RECOMMENDATION ITU-R M.1074*

INTEGRATION OF PUBLIC MOBILE RADIOCOMMUNICATION SYSTEMS

(Question ITU-R 52/8)

(1994)

The ITU Radiocommunication Assembly,

considering

a) that different mobile radiocommunication systems have been and will be introduced;

b) that those systems support a variety of services with different characteristics;

c) that service integration is of importance not only for fixed telecommunication networks but also mobile radiocommunication networks;

d) that recent developments in technology, especially software technology, have enabled mobile radiocommunication systems to be integrated to provide high levels of services;

e) that the utilization of the radio spectrum should be as economical as possible;

f) that advantages can be obtained from integration of mobile radiocommunication and fixed networks;

g) that various levels of integration are possible;

h) that disadvantages can be foreseen in inappropriate degrees of integration, thus that constraints on the integration should be taken into account,

recommends

that the following technical and operational guidelines be followed in the process of mobile radiocommunication systems integration:

1. Scope

Integration of telecommunication systems yields various benefits such as economic savings and operational simplicity. Because of these advantages, a number of considerations have been undertaken, some of which have already been incorporated in commercial systems even in the area of public mobile communication (see Annex 1).

This Recommendation gives integration considerations, guidelines and constraints. Section 2 outlines the generic integration model and identifies the applicable systems blocks. Also, it touches upon the integration time constraints and enumerates a number of integration advantages. Section 3 is devoted to technical and operational characteristics to be specified for system integration, while Section 4 illustrates some possible examples of integrated systems, ranging from a simple dual-mode user terminal to heterogeneous integration with a fixed telephone network.

2. General aspects

2.1 Integration considerations

Integration of telecommunications systems is defined as operability in which different telecommunications systems share the whole or a part of telecommunication equipment hardware or physical transmission media. Physical transmission media include both wired and wireless components, and hence radio frequencies themselves are their entities. A natural derivation of this is that the concurrent use of a certain range of radio-frequency bands by multiple radio telecommunication systems serving in the same geographical areas is included in the scope of system integration.

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* This Recommendation should be brought to the attention of the Telecommunication Standardization Bureau.

Multiple telecommunication systems are not referred to as being "integrated" if they are merely interconnected. For example, a simple interconnection of analogue and digital mobile communication systems is not recognized as an integrated system. This form of interaction is only referred to as "interconnection" and is outside the scope of this Recommendation.

Neither is the situation where terrestrial and satellite systems are independently conceived and mutually complement the service area included in the concept of integration. This situation should be simply termed a "complement" of the service area. It is also outside the scope of this Recommendation.

Multiple telecommunication systems which use but do not physically share the same telecommunication components are also not considered as "integrated". An example of this is when an identical software package providing a signalling protocol is employed in multiple systems which cover different geographical areas. Such a situation should be designated as "common" and is not a subject for this Recommendation.

2.2 Integration level

2.2.1 Generic integration model

A variety of integration forms are conceived in telecommunication systems, because they consist of a very large number of telecommunication elements in the form of software and hardware. Integrated systems can vary in complexity from simple ones to more complex ones such as:

– multiple public mobile communications systems sharing some base station hardware and software modules;

– the above public mobile communications systems with an identical data link protocol over radio channels;

– the above public mobile communications systems with an identical data link protocol and encryption algorithm over radio channels;

– a dual or multiple-mode mobile station with a single handset;

– an operation and maintenance centre which manages multiple public mobile communication systems.

A quick survey encompassing these examples leads to the need to introduce an organized approach to analyse the form of integration. It is generally conceived that system integration is characterized by three essential perspectives:

– integrated telecommunication equipment hardware and physical transmission media;

– telecommunication functionalities which are used on a shared basis in the integrated telecommunication equipment hardware or physical transmission media identified above;

– the period of time in which integrated telecommunication equipment hardware or physical transmission media are commonly used on a shared basis.

