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Interworking and Integration of the Inmarsat Standard-M with the Pan-European GSM System

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Introduction

The market demand on mobile telephone communications has been increasing since the introduction of the cellular mobile telephone systems about twelve years ago. In Europe, projections indicate a demand of about 17 million subscribers for a fully deployed Pan-European system. The Pan-European GSM system is to harmonise the growth of the terrestrial mobile system. Studies conducted by the European Space Agency (ESA) indicate that even with 60-70% of the area being covered by the GSM, a significant traffic demand (voice and data) will still exist for areas not covered by the terrestrial systems.
This demand could be satisfied by a land mobile satellite system. The satellite system is therefore seen in a complementary role rather than in competition with the terrestrial system in an integrated telecommunication network. One possible scenario may be that initially the satellite system provides services to the rural areas together with areas still not covered by the GSM system. This service area is then gradually diminished as the terrestrial system expands until an optimum point is reached where the systems coexist optimally.
The objective of this paper is to investigate the possibility of integration of a space based system, in this case Inmarsat Standard-M, with the GSM (Global System for Mobile communication). One very important advantage of incorporating GSM services in Standard-M is that it will be feasible to extend the GSM services economically worldwide, not only to land mobiles but also to aeronautical and maritime mobiles.

The GSM System

The idea of a Pan-European mobile communication system was originated in 1981 and it is to replace the many different analogue mobile telephone networks which exist throughout Europe. Roaming will be permitted within all the countries deploying the system.
The GSM offers digital voice channel together with several supplementary services and will be ISDN compatible. Very importantly the system has been structured to permit evolving technology to be incorporated.
The system adopts a TDMA structure and makes use of the CCITT Signalling System Number 7. Extensive use is also made of the other CCITT, CEPT and ISO (for layers 1,2 and 3 - the physical , data link and network layers) standards.
The main building blocks of the GSM network are shown in figure 1.
The Mobile Switching Centre (MSC) acts mainly as an ISDN exchange and represents the interface between the fixed network and mobile network. Each MSC has many Base Stations (BS) under its control, typically three. The MSC also controls mobile specific functions such as handover. In general, each MSC will have two associated location registers. Home Location Register (HLR) is used to store permanent and temporary information related to the mobile subscriber or related to the position of the MSs in each instant. Visitor Location Register (VLR) contains all kinds of information both permanent and temporary needed to handle the MSs in the area where it is roaming.
A Base Station provides radio coverage of geographical zone containing one or several cells. It provides the radio channels for both subscriber services and associated network

signalling. It is directly connected to the MSC associated with its coverage area. The Mobile Station enables subscribers to access the GSM network at any point within the service area. Various types are available of different transmission power levels- the higher powers being vehicle mounted rather than handheld.

GSM services and subscribers access

In this section, services which are supported in GSM and customer access to them will be described.

Tele/Data and Supplementary Services[1]

Teleservices

The teleservices provide complete capability for two customers to communicate with one another. The following generic teleservices are offered.

a) Speech transmission
b) Emergency call
c) Short message transmission (telegrams up to 256 characters)
d) Message handling service
e) Videotex
f) Teletex
g) Facsimile transmission group 3,4

Bearer Services

The bearer service provides a "transport-service" which enables customers to interchange data according to their specified application. The GSM services are:
a) Audio restricted 3.1 KHz
b) Data circuit duplex asynchronous 300-9600 bits/sec
c) Data circuit duplex synchronous 1200-9600 bits/sec
d) PAD access circuit asynchronous 300-9600 bits/sec
e) Data packet duplex synchronous 2400-9600 bits/sec
f) Alternate speech/unrestricted digital
g) 12.6 kbits/sec unrestricted digital
h) ISDN terminal support

Supplementary Services

a) Call forwarding
b) Call barring
c) Call waiting
d) Call hold
e) Three party service
f) Advice of charge. This is intended to provide sufficient information to a MS for an estimate to be made of the call charge incurred.

Customer access [1], [2]

Mobile stations with have different access capabilities. For example, a small compact handheld unit is unlikely to offer all services in the early 1990s. Therefore, GSM has developed a structured approach which allows for maximum evolution of products. This process is shown in figure 2. The figure shows that the MS consists of a Mobile Termination (MT) unit and terminal equipment. The function of the MT unit is to offer standard interfaces to the customer and to transfer the data on these interfaces over the radio interface (Um). For example, customers will be able to directly connect their ISDN terminal via the standard ISDN "S" interface to the MS. The ISDN terminal presents a 64 kbps data stream to the mobile termination and the composite effect of the rate adaptation in the ISDN terminal and mobile termination unit is to produce a flow of controlled data stream compatible with the capacity of the digital radio channel. Figure 2 also indicates the alternative which is being specified so that customers with non-ISDN terminals can either directly connect to the standard "S" interface or to a "R" type interface.

