RECOMMENDATION ITU-R M.1182

INTEGRATION OF TERRESTRIAL AND SATELLITE MOBILE COMMUNICATION SYSTEMS

(Question ITU-R 89/8)

(1995)

Summary

This Recommendation provides five levels of different architecture for the integration of mobile-satellite service (MSS) systems with terrestrial PSTN or cellular network. Annex 1 addresses the concepts of such architecture.

The ITU Radiocommunication Assembly,

considering

a) that various satellite mobile systems are scheduled to be implemented;

b) that there are some satellite mobile systems that interwork with terrestrial systems;

c) that worldwide roaming capability is a key feature of International Mobile Telecommunications-2000 (IMT-2000) and the satellite component defined in Recommendation ITU-R M.687 is one of the important components that encourage the IMT-2000 capability;

d) that the satellite component is an effective method to provide low volume and widespread traffic areas;

e) that interworking of the satellite mobile system with the terrestrial system can encourage user convenience within not only IMT-2000 but also general MSS;

f) that the channel capacity of the satellite component is relatively limited compared to the terrestrial component;

g) Question ITU-R 206/8,

recommends

1 that the level shown below and explained in Annex 1 should be referred to when considering the integration between terrestrial and satellite systems.

Integration level:

– Level 1: geographical integration

– Level 2: services integration

– Level 3: network integration

– Level 4: equipment integration

– Level 5: system integration;

2 that mobile terminals of an integrated system should have a capability to select the relevant component either the terrestrial or satellite based on the receiving signal level and network availability to keep certain service quality over a wide and continuous service area;

3 that it is preferable that the integrated system should have roaming capability with unique user/subscriber identifier across both terrestrial and satellite systems if it is integrated into the terrestrial mobile system at the higher or equal integration level than Level 3 above;

4 that hand-off between satellite and terrestrial mobile component in an integrated system should be carried out within the extent that execution of hand-off does not significantly decrease the system capacity or increase system complexity.

ANNEX 1

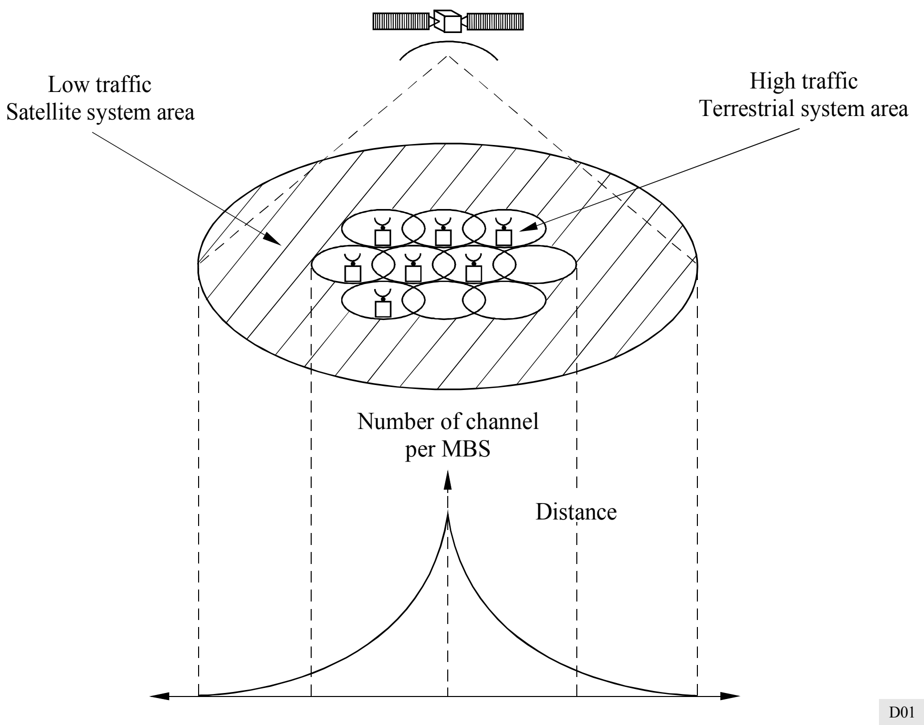
Levels of satellite mobile system integration with terrestrial mobile system

1 Concepts

There are a number of relationships and approaches that are appropriate in developing concepts for integration of satellite land mobile systems with terrestrial mobile systems. Figure 1 gives a general representation of the overall concepts.

