received LAI differs from the one stored in the MS, and the LAI or the PLMN identity is not contained in a list of forbidden LAIs or PLMN identities respectively, while being in one of the following update states:
 - * UPDATED;
 - * NOT UPDATED;
 - * ROAMING NOT ALLOWED.
- the Periodic Location Updating Timer expires while being in the update state NOT UPDATED.
- a manual network reselection has been performed, an acceptable cell of the selected PLMN is present, and the MS is not in the UPDATED state on the selected PLMN.

An LU request indicating Periodic Location Updating is made when, in idle mode, the Periodic Location Updating timer expires while being in the update state UPDATED.

An LU request indicating IMSI attach is made when the MS is activated in the same location area in which it was deactivated while being in the update state UPDATED, and the BCCH indicates that IMSI attach/detach shall be used.

Furthermore, an LU request indicating Normal Location Updating is also made when the response to an outgoing request shows that the MS is unknown in the VLR.

Table 2 summarises the events in each state that trigger a new LU request. The actions that may be taken while being in the various states are also outlined in table 2.

4.6.3 Periodic Location Updating

A timer with the following characteristics shall be implemented in the MS:

- i) Upon switch on of the MS or when the BCCH indicates that periodic location updating shall be applied, and the timer is not running, the timer shall be loaded with a random value between 0 and the broadcast timeout value and started.
- ii) The timeout value shall be within the range of 1 deci-hour to 255 deci-hours with a granularity of 1 deci-hour.
- iii) When the timer reaches its expiry value, it shall be initiated with respect to the broadcast timeout value, and the MS shall initiate Periodic Location Updating.
- iv) The timer shall be prevented from triggering Periodic Location Updating during connected mode. When the MS returns to idle mode, the timer shall be initiated with respect to the broadcast timeout value, then started. Thereafter, the procedure in iii) shall be followed.
- v) When a change in the broadcast timeout value occurs (at a change of serving cell or a change in the broadcast timeout value), the timer shall be reloaded so that the new time to expiry will be: "old time to expiry" modulo "new broadcast timeout value".

4.6.4 IMSI attach/detach operation

The BCCH will contain an indicator indicating whether or not IMSI attach/detach operation is mandatory to use in the cell. The MS shall operate in accordance with the received value of the indicator.

When IMSI attach/detach operation applies, a MS shall send the IMSI detach message to the network when the MS is powered down or the SIM is removed while being in the update state UPDATED. The IMSI detach message will not be acknowledged by the network.

When the MS returns to the active state, the MS shall perform an LU request indicating IMSI attach, provided that the MS still is in the same location area. If the location area has changed, an LU request indicating Normal Location Updating according to section 4.6.2 shall be performed.\

4.7 Service indication

This is an indication to the user that GSM (or DCS) service is available.

The service indication should be set if the following conditions are all satisfied:

- a) Cell Selection: Camped on a suitable cell and in updated state, or in connected mode having been camped on a suitable cell.
- b) Location updating: In updated state.

However due to the fact that there may be some transitory changes of state, the service indication is permitted to continue to be set for up to 10 seconds after the above conditions cease to be met. Also the service indication is permitted to take up to 1 second to be set after the above conditions are met.

4.8 BCCH allocation broadcasting and storage

The BCCH allocation is the list of BCCH carriers in use by a given PLMN in a given geographical area. (It indicates the RF channels that the MS is required to monitor while camped on a cell of that PLMN.) It is broadcast in the system information messages on the BCCH, and is referred to as the BA(BCCH).

When the MS is first switched on in a PLMN, and has no knowledge of which RF channels are BCCH carriers of that PLMN it has to search the strongest RF channels in order to find which are BCCH carriers. It then has to determine which BCCH carriers belong to the selected PLMN. Once it has found a BCCH carrier of the selected PLMN, it can read the BA(BCCH). It then knows which RF channels to monitor for cell selection and reselection purposes.

Whilst switched on in the PLMN, the MS can gain knowledge of the preferable carriers to use in subsequent cell selections in that PLMN. This knowledge may come from previously decoded BA(BCCH)s and from transmitted information from the network.

