For MS terminating calls where part of or the whole charge is to be paid by the MS, the information to be stored would be similar to that of MS originating calls. Further study is required.

5.5Traffic survey

For further study.

5.6Malicious call identification

If required and regulatory and technical constraints permit, the MSC may support the malicious call identification (MCI) facility for MS originatingand MS terminating calls. The exact implementation of this facility will depend upon national variations of the signalling system being used.

5.7Tracing of mobile stations

For further study.

i) by use of the Mobile Application Part;

ii) by use of a public data network;

iii) by use of dedicated links;

iv)by use of physical transfer of magnetic tapes containing the billing information; or

v) a combination of the above.

Case i) above is specified in Recommendation Q.1051.

The need for Recommendations covering the other alternatives is a matter for further study. They may be required to permit different manufacturers equipment to interwork.

It should be noted that the use of the Mobile Application Part will only allow charging data on a per call basis to be transferred, though not necessarily immediately after the call has been terminated. For instance if the Mobile Application Part signalling or network processing load is such that the transfer of billing information would compromise normal call set up procedures, then the transfer of billing information should be delayed until the signalling load decreases (e.g. overnight transmission of stored billing data).

In the longer term it is not clear, even if overnight transfer of billing information is used, whether the Mobile Application Part will have sufficient capacity, therefore a move to another technique will be necessary.

For calls involving a roaming mobile in a visited PLMN, the same techniques as above can be applied by bilateral agreement. For instance the situation could be imagined where a roaming service is opened between two networks, but the level of roaming traffic does not justify either the use of
a public data network, or physical transfer of magnetic tapes, therefore the Mobile Application Part is used initially.

The destination for international billing information should be the relevant billing entity of the home network, however, when using the Mobile Application Part, addressing difficulties may mean that only the HLR can be addressed.

The MSC may support facilities for debit card calls. The signalling procedure on the radio path should support this type of operation.

The MSC may also support facilities for credit card calls. This involves facilities and procedures for authentication of the credit card number and transfer of the required information to the billing authority. The procedures will not be specified for the Mobile Application Part. On a national basis Signalling System No. 7, public data networks or other networks convenient for the administration may be used for these purposes.

ii) maintenance of circuits to exchanges of the PSTN/ISDN,

iii) maintenance of signalling links to a signalling network,

iv) fault reporting to operation and maintenance centres, and

v) maintenance of their own equipment.

5.3.5Maintenance responsibilities of location registers

The location registers will be responsible for:

i) maintenance of signalling links; and

ii)restoration after restarts including information exchange with other location registers.

5.3.6Maintenance responsibilities of operation and maintenance centres

For further study.

5.4Charging

The MSC and the BS must be capable of obtaining all information required for determining call charges for MS originating calls.

For charging of MS originating calls information as follows may be required:

- address of called party,

- IMSI,

- time of the call,

- charging rate for the called destination,

-call duration and possibly also parameters such as traffic volume and radio channel resources used,

-additional charges, e.g. for use of supplementary services,

-charging conditions, e.g. normal charging, debit card, credit card, and

-location of MS (e.g. cell, location area, MSC area).

For calls within the same PLMN the information is directed to the relevant billing entity. How this is achieved is a national concern, however, examples could be:

5.3.1General

Maintenance of PLMNs may require activities in several functional units. Some maintenance activities are autonomous, i.e. within one functional unit, and others require cooperation between several functional units. Functional units which may be involved in cooperative maintenance activities are:

- mobile stations,
- base stations,
- MSCs,
- visitor location registers,
- home location registers, and
- national operation and maintenance centres.

In some cases maintenance activities may require international cooperation. In such cases the maintenance responsibilities, the information exchanges and the activities required for restoration of service should be in accordance with rules set down for the PSTN/ISDN (M-Series of Recommendations).

5.3.2Maintenance responsibilities of MSs

To some degree the MS should be capable of detecting faulty operation. When faults are detected, the MS should initiate internal testing and prevent accidental transmission.

5.3.3Maintenance responsibilities of the BSs

The BS should monitor the radio path. If faulty operation is detected, information should be sent to the MSC and/or to a national operation and maintenance centre.

The BS may also have facilities for blocking and unblocking of radio channels and BS-MSC circuits.