FIGURE 1

Concept of integrated system



2 Approaches

Various levels of integration between independent coexistence and full integration can be considered. In the approach which follows, five levels are examined, ordered according to increasing integration, in the sense that each level includes the basic features of the previous one:

– Level 1: geographical integration
– Level 2: services integration
– Level 3: network integration
– Level 4: equipment integration
– Level 5: system integration.

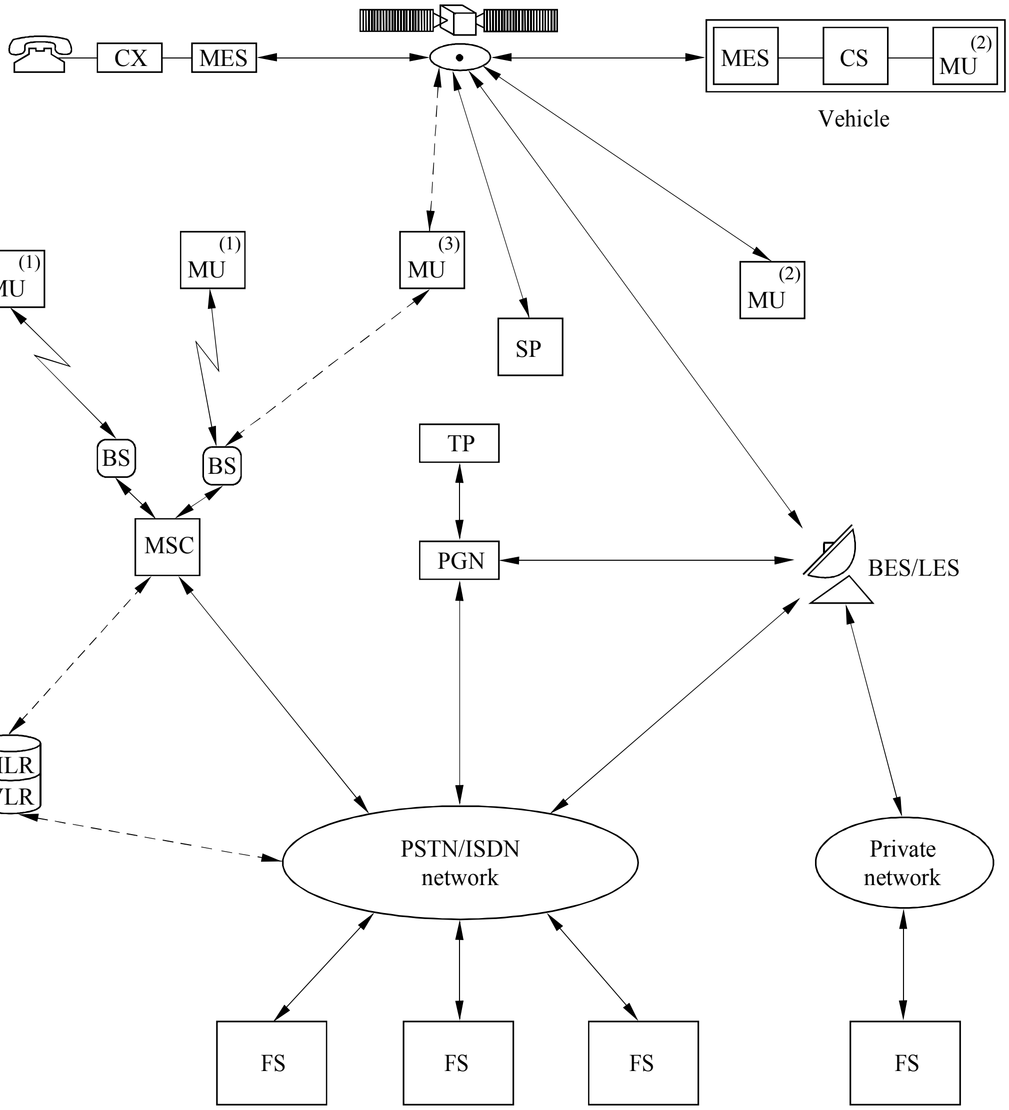
2.1 Geographical integration

This case refers to a situation where the terrestrial and the satellite system are independently conceived, so that they are based on different techniques and do not necessarily provide the same or compatible services.

Rather than speaking of "integration" of the two systems, it would be probably more correct to say that the satellite system "complements" the terrestrial one, offering communications services to users travelling in geographical areas not served by the terrestrial system. A representation of this case is given in Fig. 2.

FIGURE 2

Geographical and service integration concept
(the calling party selects the routing)



(1) Terrestrial terminal (mobile station (MS) or personal station (PS))
(2) Satellite-type terminal
(3) Dual-mode terminal
– – – Routing selected by FS

BES: base earth station
BS: base station
CS: personal base station (cell site for PSs)
CX: small rural exchange, etc
FS: fixed subscriber
HLR: home location register
ISDN: integrated services switching centre
LES: land earth station
MES: mobile earth station
MSC: mobile services switching centre
MU: mobile user
PGN: terrestrial paging network
PSTN: public switched telephone network
SP: satellite pager
TP: terrestrial pager
VLR: visited location register

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The mobile user (MU) of the mobile station (MS) or personal station (PS), will have the choice to buy a terrestrial system terminal, a satellite terminal or a dual-mode one, depending on his particular requirements and, in this last case, he will utilize, for MU-originated calls, the one which he expects to be the best for that moment.