It must also be emphasized that the generic integration model to be developed here should encompass all telecommunication functionalities with appropriate levels of grouping, which one can easily handle in the process of integration. One such approach to meet these demands is to utilize the OSI seven layer model. Although this model was not developed for the purpose of categorizing telecommunication functionalities, all functionalities residing in the telecommunication environment are included and foreseen with several levels of grouping.

Figure 1 outlines the general integration model derived from the OSI-based paradigm. With this model, different levels of integration can be envisaged with descending ambiguity:

a) *Hardware level integration*

If one or more telecommunication hardware components or physical transmission media are merely integrated, the situation is recognized as hardware level integration. An example of this is when a single transmission line is shared by multiple systems, but their signalling protocols and the corresponding software modules are different and not shared. Another example is when two different systems offering different radio signalling protocols and utilizing different frequency bands commonly use the same transmission amplifier on a shared basis.

b) *n-th level integration*

If one, or a set of, telecommunication hardware components/physical transmission media and their associated functionalities in (a) level(s) are integrated, the situation is termed *n*-th level integration. *n* can be any number(s) from 1 to 7. The situation where a network node, and software modules running within the node for the data link protocol and the dialogue functionalities are integrated and shared is called the second and fifth level integration. A similar concept can be extended to integration of the application process among multiple telecommunication systems.

The concept developed above further clarifies the conventional categorization for system integration. For example, a mobile telecommunication system which supports call completion and number identification supplementary services has been recognized as a service integrated system. This system can also be analysed as, in usual cases, an integrated system which shares all telecommunication equipment hardware/physical transmission media with the first, second and third level integration.

It is also recognized that a land and maritime integrated system with dual-mode mobile stations, each having a unique calling number, is of the third level integration, since the automatic routing function invoked by the reception of the unique calling numbers resides in the network level in Fig. 1.

2.2.2 Telecommunication equipment hardware identification

One way to analyse the system integration is to identify network nodes or physical transmission media by using their names such as the base station or the wired transmission line. This approach might be applicable to some extent, because typical public mobile telecommunications systems only consist of switching centres, databases (location registers), base stations, mobile stations, wired and wireless transmission lines, and operation and maintenance centres. However, because of the possible variations in network architecture, it may be necessary to use more general approaches to telecommunication equipment hardware identification. One possible categorization is:

– *Total integration* – In this level of integration, all telecommunication equipment hardware and physical transmission media is integrated and used on a shared basis. All or some of the software modules may be commonly shared.

– *Partial integration* – In this level, only a part of the telecommunication equipment hardware and/or physical transmission media is commonly used. Some software modules may also be integrated.

2.2.3 Period of time for integrated operation

System integration is also divided into two classes with respect to the period of time for integration:

– *Static integration* – This integration level is defined as the form where multiple systems are always integrated throughout their operation.

– *Dynamic integration* – This integration level is defined as the form where multiple systems are integrated through a limited period of time in operation. An example of this is when a certain frequency band is used commonly by two different cellular systems on a shared basis in daytime, but exclusively used by one of these systems at night.

2.3 Integration advantages

Telecommunication system integration allows the end user and the network operator to enjoy a number of advantages such as:

– *System cost reduction* – Because of the common use of telecommunication hardware and software, system integration enables cost-effective implementations.

– *Higher telecommunication traffic throughput* – A typical example is the automatic retrial performed by a dual or multiple mode mobile station, in which it tries to reconnect the user with a secondly chosen system when an initially intended system is not available. This service enables a greater volume of traffic to be carried. Integrated transit trunks also help to increase the traffic capacity.

– *Service grade improvement* – It is apparent that a completely service-integrated system offers higher utility to the end user than a single or a less service integrated system.

– *Simplified network operability* – The fewer physical telecommunication components there are within a network, the simpler the network management is. Thus, system integration also leads to operational cost reduction and quicker response time in case of network faults and user complaints.

Besides these common advantages, greater benefits can be expected in partial system integration, because individually optimized features can technically and operationally be preserved.