5.3.4Maintenance responsibilities of MSCs

The MSC should include maintenance facilities and support maintenancefunctions as for exchanges of the PSTN/ISDN. These functions include:

i) maintenance of the MSC-BS circuits and signalling links, including:

- test, observation and measurement of MSC-BS (MSC-MS) protocols; and
- blocking and unblocking of MSC-BS circuits and radio channels.

The main responsibilities of the VLRs are:

i) management of mobile station roaming numbers;

ii) management of temporary mobile station identities, if implemented;

iii) subscriber administration of visiting MSs;

iv) updating of HLRs;

v) management of MSC areas, location areas and BS areas; and

vi) radio channel management (e.g. channel allocation tables, dynamic channel allocation management, channel blocking status).

Note - Some or all of the functions in vi) may be in the MSC or the BS. This is for further study.

5.2.4 Responsibilities of MSCs

The main responsibilities of the MSCs are:

i) routing administration;

ii) charging and tariff administration;

iii) traffic administration, e.g. traffic monitoring; and

iv) sending of relevant traffic and charging information to the HLR (see § 5.4).

5.2.5 Responsibilities of national 0 & M centres

The operational responsibilities of national O & M centres could be remote control and monitoring of the operation of functional units, e.g. remote management of subscriber parameters.

5.2.6 Responsibilities of BSs

For further study.

5.2.7 Responsibilities of encryption key distribution centres

For further study.

5.2.8 Responsibilities of centres for management of equipment identities

For further study.

5.3 Maintenance

Further study is required.

5.2 Operation

5.2.1 General

In PLMNs tasks related to system operation are divided among several functional units:

- home location registers,
- visitor location registers,
- MSCs,
- BSs,
- national operation and maintenance centres,
- encryption key distribution centres, and
- centres for management of equipment identities.

It should be noted that several of these functional units may be co-located or even be accommodated in the same physical equipment.

In addition, other aspects concerning system operation will be the responsibility of subscribers, MS manufacturers, sales agents, etc.

Tasks allocated to each of the functional units are described below.

5.2.2 Responsibilities of HLRs

The main responsibilities of the HLRs are:

i) subscriber administration, i.e. management of all subscriber parameters of MSs registered in the HLR. Subscriber administration also includes the possibility of making changes to subscription conditions and subscriber parameters. It may also include additional administrative functions related to CUGs and MSs with preference;

ii) charging administration, e.g. relaying of charging information from a foreign PLMN to the charging point in the home PLMN; and

iii) updating of VLRs.

5.2.3 Responsibilities of VLRs

It may be possible to offer priority for certain subscribers for:

- incoming calls;

- outgoing calls; or

- all calls.

Priority could comprise priority in queuing systems, preemption of outgoing calls in order to service a call with priority, etc.

Procedures for handling MSs with priority are for further study.

4.5Mobile stations with preference

This is an optional facility.

Preference means that in certain circumstances only MSs with preference are allowed to access the network. The condition may be controlled by the BS by inserting a preference indication in the messages sent on the common signalling channel on the radio interface.

Procedures for handling of MSs with preference is for further study.

It should be possible to set the preference condition individually in each cell.

4.6Security related supplementary services

PLMNs may offer encryption of information sent on the radio path. Procedures for encryption and key distribution are for further study.

4.7Discontinuous reception

Discontinuous reception is a technique used to reduce the average battery consumption of mobile stations. The operation of this function is for further study.

4.8Discontinuous transmission

Discontinuous transmission is a technique used to reduce the battery consumption of mobile stations. The operation of this function is for further study.

5.Operation and maintenance oriented network functions

5.1Test facilities

The public land mobile systems may contain test facilities which can perform tests similar to those defined for the ISDN subscriber line.

Calls arriving when all positions in the queue are occupied, should be rejected with a congestion indication provided to the calling party.

Calls which have been queued for a time longer than the maximum queuing time should be released from the queue. MS terminating calls should be cleared with a congestion indication provided to the calling party.

4.2 Call duration limitation

4.2.1 General

This is an optional facility.

PLMNs may support functions whereby the call duration is limited in order to increase the call handling capacity of the PLMN. Call duration limitation may apply independently to each cell depending on the current traffic load of the cell. If possible, an indication should be provided to the subscribers that a call is subject to call duration limitation. Procedures are for further study.

4.3 Off-air-call-set-up (OACSU)

4.3.1 General

OACSU may be implemented in PLMNs in order to increase the call handling capacity of the PLMN.

