Defence Science Journal, Vol 43, No 1, January 1993, pp 17-25

Inmarsat's Worldwide Mobile-Satellite Services: Today and Tomorrow·

Jai P. Singh
Inmarsat, 40 Melton Street, London NW1 2EQ, UK

ABSTRACT

Mobile-satellite communications, now available worldwide to maritime, aeronautical and land-mobile users, is an indispensable component of the fundamental evolution in mobile communications now in progress. Inmarsat is leading the mobile satellite evolution in the 90s through a wide-ranging portfolio of services, characterised by increasing portability through reduced weight and size of terminals, continuing reduction in cost of terminals and usage, greater integration with terrestrial telecommunications infrastructure, and improved spectrum utilisation. This paper describes the status of existing Inmarsat mobile satellite services, new services under implementation for introduction in the near-term, and also the longer-term plans including: by end of the decade, hand-held satellite phone.

1. INTRODUCTION

Mobile communications have evolved from a specialised service for national security, law enforcement and private networks domains to an economic and personal necessity for millions of people. It has emerged as an important and integral component of the public telecommunications infrastructure. The 90s are set to revolutionise public and private communications on the move for personal, business and governmental use as well as for improved efficiency and safety of transport operations. In this evolution, mobile satellite services (MSS) will play an important role by complementing the terrestrial telecommunications infrastructure, providing services to specialised markets and filling gaps unreached by other communication services. Mobile satellites are helping to overcome the limitations of 'wired connections', the local nature of terrestrial mobile systems, and the time and costs involved in extending their reach. For the user, they combine the advantages of global connectivity and global roaming with a single terminal.

Mobile-satellite communication services provide communications on the move-wherever (spanning the world) and by whatever means (land, sea, air) one goes-with anyone, anywhere and at anytime as long as the other party is either connected with the international public telecommunication network or has a compatible mobile satcom terminal. The main emphasis of global mobile-satellite communications is on communications for people who cannot afford to be out of touch with their offices or beyond reach, no matter where they are and how they travel but it will have significant implications for fleet management communications, surveillance and services for long-distance transport operations.

The same functionality also provides a vital means of access to the international public-switched telephone, data or telex systems from areas where disrupted or inadequate terrestrial telecommunications infrastructure needs to be overcome while being built, rebuilt or being modernised and where immediate public, administrative or industrial development needs demand urgent solutions Such 'gap-filling' land-mobile satellite communications solutions to more basic telecommunication needs are beginning to emerge as an important ancillary function in some regions.

Received 14 September 1992

2. INMARSAT SYSTEM

Inmarsat started as a space-segment and system provider for global maritime-mobile satellite services in 1982. It has since evolved into a complete, comprehensive and global set of mobile satellite services for all mobile user communities-maritime, aeronautical and land. The steadily increasing membership of the Inmarsat cooperative now encompasses 64 member countries. International ownership and control of Inmarsat ensures that the interests of all nations are reflected in the decisions of the organisation. India is a founding member of Inmarsat and played an important role in the process leading to its formation.

The Inmarsat space-segment is open for peaceful, non-discriminatory use by all nations, whether members of Inmarsat or not. Currently over 130 countries have commissioned Inmarsat terminals and use its services. The current Inmarsat coverage is shown in Fig. 1. The world is divided into four operating regions. Each operating region has its unique access code for telephone and telex. India is naturally covered in the Indian Ocean Region (IOR).

Eleven satellites are in service at present, including four of the second-generation (Inmarsat-2) satellites launched during 1990-92. Even before the development of all Inmarsat-2 satellites, Inmarsat has proceeded to contract for third-generation (Inmarsat-3) satellites, whose service introduction is planned from late 1994. Inmarsat-3 satellites cover all of the internationally allocated 1.525–1559/1626.5–1660.5 GHz L-band frequencies for mobile satellite services, have considerably more power than Inmarsat-2 satellites, introduce spot beams for more cost-effective handling of new services traffic from regions of high traffic density, and facilitate more efficient use of limited L-band spectrum through inter- and intra-system frequency re-use.