When the MS switches off, it has the option of storing the last known BA(BCCH) in a non volatile store so that on a subsequent switch on in that PLMN, it does not need to search to find the BA(BCCH), and so can camp on a cell more quickly. If the BA(BCCH) is stored in the SIM, it shall be stored in the format specified in GSM 11.11. Any other information used by the MS in cell selection shall be stored in a non volatile store on the ME.

The BA(BCCH) may or may not be the total list of BCCH carriers in use throughout the PLMN coverage area. For example there may be differences in different geographical areas, and there may be "umbrella cells" which are only used for handover traffic and hence are not to be camped on. The BA(BCCH) shall include the BCCH carrier on which it is broadcast.

A stored BA(BCCH) is not necessarily valid when the MS is switched on again e.g., if the system operator has made a change in BA(BCCH) or if the MS is switched on in a different geographical area. In these cases, the MS may not find a suitable cell for camping on using the stored BA(BCCH). However, the MS may use other stored information to find a suitable cell before searching all the strongest RF channels to find a suitable cell of the selected PLMN.

It should also be noted that the BA(BCCH) only applies to the PLMN on which it was received. If a new PLMN is selected, only a BA(BCCH) previously obtained from that PLMN should be used.

There is another BCCH carrier list, called BA(SACCH), which is sent on the SACCH when in connected mode. This contains the list of BCCH carriers to be monitored by the MS for handover purposes. The BA(BCCH) and BA(SACCH) need not necessarily be the same. For example, the BA(SACCH) might contain umbrella cells, or the BCCH carrier of the serving cell might be omitted.

If the MS stores a BA list in the SIM, and there is a valid stored LAI, the BA list must be of the PLMN indicated by the stored LAI.

4.9 Pageability of the mobile subscriber

An MS is required to listen to all paging messages that could address it (as defined by its paging sub-channel and the page mode, see GSM 05.02), when the following conditions are all satisfied:

- A SIM is inserted.
- The MS is camped on a cell.
- The MS is not in state "Idle, No IMSI".
- The MS is not performing the task to search for available PLMNs. (Whenever possible during this task, the MS should listen for paging.) However, when the MS is camped on a cell, is registered in a PLMN and is performing its regular search for the HPLMN, as specified in GSM 02.11, then it shall listen to all paging messages that could address it.

NOTE: During cell reselection there is a certain period when the MS is no longer camped on the old cell but must decode the full BCCH before camping on the new cell. This leads to a period of slightly more than 8 51 frame multiframe when the MS will not necessarily be pageable.

Table 1: Effect of LU Outcomes on PLMN Registration

Location Updating Task State	Registration Status	Registered PLMN is
Updated	Successful	Indicated in the stored LAI
Idle, No IMSI	Unsuccessful	No registered PLMN
Roaming not allowed:		
a) PLMN not allowed	Unsuccessful	No registered PLMN
b) LA not allowed	Indeterminate(1)	No registered PLMN
c) Nat'l Roaming not allowed in this LA	Indeterminate (2)	No registered PLMN
Not updated	Unsuccessful	No registered PLMN