There are three types of MT:
MT0: includes functions belonging to MT, with support of no terminal interfaces.
MT1: includes functions belonging to MT, with an interface that complies with the GSM recommended subset of ISDN user-network interface.
MT2: includes functions belonging to MT, with an interface that complies with non-ISDN interface eg., CCITT X or V series interface.

The MT plus a TE/(TE+TA) constitutes the mobile station.

Inmarsat Standard-M Land Mobile System [3]

The Inmarsat Standard-M which will start commercial service by 1993, provides a digital communications service between the public switched terrestrial networks and mobile users on land or sea. Standard-M supports medium quality telephony, facsimile and 2400 bits/sec. Links to and from mobile installations are established via Inmarsat geostationary satellites and the associated ground segment. Near global coverage provided between latitudes 75° north and south of the Equator.

The major elements of Standard-M system are shown in figure 3 and are described briefly as follows:

The Space Segment capacity is provided by Inmarsat's first generation (i.e, intelsat-V Maritime communications sub-system satellites) and subsequent generation space segment (Inmarsat-3).

Standard-M Mobile Earth Station (MES), which interface with the space segments at L-band (1.5/1.6 GHz) for communication with LESs.

Land Earth Stations interface with the space segment at C-band (4/6 GHz) and L-bands and with the terrestrial networks for communications with MESs.

Network Coordination Stations (NCS), located at the designated (co-located) LESs, which interface with the space segment at C-band and L-band for the purpose of signalling with MESs and LESs, and for overall network control and monitoring functions.

Standard-M services and customer access

This section describes the services which are recommended for Standard-M system. This, in no way, means that these are the only services which Standard-M system is capable of supporting.

Telephony Services are provided through 6.4 Kbits/sec full duplex.

CCITT Group-3 Facsimile Service is provided in accordance with the transmission standard CCITT Rec.T4 regarding Group-3 facsimile service.

2.4 Kbits/sec full duplex baseband data services (with optional fall back mode capability of operating 1.2 Kbits/sec) are supported. Figure 4 shows the customer access to data services. The recommended interface requirement between an MES (DCE) and its data terminal equipment (DTE) is the CCITT V.24, V.28 and ISO 2110 (equivalent to EIA specification RS-232C).

The recommended auto-calling and auto-answering protocol at the MES V.24 interface is the CCITT Rec.V.25 bis.

Modem Interface Unit (MIU) is a logical block allowing a fixed Hayes compatible modem to interface with the LES and a DTE to interface with the MES. MIUs are useful on MESs to allow selection to off-the shelf modems and DTEs by the end users (using "multi-numbering scheme").

The primary function of the MIU at the LES is to interface with the terrestrial modems, and to convert the analogue baseband voice and data format originated from fixed-user voice band modems to the Standard-M 2.4Kbits/sec SCPC satellite data channel format. The recommended protocol between the LES MIU and the terrestrial fixed-user's data modem is the CCITT Rec. V.22 bis.

Interworking between Inmarsat Standard-M and GSM Systems

The main purpose of this section is to prepare the ground for integration of GSM and Standard-M systems which is to be the subject of the next section. Before considering integration an understanding of the concept of interworking and how it can be achieved is necessary. The interworking in this chapter is described on the ability of GSM network to interwork with non-ISDN networks.

The concept of Bearer services was developed for the ISDN and has been extended to the GSM. Here an attempt will be made to interwork GSM Bearer services and hence its Teleservices with Inmarsat Standard-M network within the limitations of the two systems. Three areas of interworking were identified and thoroughly investigated:

1. Service interworking

Service interworking is required when the teleservices at the calling and called terminals are different (e.g. Teletex interworking with Facsimile).

2. Signalling interworking

For network interworking, signalling requirements have to be defined. Existing call control signalling procedures e.g SS#7, is used in the GSM while a subset of SS#5 is used in Standard-M.

3. Supplementary service interworking

From the network interworking, the following can be deduced:

1. Additional signalling messages "bearer capability" are required to be transmitted between MESs and LESs to support GSM services. Such messages will be needed to indicate things like service nature (i.e simple or duplex), service type (i.e short message service) etc. These signals can be accommodated since both MESs and LESs will be equipped with software expansion capabilities to accommodate new signalling codes for future Inmarsat service offer-

ings[3]. Hence this can be utilised to support new signalling messages required for GSM services.