3. Requirements and constraints for system integration

In the process of system integration, technical and operational characteristics of targeted telecommunications systems should be identified to assess the degree of improvement provided by system integration. The technical and operational characteristics to be specified are:

– network architecture, functional assignments and telecommunication equipment structures of targeted telecommunication systems;

– possible telecommunication equipment components to be integrated;

– additional hardware and software modules required for integration – System integration generally requires the addition of some hardware and software modules. For example, when different types of transceivers for different systems are installed in the same bay, some means of distinguishing the different types is required. An integrated system may also require an additional means to prevent faults in a member system from causing a great loss in other member networks. Measures should also be taken to ensure that congestion in a member system does not cause blocking or excessive delay of other traffic to be carried by other member systems. If the overhead required for these means is substantial, the inherent advantages may be severely diminished;

– economic aspects of system integration;

– procedures to notify end users of the differences in service provision, including quality and charges, in situations where the user may be aware of the system integration – Care may be required to ensure that customers do not blame the network operator for service provision difference. Network operators should seek to minimize user dissatisfaction caused by system integration;

– responsibility assignment among network operators, in the situation where multiple network operators share an integrated system to provide services – Examples of responsibility assignment include division of network facility related costs, and establishment of inter-operator recovery and equipment renewal procedures.

A practicable integration level can be determined through assessment of these technical and operational characteristics as well as by regulatory constraints in each country/region. Partial and static integration becomes more viable if these requirements, as well as current technologies for hardware and software manufacturing, are taken into account.

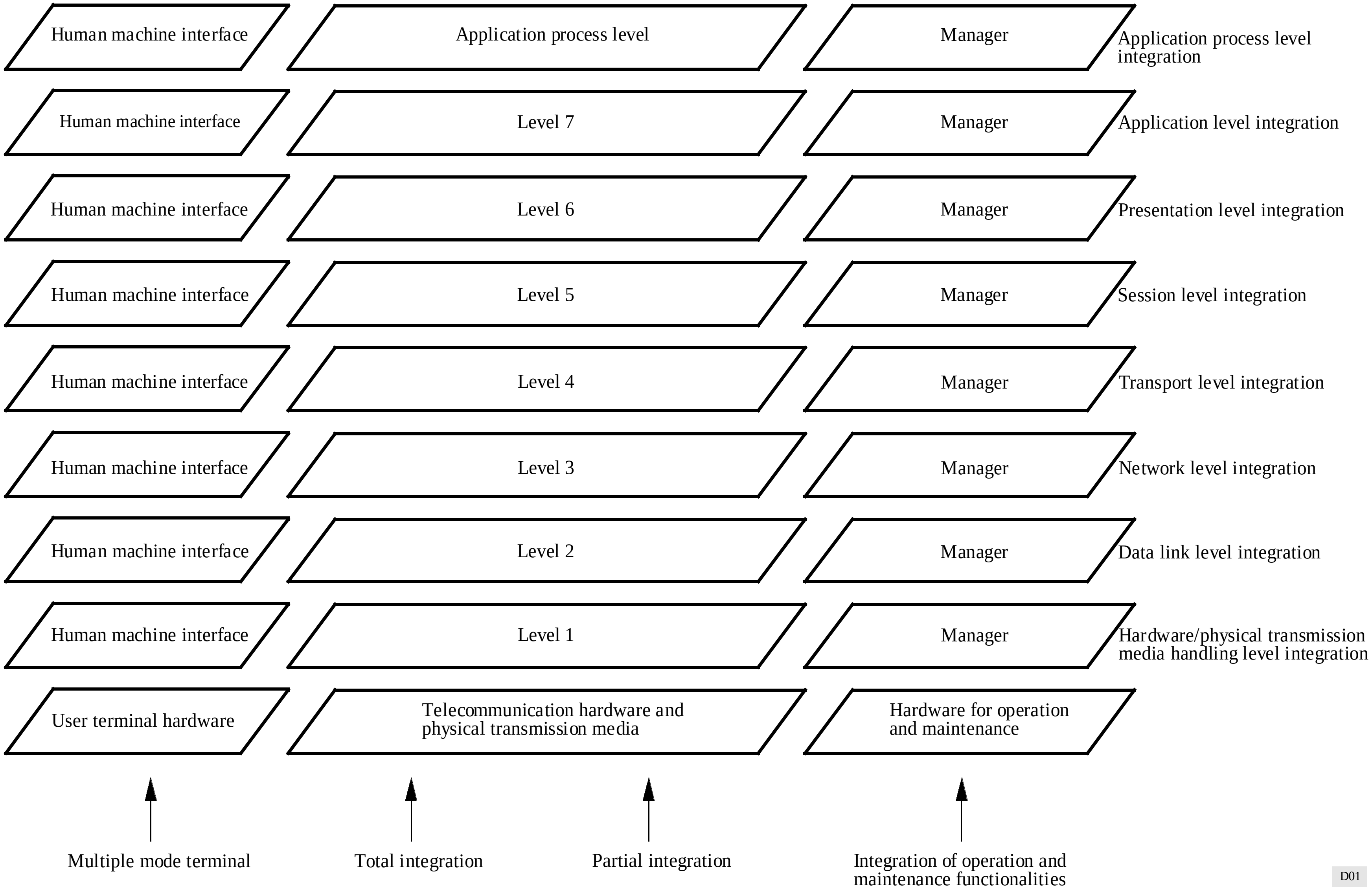
It should be noted that the large differences of the radio aspects between some systems may also put additional constraints on system integration. These include differences in output power, radio frequency bands to be used, modulation schemes, interference-related parameters, and other radio access features.