Table 1 shows the evolution of Inmarsat satellite systems. Follow-on satellites to Inmarsat-3 for introduction towards the end of this decade are already under definition. In addition to providing continuity for existing and planned services, new capabilities, including the hand-held satellite phone, are being addressed. There are a number of possible pathways to enhance Inmarsat space-segment assets to bring in

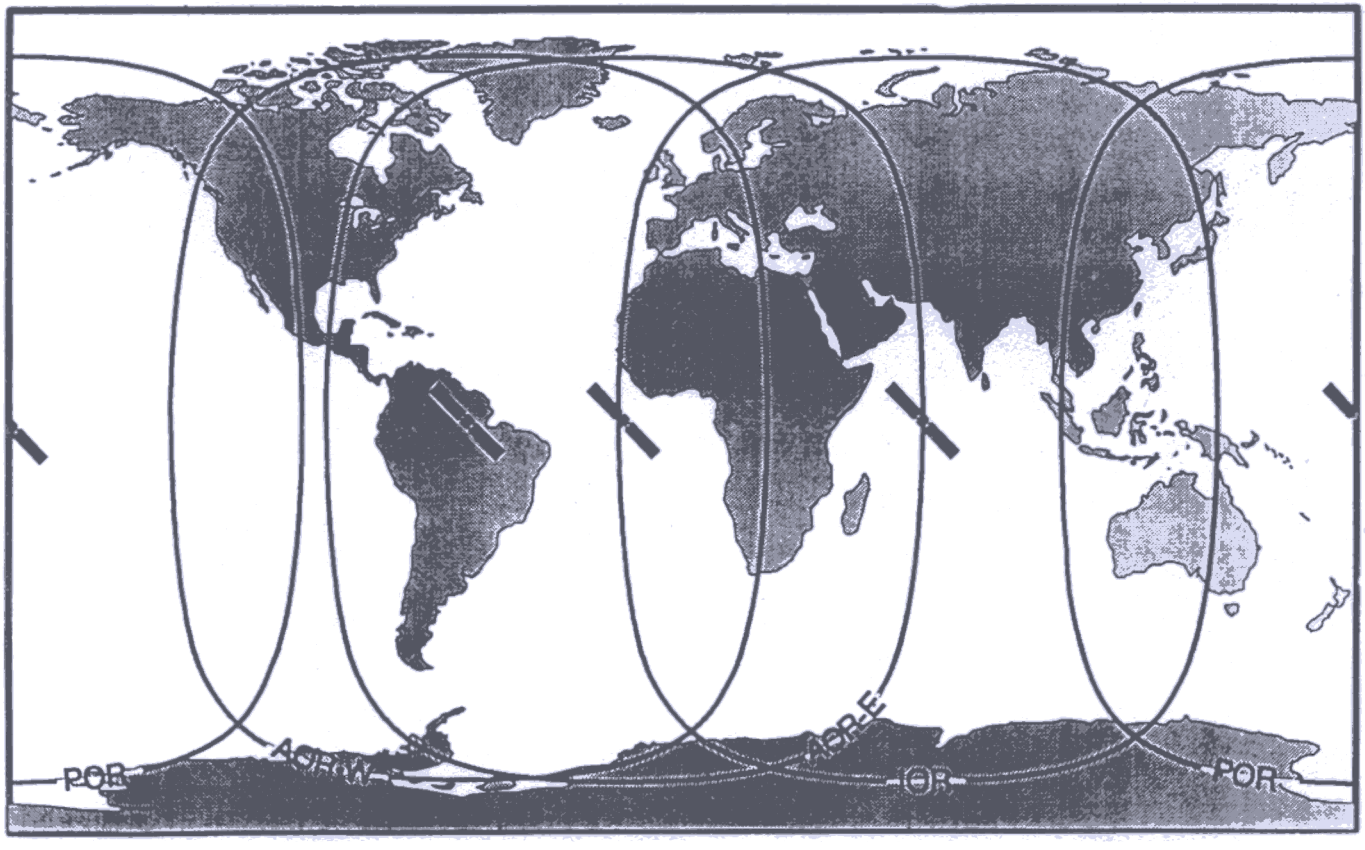

Figure 1 Inmarsat global coverage.

Table Inmarsat satellite system evolution

Parameter	Generation			
	2	3	4	
Capacity (channels)	50	250	1500	25,000 + (globally)
Power (EIRP)	33-35 dBW	39 dBW	48 dBW	60 dBW +
Features	GEO, global beam leased	GEO, global beam	GEO global and spot beams, navigation	GEO + possible lower earth orbits
Year of operation	1982	1992	1995	1998

hand-held satellite phone service. These include GEO alone, GEO+LEO, and GEO+HEO. The key to the selection of the appropriate configuration for the Inmarsat-4 space-segment lies in a careful definition of the mobile-satellite markets and services and their sizes into the twenty-first century and a carefully considered study of the commercial viability vis-a-vis the alternatives available. Each has its own costs, characteristics, advantages and risks. The identification of the preferred configuration for the new space-segment capability needed to support Inmarsat hand-held satellite phone (Inmarsat-P) is expected to be completed by the end of 1992.