The fixed subscriber (FS), wanting to place a call to the MU, shall have the responsibility to select the terrestrial or the satellite system, by dialling either the terrestrial system number or the number which provides access to the closest satellite base earth station (BES) or land earth station (LES). This means that the FS must have available to it knowledge of the kind of terminal (and service authorization) available at the MU.

If the MU has a double service authorization and a dual-mode terminal station, the FS may be forced to repeat his call over the satellite system, should the first attempt via the terrestrial system fail. In this situation, it may well happen that, for instance, a FS, intending to place a voice call, may need to accept a message service, where the satellite system is designed to only provide this.

An advantage of the geographical integration is the possibility to independently optimize the characteristics of the two systems, for each of which one tailored technical solution is to be used, in consideration of the significant and different constraints affecting the two cases.

It can be concluded that, with this approach the satellite system fulfils its role in extending the coverage area.

2.2 Services integration

The network configuration is essentially the same as in case 1 (see Fig. 2). In this case, in the satellite system design phase, the system parameters are selected in such a way that the satellite links are able to support services compatible with those offered by the terrestrial system, in the sense that the local terminals (either ITU-T terminals or any future terminals) utilized by the user to support the desired service can be employed independently of whether a terrestrial or a satellite link is selected. This does not imply that the technical solutions (e.g. access scheme) adopted for the two systems are the same.

It can be expected that the satellite system will only be capable of supporting a subset of the services available from the terrestrial system because of limitations in the radio path. Additionally the service quality may not be the same for the two cases.

Harmonization of services is also important to ensure the possibility of interworking between MUs of the satellite system and MUs of the terrestrial system, for MU-to-MU communications.

2.3 Network integration

This is a key concept because it is the first integration level allowing features to be shared between space and terrestrial systems.