2. Signalling conversion is required to convert the forward and the backward signals of SS#7 (ISUP) messages and information elements of Standard-M signalling system (subset of SS#5).

3. Appropriate interfaces at the MSSC are required to support GSM services within Standard-M network e.g X.30 and X.31 to support packet data services.

4. The MSSC must support all of GSM supplementary services.

5. Additional interworking functions (IWFs) will be required to support various GSM services. The IWFs will be in the following form:

i) Echo control devices at the MSSCs
ii) Modem pools and network based rate adaptation (i.e to allow for no more than 2400 bits/sec and no less than 1200 bits/sec user data rate) at LESs.
iii) Functions to select the appropriate modem and rate adaptation for each requested service.
iv) Appropriate interfaces at the MSSC (ISDN switch) to support data services with other specialised networks e.g X.32 access, to interface with packet networks including GSM.

6. To support short message services, provision must be made for a use of service centre, which acts as a store and forward centre for short messages. This centre can either be located at each LES or the GSM PLMN centre can be shared with the home LES.

Integration of Standard-M and GSM Terminals

In this section, the possibility of proposing a single terminal to access both networks will be looked at. The achievable level of integration will be determined by the amount of similarities between the two systems.

The two systems are very different at all the three lower layers of OSI model, thus there is no point in trying to integrate the Mobile Termination unit (MT) in GSM and the Mobile Earth Station (MES) in Standard-M into a single terminal. Hence customer interfaces at both the MT and MES were examined in order see how the GSM services can be supported in a dual-mode terminal. The dual-mode terminals for both non-ISDN and ISDN services are shown in figures 5 and 6 respectively. In ISDN compatible terminal, the GSM Mobile Termination 1 (MT1) was considered, as MT1 is designed to support ISDN user interface, i.e "S" reference point, allowing TE1 to be connected directly to MT1. As Standard-M MES is designed to support non-ISDN terminals, some modifications were required to enable the MES to support ISDN terminals.

Integration of Standard-M and GSM Networks

The important elements of the two separate networks which monitor the mobile position and thus allow calls to be forwarded to the mobiles are the HLR in the GSM and NCS in the Standard-M system. The gateway between the two networks must therefore be a link between these two elements so that information can be exchanged as to the mobile location within the whole network. This is shown in figure 7. The GSM Directory Number (DN) is incorporated in the Integrated Network for the following reasons:

1. The GSM is designed to provide flexible and economic call set up procedures by incorporating network elements such as HLR, VLR and Mobile Network identity such as MSRN.

2. The main purpose of this integration is to allow Standard-M to complement the GSM by providing similar services as the GSM in the rural/maritime areas. Thus it is essential to harmonise the user access methods by adopting the GSM numbering scheme.

To reach this integrated scenario, careful steps were also taken to minimise the propagation delays due to satellite links and the terrestrial tails, by extensive use of the terrestrial elements. This also resulted in the following advantages:

i) Avoided many changes in the space segment due to the need to transmit many signalling messages to support roaming in the integrated network.
ii) Efficient utilization of the space segment radio resources i.e roaming can be supported with very little use of the satellite radio channels.

Summary
In this paper two main areas were examined in order to achieve maximum possible level of synergy between the Inmarsat Standard-M and the GSM systems.
In the interworking, signalling, supplementary services and network issues were addressed and many additional network interfaces were proposed. These solutions were aimed at incorporation of GSM services in Standard-M system as much as possible.
The network integration was obtained through detailed comparisons of the two systems in accordance with OSI/RM model. This resulted in the suggestion of a dual-mode terminal with fully defined user-machine interfaces to access both GSM and the "enhanced" Standard-M services.

References

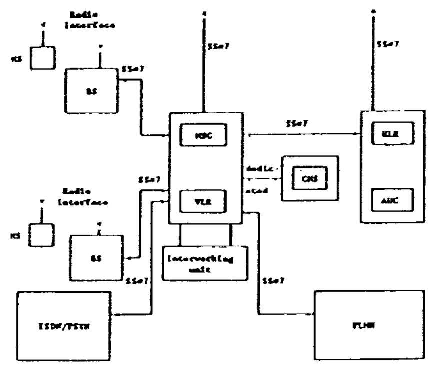
[1] Mallinder B.J.T., 1988 "The GSM digital cellular system", GSM noyan permanent, CEPT, Paris.

[2] 1990, "GSM PLMN Access Reference Configuration", GSM Recommendation 04.02.

[3] 1988, "INMARSAT-M System Definition Manual", Issue 3.0, Module 1, INMARSAT Satellite Organisation- London.