3. EXISTING SERVICES AND APPLICATIONS

The portfolio of existing Inmarsat services includes Inmarsat-A and -C for maritime and land users and aeronautical high-gain (voice and higher rate data) and low-gain (low-speed) data. Inmarsat-B, a digital companion to Inmarsat-A, and Inmarsat-M, a low-cost, smaller, digital phone, for maritime as well as land applications are on track for service introduction beginning around middle of this year. A wide-area satellite paging service with a global reach is on the anvil with a 1993-94 service introduction target. A number of specialised services, such as audio, data and facsimile broadcasting to Inmarsat-A mobiles, are in service. Audio and data broadcasting services to mobiles with medium gain antenna (for example, Inmarsat-M and aeronautical high-gain) are under development. Considerable advances have been made in integration of communications and navigation for mobile users-for example, automatic dependent surveillance (ADS) for the aeronautical community, precise positioning services through differential GPS broadcasts to the survey and exploration community on a subscription basis, and development of L-band Inmarsat-C mobile terminals integrated with GPS navigation receivers. Figs 2-4 show the evolution of Inmarsat services, land-mobile terminals and usage costs. Table 2 provides a summary of the key technical features of Inmarsat-A/B/C/M and aeronautical mobile earth stations (MESs).

3.1 Inmarsat-A

Inmarsat-A mobiles to-date have been the workhorse of Inmarsat maritime and land-mobile services. They provide a direct dialling capability for voice, G-3 fax, telex and voice band data (up to 9.6 kbps) to other Inmarsat-A mobiles as well as to any other user connected with the international switched public telecommunications network. Currently some 17,000 Inmarsat-A mobiles are in service worldwide; about 90 of these are commissioned by India. Over 3,700 of these operate on land in about 134 countries, mostly as land transportables. There are more than 10 manufactures of Inmarsat-A terminals. Inmarsat-A service is available from some 35 gateways around the world; India is implementing an Inmarsat-A land earth station (LES 'gateway') at Arvi, which is expected to be in operation before the middle of 1992. Since their introduction in the late 70s, Inmarsat-A terminals have shrunk in size, weight and cost. The latest land transportable versions are small enough to be checked in aircraft as personal baggage. One particular model is portable enough to be carried as cabin baggage. An optional capability for 56 kbps highspeed data (HSD) from mobiles is now available, and a two-way 64 kbps service is under introduction. Though some Inmarsat-A mobiles, particularly on land, are used as personal communication terminals, they are essentially 'community' or 'group' use mobiles.

3.2 Inmarsat-C

A low-speed (600 bps) data messaging service for maritime and land-mobile users, named Inmarsat-C, was introduced in 1991. Inmarsat-C terminals are very compact in size and cheaper; some of the new models are the size of an 1.5 inch thick A4 file. This compact yet versatile data messaging communications engine caters to a large number of services—store and forward telex, X.25 and X 400 terrestrial interfaces and services,