2.3.1 Network architecture

The objective is to use as far as possible the same equipment and protocols, i.e., the same hardware, software and facilities for both satellite and terrestrial cellular networks to minimize costs. Because of propagation delays and frequencies, etc., which are different for the satellite network compared to the terrestrial cellular network, some elements however differ. Figure 3 shows the global system architecture.

An example of network architecture featuring network integration with GSM is presented hereafter and in Fig. 4.

The global architecture would be composed of:

– a satellite constellation,

– mobile station,

– gateway station,

– mobile networks facilities: switching, locations registers and authentification centres.

The different interfaces would be:

– the “Air” interface which defines the exchanges between the MS and the GS;

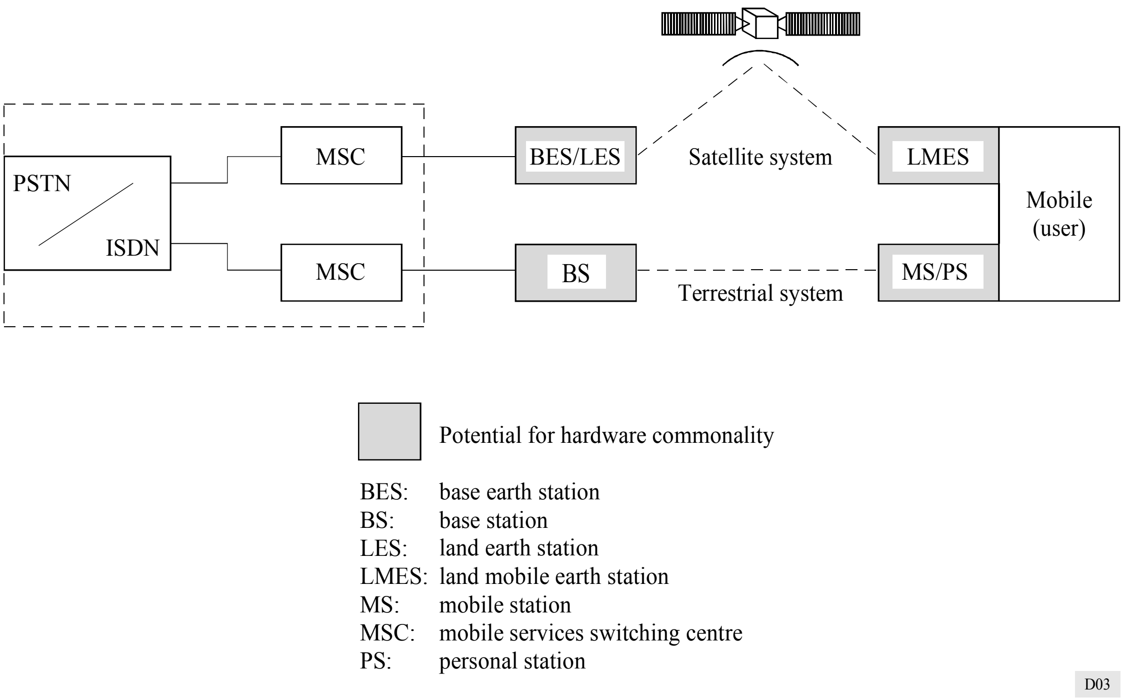
– the X interface which defines the exchanges between the GS and the MSC;

– the MM (mobility management) interface which defines the protocol between the MSC and the HLR and VLR.

All these interfaces would be proposed to save development costs of the satellite system ground segment.

FIGURE 3

Concept of commonality for mobile and base station facilities



The signalling information exchanged among the different functional entities (except the MS) in the terrestrial network would use the ITU-T signalling system No. 7 (SS No. 7).

The data messages between the gateway station and the other entities (more particularly for the exchanges between the MSC, HLR and VLR) would use X.25 protocol.

The MS-GS link would use its own signalling system.