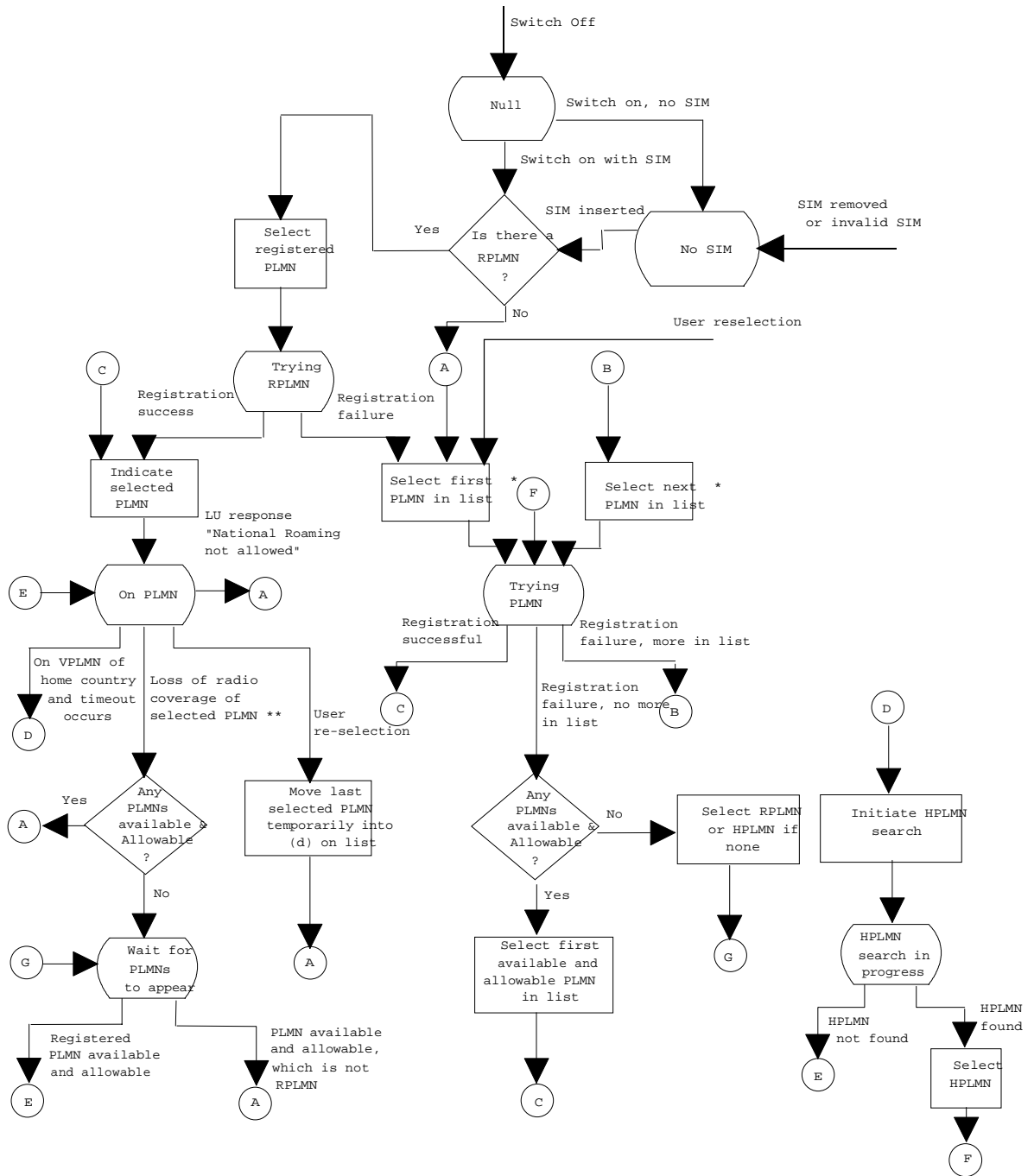
- 1) The MS will eventually either enter a different state when the registration status will be determined, or fail to be able to camp on a cell, when registration will be unsuccessful.
- 2) The MS will select the HPLMN if in automatic mode and will enter Automatic Network Selection Mode Procedure of section 4.4.3.1. If in manual mode, the MS will display the list of available PLMNs and follow the Manual Network Selection Mode Procedure of section 4.4.3.1. If the appropriate process does not result in registration, the MS will eventually enter the limited service state.

NOTE: The registered PLMN is determined by looking at the stored LAI and stored location updating status.

Table 2: LU Process States and Allowed Actions

Location updating task state	New LU request when				Normal Calls Supported (1)	Paging responded to
	Changing Cell	Changing LA	Changing PLMN	Other		
Null (4) No	Yes	Yes	No	No	No	
Updated, (5)	No	Yes	Yes	(2)	Yes	Yes
Idle, No IMSI	No	No	No	No	No	No
Roaming not allowed:						
a) Idle, PLMN not allowed	No	No	Yes	No	No	Optional if with IMSI
b) Idle, LA not allowed	No	Yes	Yes	No	No	Optional if with IMSI
c) Idle, Nat'l Roaming not allowed in this LA	No	Yes	Yes	No	No	Optional if with IMSI
Not updated	Yes	Yes	Yes	(2)&(3)	(3)	Yes if with IMSI

- 1): Emergency calls may always be made, subject to access control permitting it.
- 2): A new LU is made when the periodic registration timer expires.
- 3): If a normal call request is made, an LU request is made. If successful the updated state is entered and the call may be made.
- 4): The MS is in the null state from switch on until it has camped on a cell and either made an LU attempt or decided that no LU attempt is needed.
- 5): In this state, IMSI detach is performed if the MS is deactivated and the BCCH indicates that IMSI attach/detach shall be used. An LU request indicating IMSI attach is performed if the MS is activated in the same location area in which it was deactivated while being in this state.