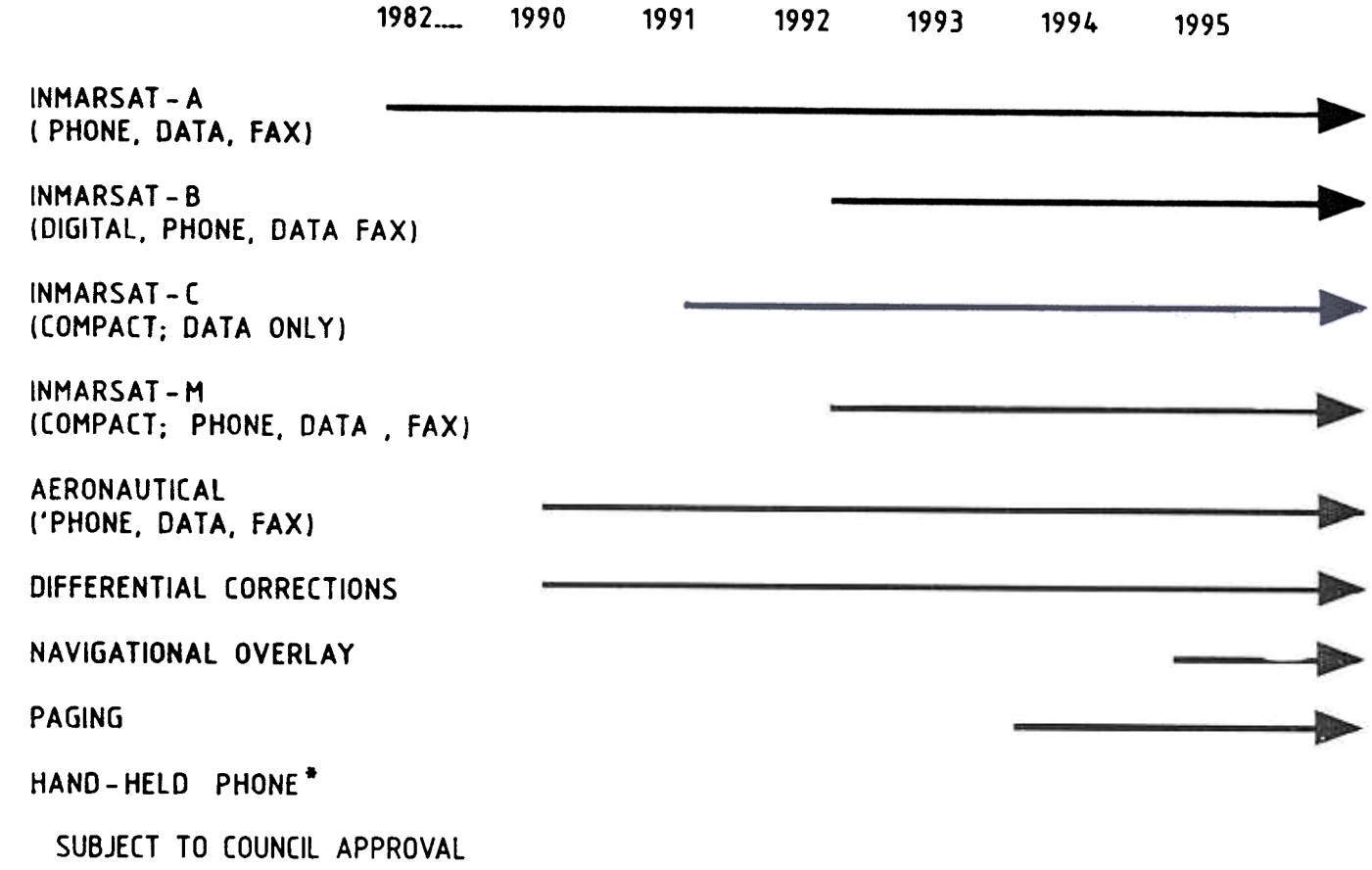

Figure 2. Inmarsat services.

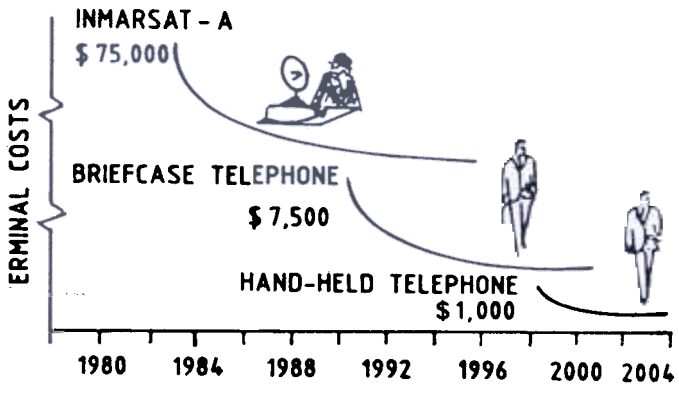

Figure 3. Smaller, lower cost terminals (MESs).