The choice of X as GSM A interface and "MAP" as MM interface would bring up, in mobile network GSM type, the following consequences: modify in the network where X would be connected, report in the GS the functions linked to satellite communications system (handover), reuse as far as possible the protocols and the MM entities (MSC, HLR, VLR and AUC) of cellular terrestrial networks.

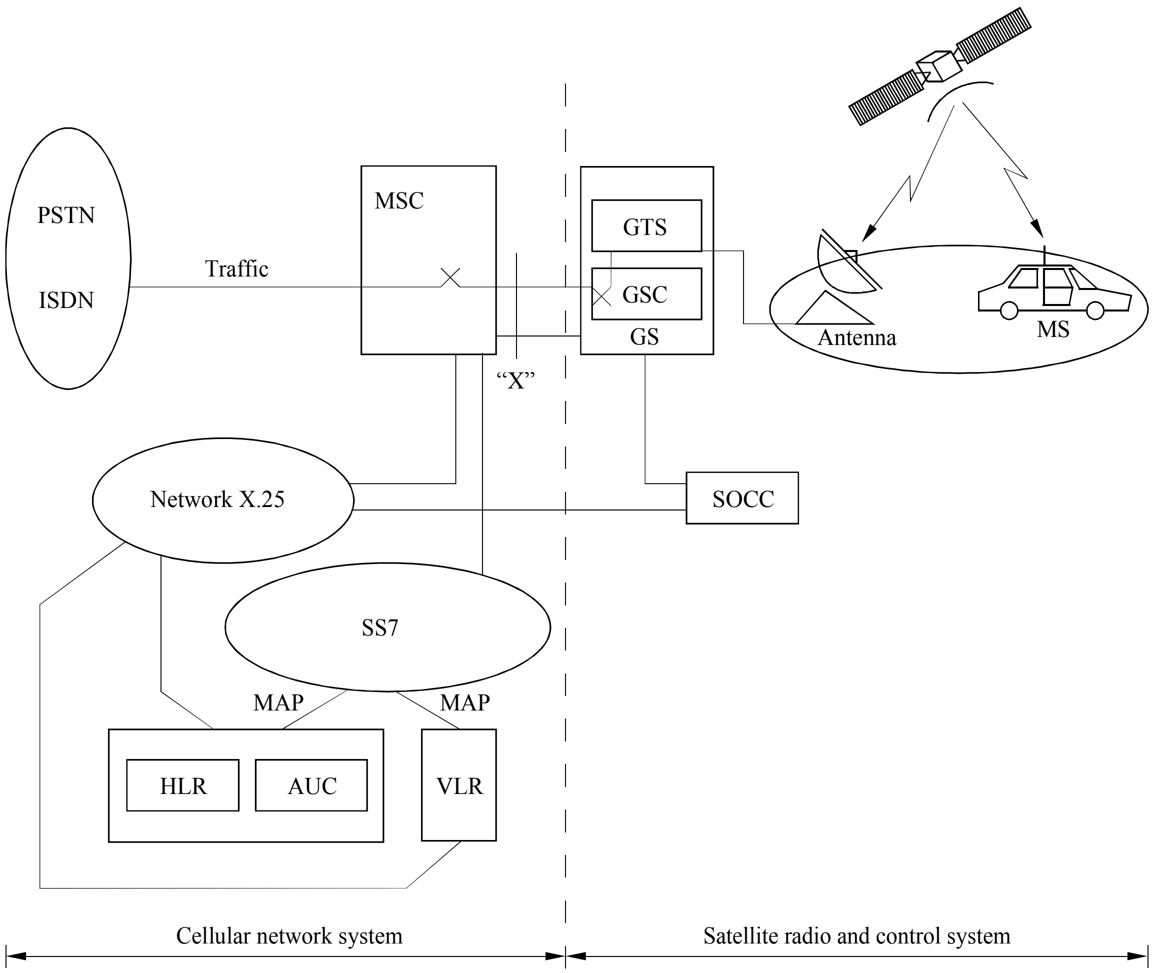
2.3.2 Protocol aspects

It has been assumed above to use as far as possible the same protocols for the mobile satellite communications system and the terrestrial cellular system. As an example, the same channel types (same functionalities) as for the terrestrial and satellite link could be adopted.