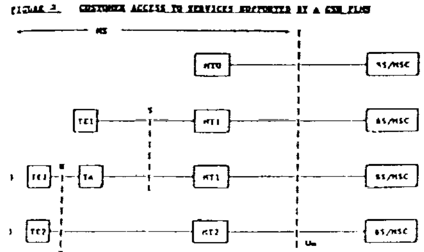
[4] Alverche, M., And Branes, D., 1988, "Overview of the GSM Services and Facilities", Digital Cellular Radio Conference, Hagen, Germany.

FIGURE 1 GSM NETWORK ARCHITECTURE



CMS: Charging System
AUC: Authentication Centre

FIGURE 2. CUSTOMER ACCESS TO SERVICES SUPPORTED BY A GSM PLMN



MS	Mobile Station
TE	Terminal Equipment: supports man-machine (access point 3) to the User and may support a physical interface at access point 1 or 2. TE may consist of one or more pieces of information and may include the following entities: - telephone set - customer terminals, eg. Data Terminal Equipments, Telex terminals - customer systems
TE1	TE Presenting an ISDN Interface
TE2	TE Presenting a non-ISDN (eg. a CCITT V or X series) interface
TA	ISDN Terminal Adapting functions may be used to adapt between access points 1 and 2
Um	Radio Interface

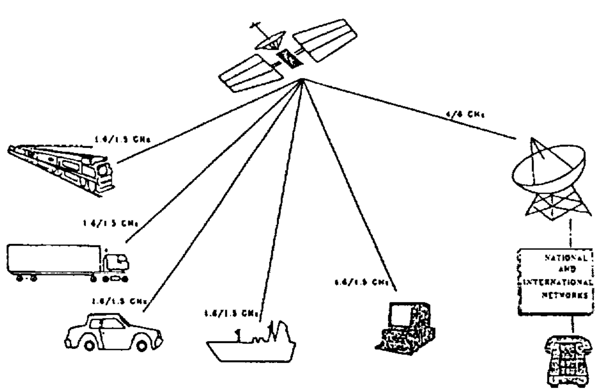


Figure 3 : Inmarsat-M Network Configuration

MES CONFIGURATION

FIGURE Y . CUSTOMER ACCESS TO A TELEPHONY SERVICE SUPPORTED BY MES

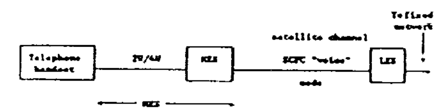


FIGURE 5 DUAL-MODE TERMINAL FOR

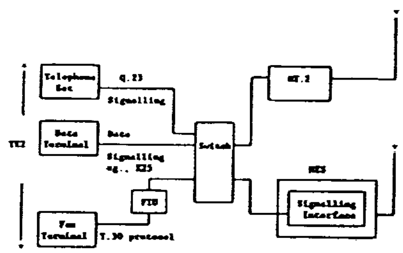


FIGURE 6 DUAL-MODE TERMINAL FOR AN ISDN INTERFACE

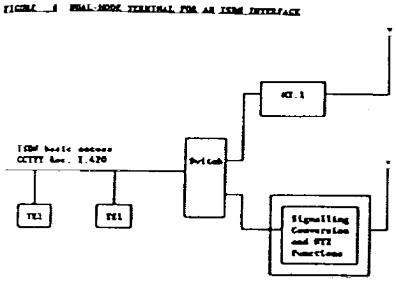
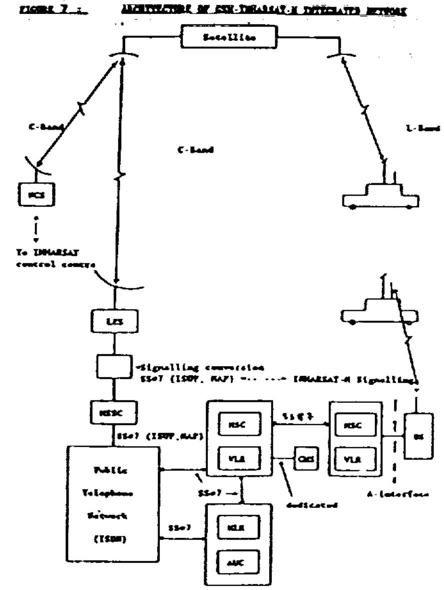


FIGURE 7 : ARCHITECTURE OF GSM-INMARSAT-M INTEGRATED NETWORK



LES: Land Earth Station
MSSC: Maritime Satellite Switching Centre
NCS: Network Coordination Centre
AUC: Authentication Centre
CMS: Charging System