OACSU may be implemented in PLMNs on an optional basis subject to the following conditions:

i) OACSU should not be used for calls to an international number;

ii) OACSU should not be used for incoming international calls;

iii) foreign MSs not supporting the OACSU procedure should be allowed to access the PLMNs where OACSU is used;

iv) MSs supporting OACSU should be capable of operating in PLMNs where OACSU is not implemented;

v) OACSU must not be used for calls involving an ISDN or a PDN or for non-voice services in the PSTN.

4.3.2 Signalling procedures

Interworking requirements for supporting OACSU are described in Recommendation Q.1031

4.4 Mobile stations with priority

This is an optional facility.

4. Additional network functions for call handling facilities

4.1 Queuing

4.1.1 General

Queuing of calls from fixed and mobile subscribers may be offered as an optional facility. Calls should only be queued when there is congestion on the radio path when the call arrives. The queuing facility is accommodated in the MSC.

4.1.2 Queuing of MS originating calls

When an MS originated call is placed in a queue, a queuing indicator should be provided to the MS as display information. The maximum time that the call will be kept in the queue should also be indicated. This would enable timers to be set in the MS in accordance with the queuing arrangements of each PLMN.

The MS should be marked as busy when the call is placed in the queue.

The call is cancelled when:

-the MSC receives a clearing message from the MS;

-there is time-out on the queuing time; or

-the VLR receives a location cancellation message from the HLR. Note - It is for further study whether or not this is practicable.

4.1.3 Queuing of MS terminating calls

Queuing facilities for MS terminating calls may also be provided in the MSC. If so, general PSTN/ISDN specifications on abnormal release conditions and post dialling delays should be taken into account. Further study is required on interworking with the fixed network.

The MS should be marked as busy when the call is placed in the queue.

MS terminating calls should be released if a location cancellation message is received while the call is being queued. Note - It is for further study whether or not this is practicable.

4.1.4 Queuing conditions

Not more than one call should be queued for each MS.

Calls should be queued and serviced in the order they arrive at the MSC, except for calls subject to some priority condition, e.g. calls which are handed over should have priority over normal calls and emergency calls should have priority over any other call.

procedures are defined in Recommendation Q.1004.

3.1.3Information stored in location registers

Information to be stored in location registers is listed in Recommendation Q.1003.

3.2Handover

3.2.1Definitions

The following cases are considered:

i)handover between radio channels of the same base station;
Note: This capability could be used in the following situations:

-when the radio channel carrying the call is subject to interference or other disturbances; and/or

-when a radio channel or channel equipment carrying a call has to be taken out of service for maintenance or other reasons.

ii)handover between base stations of the same MSC in order to ensure continuity of the connection when an MS moves from one BS area to another;

iii)handover between base stations of different MSCs of the same PLMN; and

iv)handover between base stations of MSCs in difference PLMNs.

For cases iii) and iv) two procedures are defined:

a)basic handover procedure where the call is handed over from the controlling MSC (MSC-A) to another MSC (MSC-B); and

b)subsequent handover procedure where the call is handed over from MSC-B to MSC-A or to a third MSC (MSC-B').

3.2.2Procedures

The procedures are described in Recommendation Q.1005.

3.3Power control

For further study.

3.4Dynamic channel allocation

For further study.

It may be permissible to initiate emergency calls from card operated MSs also when the card is not inserted. This point is for further study.

2.4Supplementary services

The support of supplementary services may require control procedures in HLRs, VLRs and MSCs in addition to the control procedures in the fixed network.

3.Network functions for supporting cellular operation

3.1Location registration

3.1.1Definitions

Location registration means that the PLMNs keep track of where mobile stations are located in the system area. The location information is stored in functional units called location registers. Functionally there are two types of location registers:

- the home location register where the current location and all subscriber parameters of a mobile station are permanently stored, and

- the visitor location register where all relevant parameters concerning a mobile station are stored so long as the station is within the area controlled by that visited location register.

See also Recommendation Q.1001 where the network architecture is described.

3.1.2Procedures

Procedures related to location registration are specified in Recommendation Q.1003.

They comprise:

i) location register updating which enables the MS to inform the network that its location has to be updated, i.e. the MS has received a location area identity which is different from that contained in its memory. In order to avoid unnecessary updating, the current location area identity should be stored in a non- volatile memory in the MS;

ii) location cancellation which is used to delete an MS from a previous VLR;

iii) periodic location updating which enables the location of silent and stationary MSs to be updated at a reasonable rate; and

iv) as a network option, IMSI detach/attach operation which will enable MSs to inform the network that they have entered a power down/power up state.