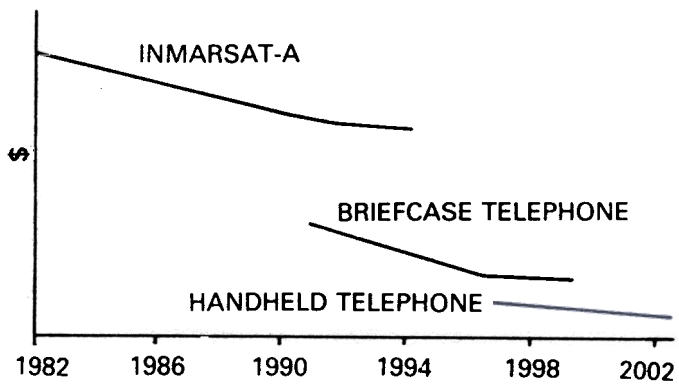

Figure 4. Lower cost voice services.

short-messagings (data reporting, including position reporting), polling, group broadcasting (EGC, SafetyNET and FleetNET), and maritime (GMDSS) distress alerting and land-mobile alertings.

Inmarsat-C service is now available globally from a total of 13 gateways. Network control stations (NCSs), currently with a combined capacity of handling over 100,000 Inmarsat-C mobiles, are installed in the four operating regions. In 1992, 9 more gateways under construction, are expected to be introduced in service in various parts of the world. Twelve more gateways, including one at Arvi in India, are in planning.

Thirty-two Inmarsat-C MES models from 20 manufacturers are now type-approved. Eleven more are in the type approval, and several others are under development. These include maritime models, models

Table 2. Inmarsat MESs

Parameter	Inmarsat-A	Inmarsat-B	Inmarsat-C	Inmarsat-M	Aeronautical
Steering	Steerable	Steerable		Steerable Az only	Electronic
Type	Parabolic	Parabolic	Omni	Linear array	Phased array
Eirp	36 dBW	25-33 dBW	12 dBW min at 5°	22-28 dBW	14 dBW low-gain 26 dBW high-gain
Receive G/T	–4 dB/K min	–4 dB/K	–23 dB/K at 5°	–12 dB/K	–26 dB/K low-gain –13 dB/K high-gain
Telex & data rates	50 baud telex*	50 baud telex 9.6 kbps	600 bps	2.4 kbps	600, 1200, 2400 10,500 bps
Telephony	FM	Digital coded	Data only	Digital coded	Digital coded
Voces coding rates	12 kHz deviation	16 kbps		4.2 kbps	9.6 kbps
Channel spacing	50 kHz	20 kHz	5 kHz	10 kHz	5 kHz, 17.5 kHz

*56/64 kbps HSD and 64 kbps DHSD options

providing EGC add on to Inmarsat-A MESs, land-mobile models for installation on commercial vehicles, briefcase models for professional travellers, and models for supervisory control and data acquisition (SCADA) applications. Inmarsat-C mobiles provide an easy interface for connecting a wide variety of navigation equipment and sensors for position reporting, and for data reporting and fleet management applications, respectively. Some Inmarsat-C models have in-built GPS receivers. A briefcase model for business travellers announced by one particular manufacturer, with a flat antenna on top of the briefcase lid, weighs under 4 kg. Recently, voice input/output for hands-off operation, particularly important in road transport, has been successfully demonstrated.

At present, five manufacturers supply Inmarsat-C gateways, i.e., LESs. In the 16 months since service began, the number of Inmarsat-C mobile terminals has grown to over 3600; these are commissioned in about 80 countries. With larger scale production and widespread availability of Inmarsat-C terminals expected from the second half of this year, the infrastructure is in place to growth of number of terminals in 1992.

3.3 Inmarsat Aeronautical Services

The Inmarsat aeronautical data and voice services are now commercially available worldwide from twelve gateways. Inmarsat Aero-L, uses low-gain antenna on-board aircraft, and supports information data rates of 300 or 600 bps at transmission rates of 600 or 1200 bps using rate 1/2 error correction coding. Inmarsat Aero-H, using high-gain antenna, supports voice and high speed data. Voice signals are digitised at 9.6 kbps and are combined with signalling data, resulting in an information data rate of 10.5 kbps. FEC encoding is used to reduce the bit error rate, giving a data transmission rate of 21 kbps. The voice channel is capable of handling data traffic, both combined with the voice signals and independently, as a high-speed data channel.

These services are designed to aeronautical industry satcom standards (ARINC Characteristic 741 Aviation Satellite Communications System) and are offered by a number of competing global service consortia—Skyphone, consisting of BT, Norwegian Telecom and Singapore Telecom; Aircom consisting of Teleglobe Canada, France Telecom and OTC/Australia in association with SITA and IDB-Aero.Nautical; and COMSAT-KDD. ARINC provides Inmarsat aeronautical services through the Skyphone as well as COMSAT-KDD consortium. These services cater to airline passenger communications and to corporate aviation needs. Air traffic control (ATC) and airline operational and administrative communications are major target applications for Inmarsat aeronautical communication services. As of the writing of this report, over 120 aircraft were equipped with Inmarsat satcom

terminals. More and more airline orders for new long-distance aircraft are including Inmarsat aeronautical satcom terminals.