* "List" consists of (in order)

- a) HPLMN
- b) Each PLMN in SIM list in priority order provided they are "available"
- c) All other PLMNs above -85 dBm in range are "available"
- d) Other PLMNs in decreasing order of signal strength

** Includes effective loss of coverage due to LAs being forbidden in all potentially suitable cells

Figure 2a: PLMN Selection State Diagram (Automatic Mode)

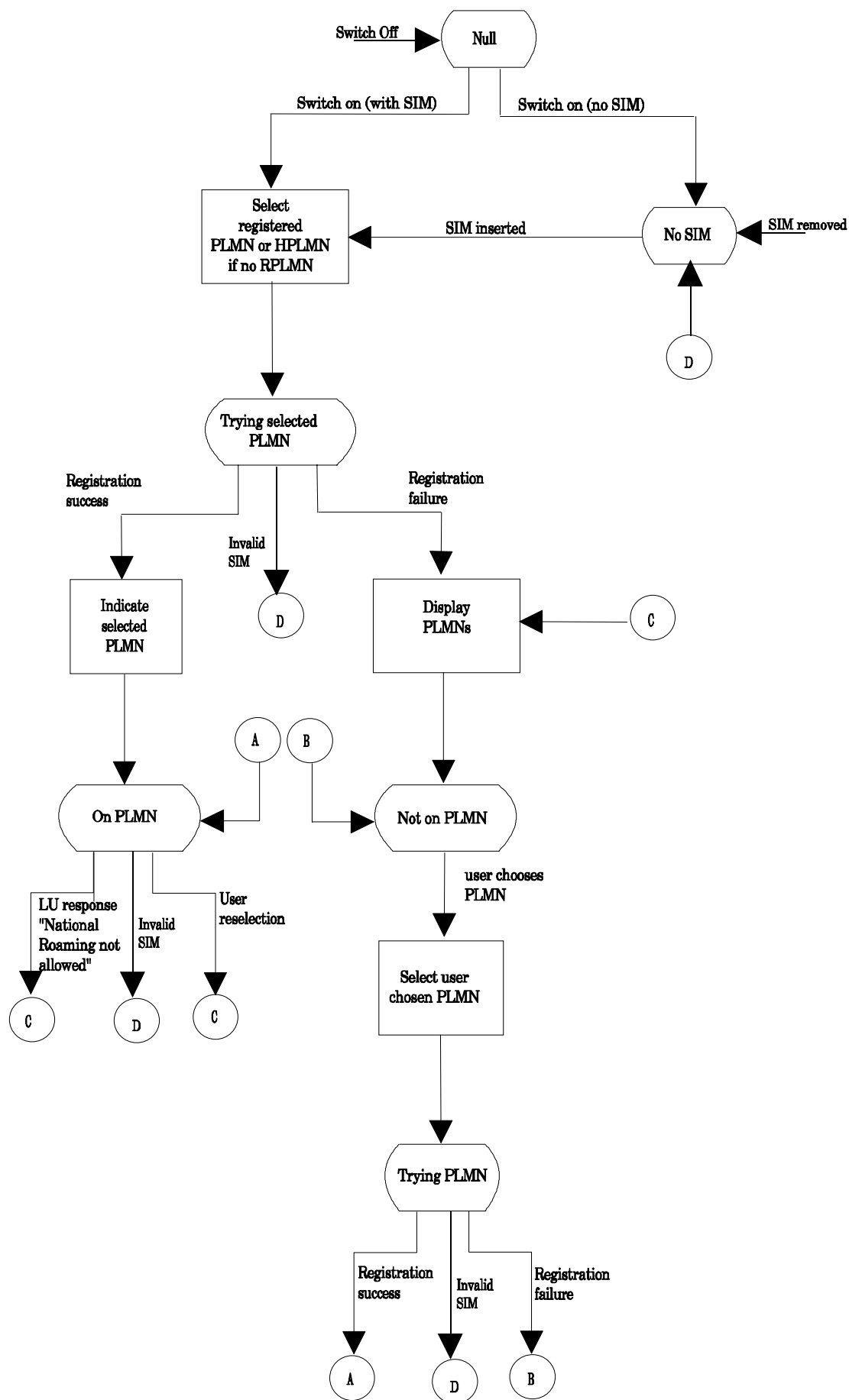
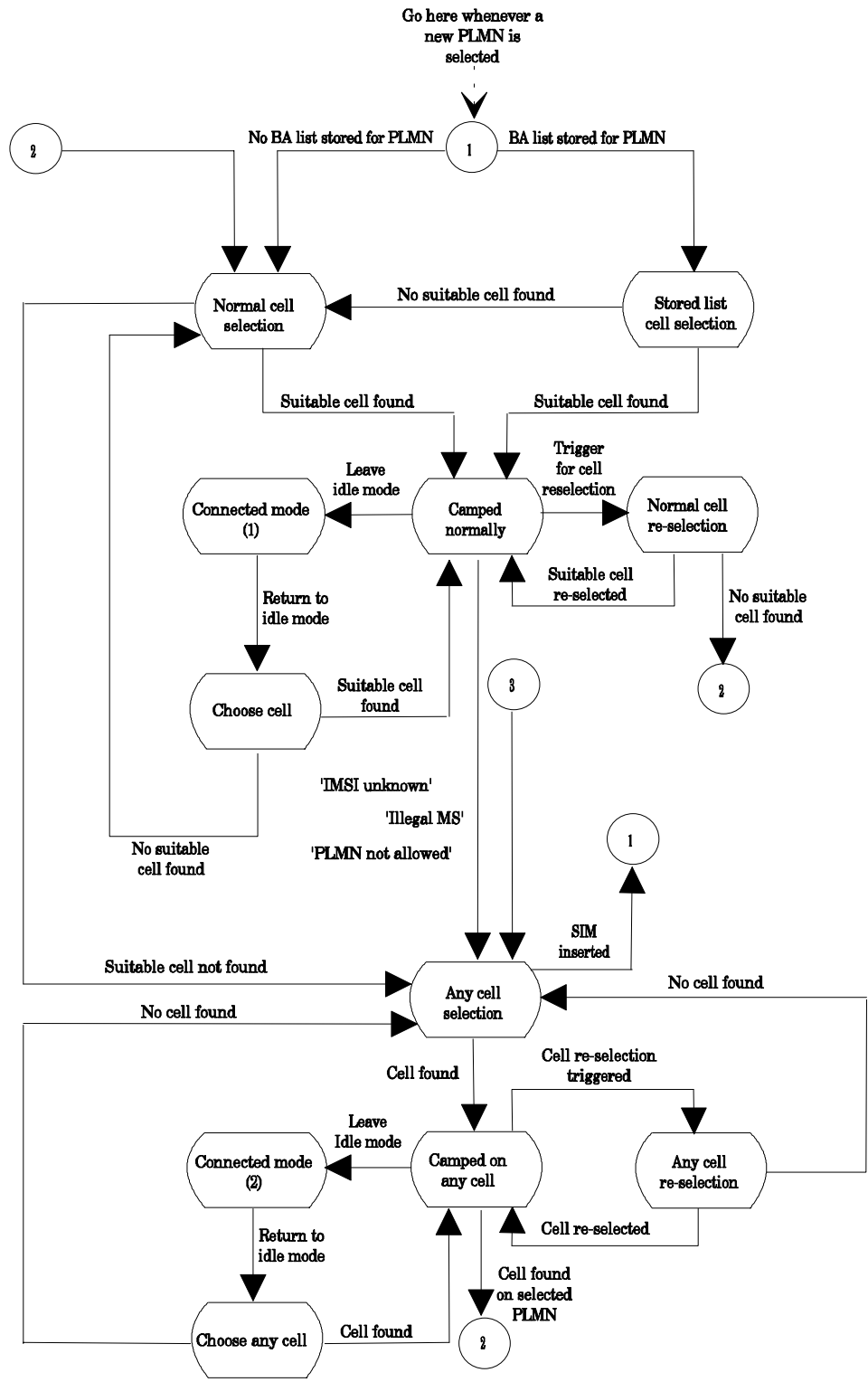
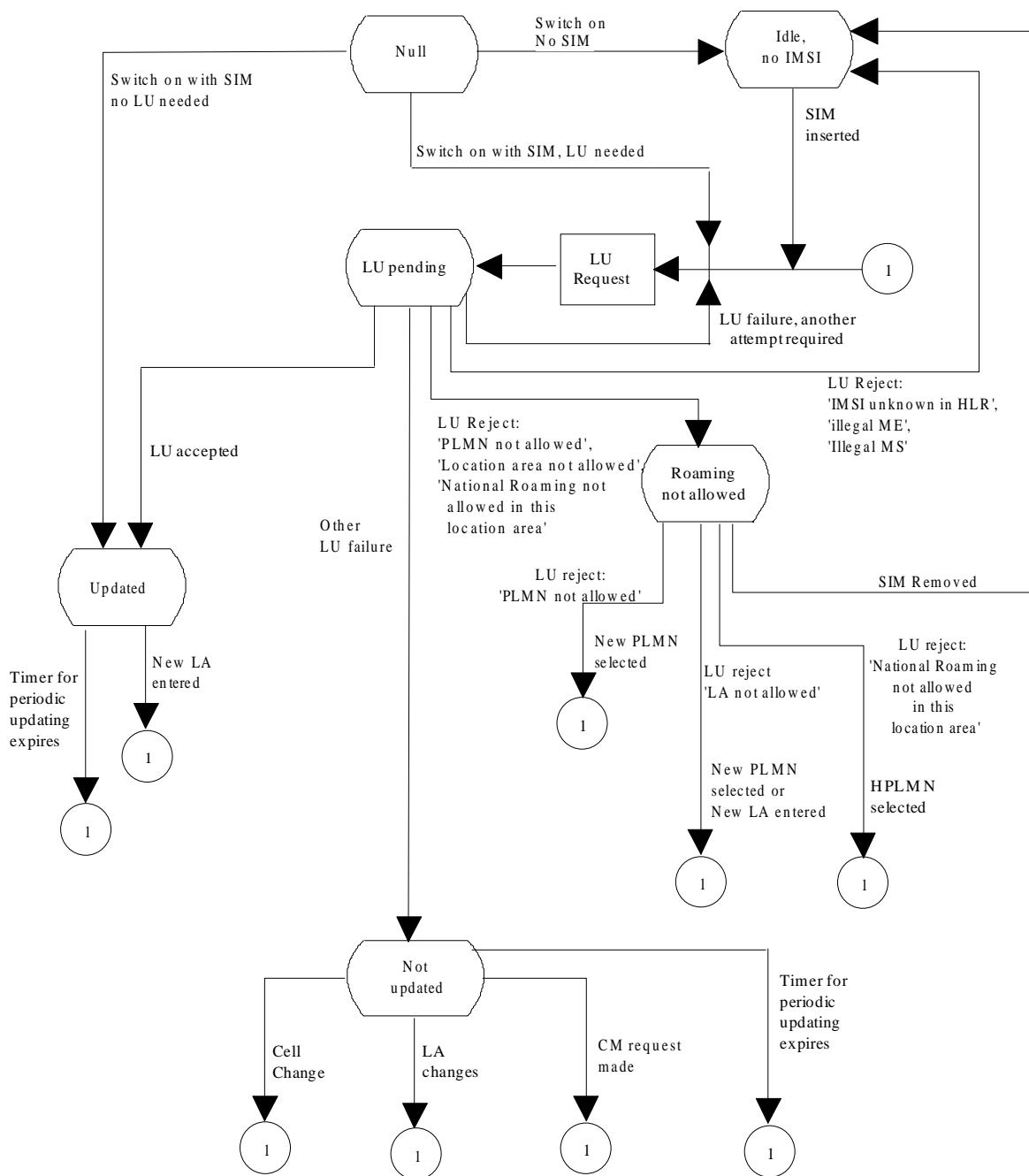


Figure 2b: PLMN Selection State Diagram (Manual Mode)



Notes:- (1) To make or receive call
 (2) To make an emergency call
 In any state, a new PLMN selection causes an exit to 1
 Go to 3 if no SIM in MS

Figure 3: Cell Selection State Diagram



Note:-

Whenever the MS goes to connected mode and then returns to idle mode again the MS selects the appropriate state.

Figure 4: Location Updating Task State Diagram

History

Document history	
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