The procedures also include mechanisms for restoration of location registers after failure. These

	Traffic survey	(x)
	Malicious call identification	-
	Tracing of mobile stations	

2.2Subscriber authentication

Authentication procedures should be implemented in order to protect the network from access by non-registered or fraudulent MSs. The authentication method is for further study.

A possible procedure could be as follows.

The procedure is based upon a challenge/signed response method which goes as follows:

- the fixed subsystem transmits a non-predictable number RAND (the challenge) to the MS;

- the MS calculates the signature SRES (the signed response) of RAND;

- the MS transmits the signature SRES to the fixed subsystem; and

- the fixed subsystem tests the signature for validity.

Authentication may take place in the following cases:

i) at location registration,

ii) at call set-up,

iii) when requesting operation of a supplementary service, or

iv) after handover.

2.3Emergency call

2.3.1General

The land mobile system should be capable of efficient handling of emergency calls from mobile stations. Signalling procedures on the radio path require further study.

2.3.2The call should be routed automatically to an appropriate emergency centre based on the geographical location of the mobile station. For this purpose the accuracy of geographical location determination may be the cell serving the MS.

2.3.3Card operated stations

TABLE 1/Q.1002

Overview of network functions

Class of net-work function (NF)	Network function	Interworking with MAP	work function
NF needed for basic service provision:	Call handling	x	
	Subscriber authentication	x	
	Emergency calls	-	
	Supplementary services	x	
Additional NF needed for call handling	Queuing	x	
	Call duration limitation	-	
	OACSU	-	
	Mobile station with priority	-	
	Mobile station with preference	-	
	Security related services	x	
NF needed for supporting cellular operation	Location registration	x	
	Hand-over		
	- in the same BS	-	
	- in the same MSC	-	
	- in the same PLMN	x	
	- between PLMNs	x	
	Power control	-	
	Dynamic channel allocation	(x)	
Operation & maintenance oriented NF:	Test loops	-	
	Operation	x	
	Maintenance	x	
	Charging	x	

restrictions. The call is then set up as in § 2.1.1.

2.1.3 Call to a mobile subscriber

The call is routed (rerouted or forwarded) according to location data obtained from the HLR to the actual MSC.

2.1.4 Call handling functions in HLR

The HLR should accommodate call routing functions as described in § 2.1.3.

The HLR should also support control functions for handling of supplementary services.

2.1.5 Call handling functions in VLR

The VLR should provide subscriber parameters to the MSC as required for call handling.

The VLR should also support control functions for handling of supplementary services.

2.1.6 Call handling functions in MSC

The MSC should perform normal call routing and call control functions. The MSC will obtain subscriber parameters from its associated VLR.

The MSC should also be capable of performing handover as defined in § 3.2.

In some cases the MSC should be able to act as a gateway MSC.

Recommendation Q.1002

NETWORK FUNCTIONS

1.Introduction

2.Network functions for basic service provision

3.Network functions for supporting cellular operation

4.Additional network functions for call handling

5.Operation and maintenance oriented network functions

Recommendation Q.1002

NETWORK FUNCTIONS

1.Introduction

This Recommendation defines network functions which may be necessary to support services and facilities provided by PLMNs. A summary of the network functions is given in Table 1/Q.1002. The table also indicates whether or not a function requires internetwork signalling between PLMNs (i.e., use of Mobile Application Part, Recommendation Q.1051).

All functions require signalling on the radio path either as subscriber line signalling or as mobile management signalling.

2.Network functions for basic service provision

2.1Call handling

This set of functions enables the establishment of communications between a mobile subscriber and another network subscriber in one of the following types of networks: PSTN, ISDN, PSPDN, CSPDN and other PLMNs.

2.1.1Call from MS registered in VLR

This is the normal case where the call is routed according to the dialled number. After the call, the MSC shall send the charging information to the HLR, a billing entity and/or store the charging data on tapes or discs.

2.1.2Call from MS not registered in VLR

When the VLR receives a request for call set-up parameters from an MSC for an MS originating call, where the MS is not registered in the VLR, the VLR shall initiate a location updating procedure toward the HLR and in response parameters are given concerning category, services and