4. NEW SERVICES IN THE NEAR-TERM

As part of its commitment to improve the range of services to mobile users and to reduce costs to users, Inmarsat has developed two new service standards which have entered commercial operation during 1992.

Inmarsat-B, will provide capabilities similar to Inmarsat-A, except that the system uses digital transmission techniques which increase the range of data services and reduce the power and bandwidth demands on the space-segment. This latter effect should permit a significant reduction in end-user charges. The system will appeal to maritime users as well as the many land-based users who need more than basic services.

Inmarsat-M, designed for low cost, portable voice, will appeal to major new markets such as small maritime craft, commercial vehicles and international travellers for which the unit will be packaged as a briefcase phone. Inmarsat-M provides a near-toll quality 4.2 kbps voice, group III fax, 2400 bps circuit-switched data, and group call capabilities.

Implementation of NCSs in each of the four operating regions for Inmarsat-B/M has been completed in 1992. Four Inmarsat signatories have already announced contract awards for their gateways, and many more signatories have announced their intentions to proceed with Inmarsat-B/M services. The first Inmarsat-M gateway has recently been completed and is expected to enter commercial service around the middle of 1992. A technical demonstration facility for Inmarsat-M using recently delivered prototype terminals is now available and has succesfully completed an extensive technical trial programme in Europe.

A *navigation payload* is included on Inmarsat-3 satellites under construction. This payload is intended to support development of an international civil geostationary complement to GPS and GLONASS, national satellite navigation systems with worldwide coverage (Fig. 5). This is to facilitate civil use of these systems through provision of independently monitored 'integrity' of their individual satellites. The GPS/GLONASS integrity information is proposed to be broadcast in GPS look- alike signal format. This signal will also serve as an additional navigation reference signal, improving the coverage of these systems. In the longer-term, should GPS and GLONASS not be available to the international community or should their conditions of availability change, the geostationary complement can also provide