4. Examples of integrated systems

This section serves to demonstrate architectures of some integrated systems. These specific examples are not exhaustive and not necessarily the only configurations possible.

FIGURE 1

Example of integration model



4.1 Cellular and paging systems

Figure 2 shows an example of cellular/paging integrated systems, which accommodate both cellular and paging terminals. Six physical resources are integrated in this example:

– cellular exchange (MSC) and paging message handling unit;

– transceiver bays;

– base station controllers (BSC);

– antennas;

– operation and maintenance centres;

– bearer transmission networks;

– data communication networks.

Central processors, their operating systems, bays and power supplies are major areas for integration of the cellular exchange and the paging message handling unit. The two systems probably need to employ different transceiver architectures, because the systems have different frequency bands and signalling protocols. Thus, the other parts of the transceiver section, i.e., the processing units, operating systems, bays and power supplies, can be integrated.

The operation and maintenance centres (MO&M) have much commonality, especially in their workstations, operating systems, display and data handling software modules.

In addition, the first and second level integration can be made in the signalling links between MSCs and BSCs, if paging messages are packetized and sent through those links from MSCs. Higher level integration is also conceived in the data transmission between BSCs/MSCs and MO&Ms.

It should be noted that integrating these types of telecommunication network equipment implies additional integration of the associated telecommunication support environment such as the equipment site and the air-conditioning facilities.

4.2 Cellular system and public switched telephone network

Infrastructures for cellular systems and the public switched telephone network (PSTN) have a wide range of common features represented by software-oriented switching and signalling protocols. Thus, some excellent possibilities of effective integration between the two systems are foreseen, one of which is shown in Fig. 3. Physical resources to be integrated are:

– cellular and PSTN exchanges;

– location registers and databases storing end user profiles;

– operation and maintenance centres;

– bearer transmission networks;