For the satellite system, it would be necessary to consider a specific synchronization channel in order to estimate and compensate the delay and the Doppler effects for mobile-satellite link. The reduction of frequency errors and mobile positioning errors would allow the reduction of preambles and would increase the frame efficiency.

The localization procedure is specific for satellite systems, but the other procedures like registration, set-up, clear-down and mobility management could be considered the same as those of the GSM system.

FIGURE 4



AUC: authentification centre
GS: ground station
GSC: ground station controller
GTS: ground transceiver station
SOCC: satellite operation control centre
SS7: common channel signalling system No.7

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A brief description of the three layers involved in the definition of satellite protocols is given below.

Layer 1

The physical layer (frame structure) only on the radio path between the MS, the satellite or satellite constellation, and the GS.

Layer 2

It specifies the link access procedures on the control channels to be used to convey information between layer 3 entities across the GSM radio interface. The layer 2 protocol is a Link Access Protocol Dm (LAPDm) type protocol.

Layer 3

This layer has to implement the dynamic routing of information related to the localization of the MS when idle and the dynamic routing of calls in progress when the MS leaves the cell or the area covered by a VLR. This layer is subdivided into three parts: circuit-switched call control (set-up, clear-down, etc.); mobility management and radio frequencies transmission management.

The first layer of the network (layer 1) requires important modifications (specific synchronization channel, modulation, interleaving, coder, channels structure). The layer 2 has no need to be changed, just the adaptation of a few parameters is necessary (temporization due to propagation delays, etc.). The layer 3 (the radio frequencies transmission management part) has to undergo modifications to perform initial localization and handovers. The other sub-layers (mobility management and call control) do not need much change.

2.4 Equipment integration

This approach is architecturally equivalent to that of network integration, with the main difference that the techniques (access parameters, bit rates, protocols, etc.) adopted for the satellite system are similar to hardware commonality or even the same as those of the terrestrial system (see Fig. 3).

The advantages of this approach essentially concern the simplification of the dual-mode mobile terminal implementation, as a common core (logic, baseband and possibly modulation equipment) can be utilized for both the terrestrial and satellite operating modes.

It has however to be noted that, due to the possible utilization of adjacent or different frequency bands for terrestrial and satellite communications, the upgrading of a terrestrial terminal to operate also with the satellite system will probably require extra equipment.

Despite the fact that this approach appears very close to a full integration of the two systems, it has to be noted that the terrestrial system still looks to the satellite system as an alternative routing, in cases of being unable to support the call request due to coverage limitations, and not as part of its system.

2.5 System integration

This last solution envisages the maximum conceivable level of integration of the satellite network with the terrestrial system, in the sense that the coverage(s) provided by the satellite system are regarded as one (or more) “big cells” of the cellular system.

All the advanced system features, such as handover of calls in progress from one cell to another, also apply to the big cell(s). (Handover across the satellite spot beams may not be mandatory, in consideration of the size of these beams.) The terrestrial/satellite handover procedure will clearly only be enabled, if the MU has a dual-mode terminal (information available at the HLR).

3 Conclusion

Several projects are presently being developed to provide a worldwide, regional or national service for mobile terminals using different satellite constellations. These systems could stand as a complement to the terrestrial cellular systems: this points out the interest of dual-mode terminals.

Some degree of integration between space and terrestrial systems would be desirable to reuse to the extent possible existing facilities. As far as the GSM integration example described in § 2.3 is concerned, a great part of the Open System Interconnection (OSI) Layers 2 and 3 protocols could be re-used.