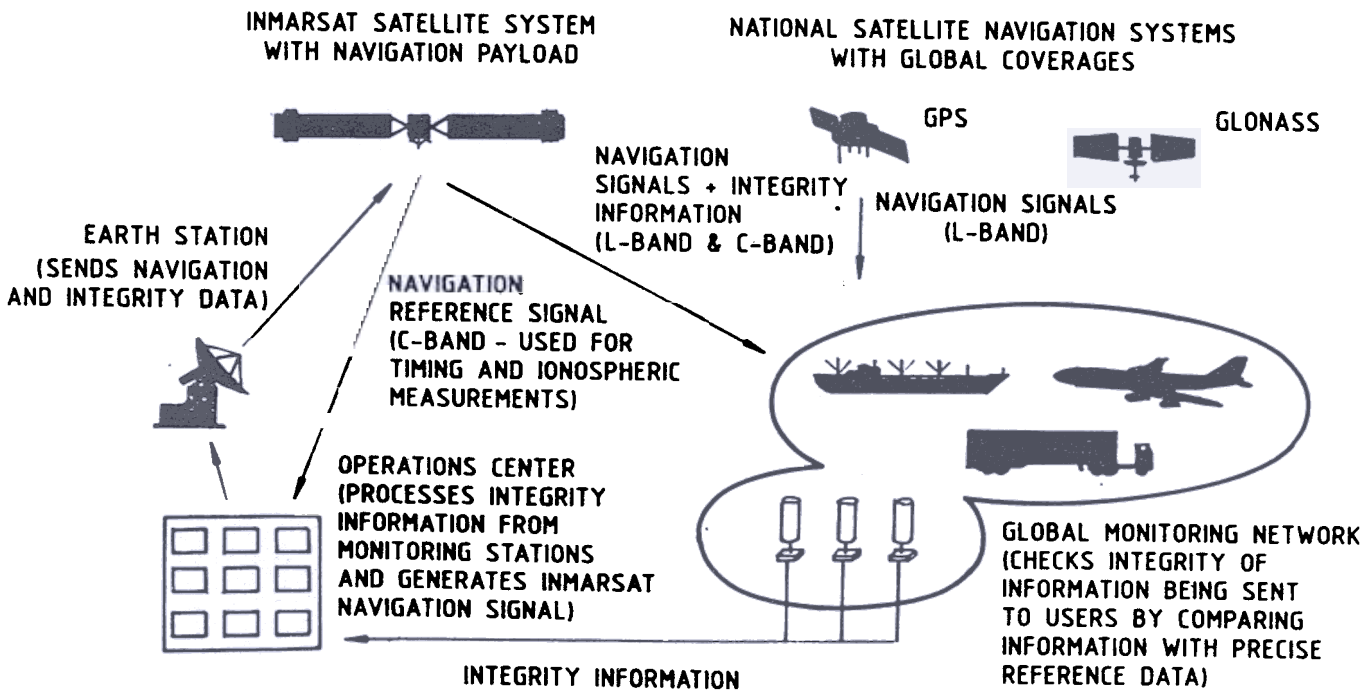

Figure 5. Inmarsat global satellite navigation enhancement.

the core for building an international, independent, civil satellite navigation system by adding a complement of orbiting satellites to it. Navigation is emerging as the next utility, and Inmarsat is fully cognizant of its value in the emerging intregrated communication/navigation mobile environment.

Inmarsat has also defined a global *Satellite Paging system* which will offer tone-numeric and alphanumeric facilities to users worldwide. The service aimed principally at the international business traveller and designed to operate in urban areas will provide a limited penetration into buildings. It is also envisaged that satellite pagers will be incorporated into briefcase versions of Inmarsat-C and -M so that office originated calls could be returned. Service introduction is targeted for 1993-94. Figure 6 illustrates typical realisations of the existing family of Inmarsat satellite phones—an Inmarsat-A land transportable small enough to be carried as a hand baggage, an Inmarsat-C data messaging in a briefcase packaging, and an Inmarsat-M briefcase satellite phone.

5. FUTURE SERVICES, HAND-HELD SATELLITE PHONE

The Inmarsat evolution towards an ever-widening family of new services and terminals will inevitably lead to the global, hand-held satellite phone (Fig. 7) by the end of the decade.

It is clear that there will be a market for hand-held satellite voice terminals for some, but not all, mobile satellite applications. Hand-held terminals will be used primarily by international travellers (especially business travellers who pass in and out of the range of other communication services or who roam across areas of different cellular standards), in developing countries,