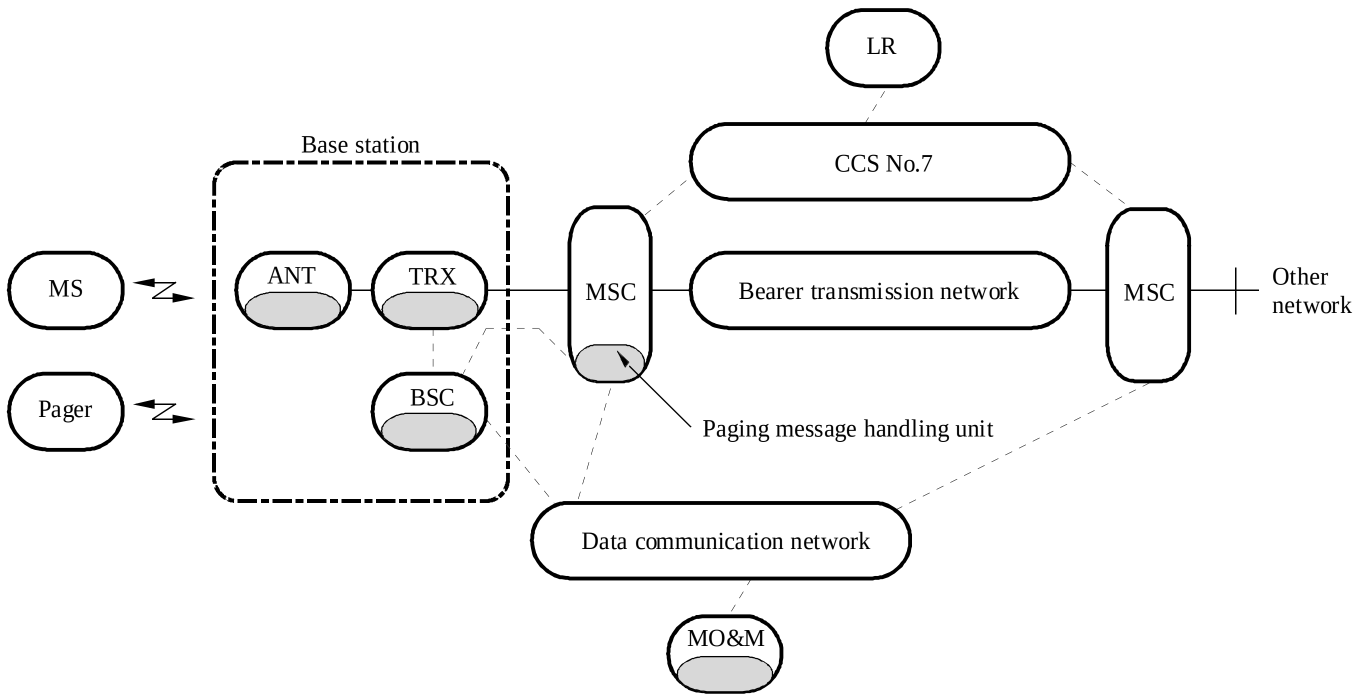
– common channel signalling networks;

– data communication networks.

Apart from some mobile specific adaptors and software modules, cellular and PSTN exchanges can be integrated. Signalling protocols and their corresponding hardware/software modules also cater for the need for integration. Commonality is also found in location registers and the PSTN real-time databases, which have recently been installed to support a new set of services.

FIGURE 2

Integration of a paging system with a cellular system



MSC: mobile switching centre
LR: location register
BS: base station
BSC: base station controller
CCS: common channel signalling

TRX: transceiver
ANT: antenna
MS: mobile station
MO&M: mobile telecommunications system operation and maintenance centre

Shaded areas denote integrated parts.

—— traffic channel
- - - control channel

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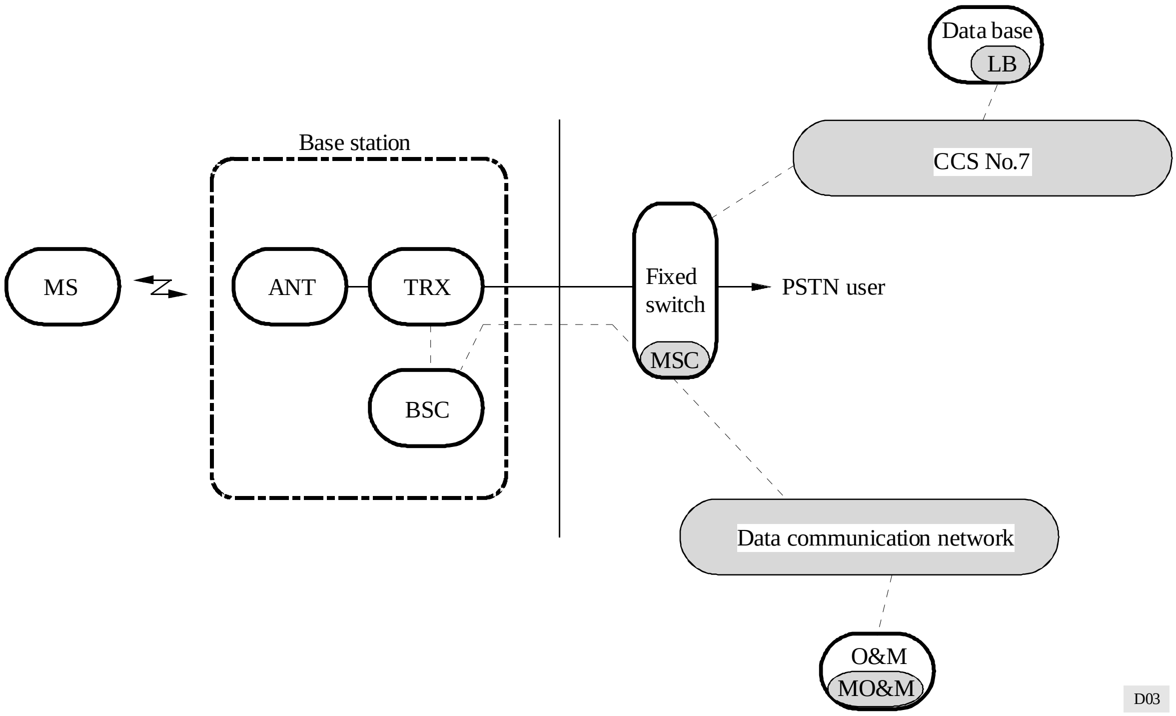
FIGURE 3