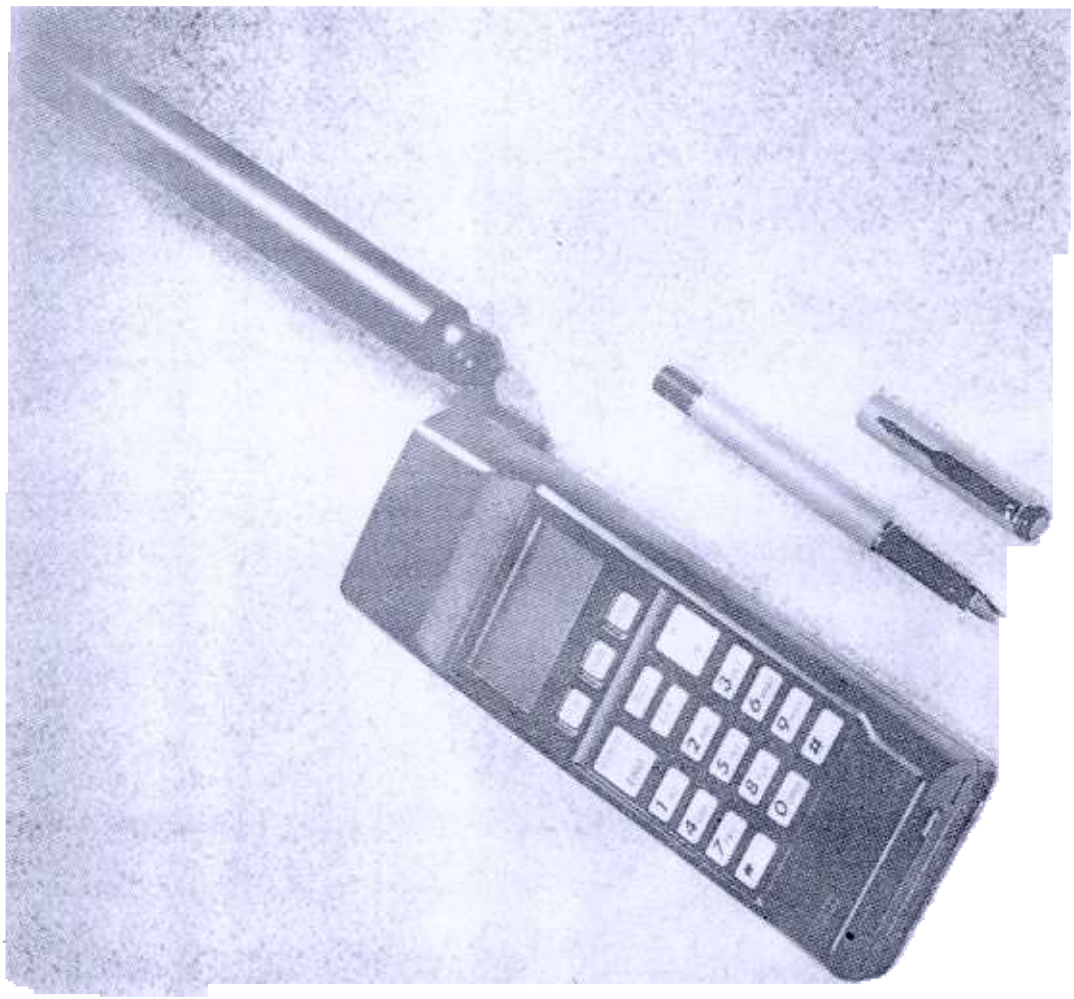

Figure 7. Hand-held satellite phone: integration of satellite and cellular.

in areas of the world where cellular services have not penetrated, in providing extensions to cellular services in industrialised countries, in non-commercial aircraft, and in coastal shipping markets.

Our planning is guided by the realisation that, while mobile satellite market are increasing as the cost of equipment and use comes down and portability increases, they will remain rather specialised, relatively small niche markets, which when aggregated globally provide a viable business base. Even with major improvement in satellite technology and design, we do not see the mobile-satellite services competing with terrestrial cellular services in areas of medium to large user population densities. Although difficult to predict, the worldwide mobile satellite user population may reach one or two million by the end of year 2000. The terrestrial cellular markets, by contrast, are forecast to reach up to a hundred times that figure.

Inmarsat is actively examining various space-segment alternatives to decide on the preferred alternative for expanding the capability of the Inmarsat space-segment, to meet the needs of new services, including hand-held satellite phones towards the end of this decade. The hand-held satellite voice terminal is a natural next step beyond the portable satellite phone (Inmarsat-M; 1992) in the evolution of Inmarsat services. From the evaluaion of market trends, the technology and the economics of mobile satellite services, Inmarsat has developed a set of principles which are feasible and which guide the planning for hand-held satellite phone service. These include:

(a) Targeting the introduction of global hand-held satellite phone by the end of this decade.

(b) Hand-held satellite voice terminals to be inter-operable with terrestrial cellular systems to provide the maximum utility for the user.

(c) Target retail cost of the dual-mode, cellular and satellite, hand-held voice terminal equipment should be less than US$ 1,500.

(d) The production cost of delivering voice services to hand-held terminal should be less then US$ 1 a minute.

(e) Inmarsat's fourth generation satellite system would continue to have a strong geostationary satellite component. Inmarsat has an obligation to its thousands of customers in the maritime, aeronautical and land-mobile communities to continue to provide the services they have come to depend on and which use geostationary satellites.

(f) The Inmarsat system would not bypass national telecommunications systems. The satellite system would provide the initial link between the mobile and the worldwide public-switched telecommunications networks, via the Inmarsat earth station network.

6. CONCLUSION

In just over ten years since Inmarsat commenced operation, global mobile-satellite communications services have grown from a single market (maritime), a single service system (Inmarsat-A) and 1500 terminals to all markets (maritime, aeronautical and land-mobile), a wide range of terminals and services, and over 20,000 terminals in use by over 130 countries. With shrinking weight and size of terminals, increasing portability, steadily reduced costs of terminals and their usage, and a wide range ot new terminals and services, it is expected that new markets will open up. The vision of hand-held satellite phone by the end of the decade, free from encumbrances of a wired connection is seen as the natural next step in the evolution from briefcase satellite-phones introduced in 1992. It heralds the promise for wider use of satellite communications, with numbers which approach a mass market.