Integration of a cellular system with PSTN

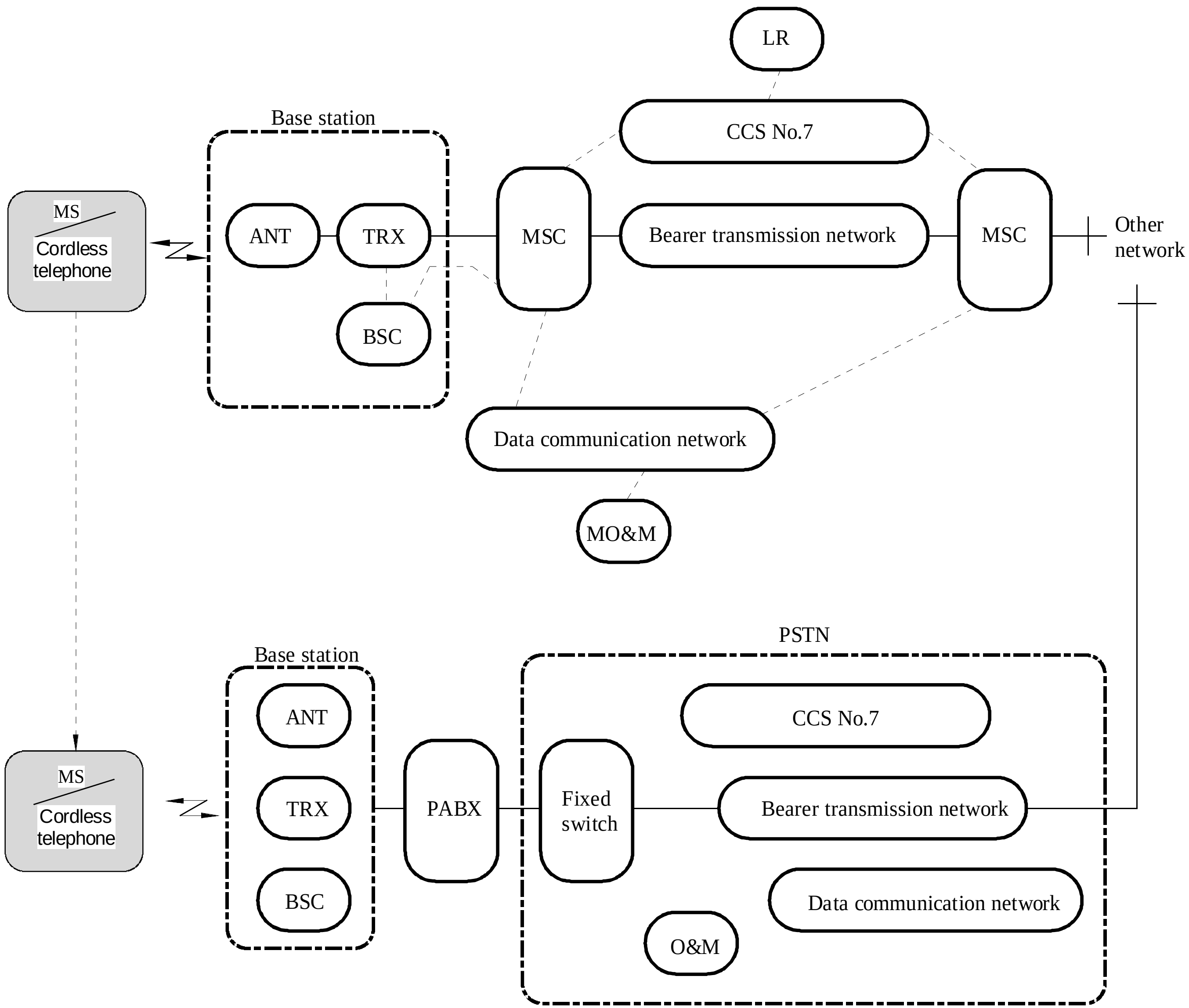


4.3 Cellular and cordless user terminals

Because of the incomplete coverage provided by cellular systems, dual-mode mobile stations accessible to both cellular and cordless telephone systems may be attractive to users. In the example shown in Fig. 4, the dual-mode mobile station automatically registers attachment to a cellular network as its first choice when it enters a service area. If the mobile station travels into cordless telephone areas not served by the cellular system, it works as a cordless telephone after some initial procedures (user authentication and numbering negotiation) have been completed. A personal communication scenario, where users are allowed to register their position and receive calls with a single user terminal either through the PSTN-associated cordless networks or through public mobile telecommunication networks, will further facilitate the availability of this service. In this example, it is possible to integrate handsets (human machine interfaces), and some radio and logic circuit parts.

FIGURE 4

Integration of user terminals



PABX: private automatic branch exchange

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ANNEX 1

Integration of public mobile radiocommunication systems in Japan

The aeronautical and the maritime mobile systems were integrated into the public land mobile telephone system in May 1986 and November 1988, respectively. In this integrated system, control procedures, O&M facilities and related equipment are shared in order to improve system economy and to simplify system operation.

1. System configuration

The system configuration is shown in Fig. 5.

The system is composed of the following equipment:

– mobile stations/portable stations dedicated to each service;

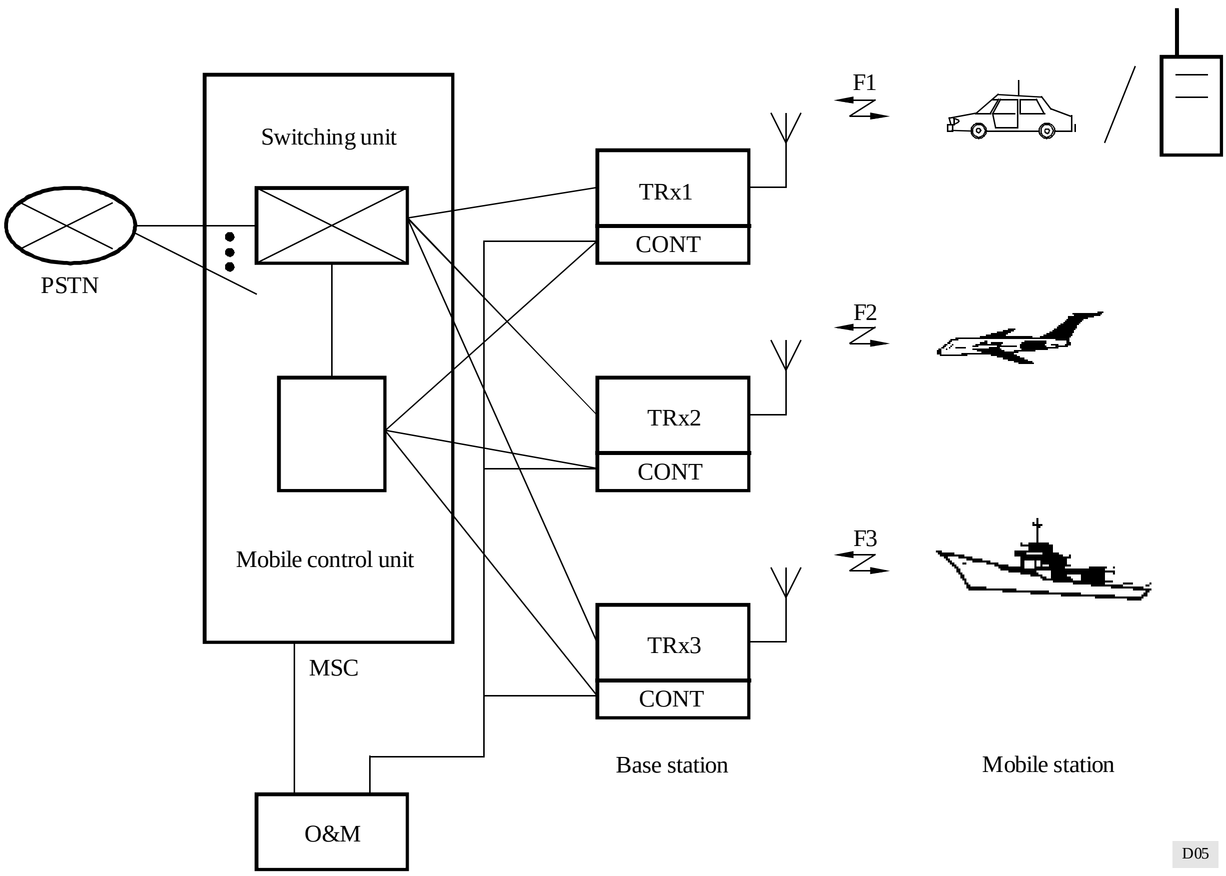
– base stations dedicated for each service;

– mobile switching service centre comprising a mobile control unit and a switching unit;

– operation and maintenance (O&M) facilities.

FIGURE 5

Configuration of the integrated system



2. General characteristics

The operational and technical characteristics of the integrated system are based on Recommendation ITU-R M.622.

The major characteristics of this integrated system are shown in Table 1.

TABLE 1

Technical characteristics of the integrated system

Item	Land	Maritime	Aeronautical
Frequency (MHz)	800-900	250	800-900
Channel spacing (kHz)	25	12.5 interleave	25
Maximum base station e.r.p. (W)	50	40	130
Nominal mobile station transmitting power (W)	5	5	10
Zone radius (km)	3-10	50-100	400
Numbering plan	Common		

3. Integration level

Most items, except for the radio frequencies, have been integrated. The detailed integration levels are as follows.

3.1 Equipment

The following equipment is compatible:

– switching unit and mobile control unit;

– telephone part of the mobile station;

– O&M equipment.

The following equipment remains dedicated because of differences in assigned frequencies, location of base station and coverage areas:

– transceivers in mobile/portable stations or base stations.

3.2 Control procedure

The control procedure for the radio path is compatible except for the control channel scheme and the service quality parameters. In the maritime and aeronautical systems, the paging channel and access channel are combined into one radio control channel because of low traffic.

The control procedure between the base stations and switching unit is compatible.

3.3 Operational features

The following elements are shared:

– charging principle, except for the charging rate;

– numbering plan (commonly used in the newly introduced public land mobile telephone system, as well as in the above-mentioned system);

– supervision and control of all equipment, radio paths and wire lines;

– operation and maintenance.