Zoran Mrak, dipl.ing.
Dario Ogrizović, ing.
Faculty of Maritime Studies
Studentska 2, 51000 Rijeka
Croatia

Review
UDK: 629.783
004.738.5
Received: 18th July 2005.
Accepted: 20th July 2005

INMARSAT BROADBAND GLOBAL AREA NETWORK

Delivered over Inmarsat's I-4 satellite system, Inmarsat BGAN will be the first global, high-speed mobile data network that will serve remote mobile staff with easy-to-use, fast and reliable access up to 492 kbps to the Internet and the corporate intranets. Inmarsat BGAN will offer voice, packet data and streaming and a whole range of services for the future users. Inmarsat BGAN, scheduled for commercial launch at the end of 2005, will initially concentrate on land users and with maritime and aero services being the focus from 2007 onwards.

Key words: Inmarsat BGAN, I-4 satellites

1. INTRODUCTION

Inmarsat manages and operates a global GEO mobile satellite service system that is used by independent service providers to offer a range of voice and multimedia communications. The Inmarsat business strategy is to maintain a leadership profile in high speed broadband mobile data services while continuing to serve traditional maritime, aeronautical, land-mobile and remote-area markets. The Inmarsat evolved from COMSAT, in the late 1970s, as an international mobile satellite service joint venture of governments and telecommunication operators. The acquisition of Inmarsat by funds advised by Apax Partners and Permira was successfully completed in 2003.

Today, the keystone of the strategy is the new Inmarsat I-4 space segment with new ground infrastructure to provide the terrestrial network interconnects. The first new service to be launched on the Inmarsat-4 satellites will be the Inmarsat Broadband Global Area Network (BGAN). BGAN will support standard and streaming IP services as well as traditional circuit-switched voice and ISDN data. The service will enable the delivery of Internet and intranet content and solutions, video-on-demand, video conferencing, fax, e-mail, voice and VPN access at speeds up to 492 kbps accessed via a small, lightweight satellite terminal.

The BGAN system will be compatible with third-generation (3G) cellular terrestrial systems. Users would be able to roam between terrestrial to satellite networks using a common subscription and service provision relationship.

Inmarsat BGAN will be initially available across Europe, the Middle East, Africa and Asia in late 2005. After the successful launch of the second Inmarsat-4 satellite, the service is expected to launch in North and South America in Q2, 2006 [1].

2. SATELLITE SYSTEMS

Inmarsat's primary satellite constellation consists of four Inmarsat-3 satellites backed up by a fifth Inmarsat-3 and four previous-generation Inmarsat-2s in geostationary orbit.

The Inmarsat-2 satellites were built by an international group headed by British Aerospace (now BAE Systems).

The Inmarsat-3 satellites were built by USA Lockheed Martin Astro Space (now Lockheed Martin Missiles & Space) which developed the basic spacecraft and the European Matra Marconi Space (now Astrium) which developed the communications payload. The Inmarsat-3 communications payload can generate a global beam and a maximum of seven spot-beams.

Inmarsat-2 F1 was launched in 1990 and is now located over the Pacific, providing lease capacity. Inmarsat-2 F2, launched in 1991, is over the western Atlantic, providing leased capacity and backing up Inmarsat I-3 F4. Also launched in 1991, Inmarsat-2 F3 is stationed over the Pacific Ocean, providing lease capacity and backing up Inmarsat I-3 F3. The fourth Inmarsat-2 was launched in 1992 and is used to provide leased capacity over the Indian Ocean and backing up Inmarsat I-3 F1 and Inmarsat I-3 F3.

Inmarsat-3 F1 was launched in 1996 to cover the Indian Ocean Region. Over the next two years F2 entered service over Atlantic Ocean Region-East, followed by F3 (Pacific Ocean Region), F4 (Atlantic Ocean Region-West) and F5 (limited services on a single spot beam, back-up and leased capacity).

The satellites are controlled from the Satellite Control Centre (SCC) at Inmarsat Headquarters in London. The control teams there are responsible for keeping the satellites in position and for ensuring that the onboard systems are fully functional at all times. Data on the status of the nine Inmarsat satellites is supplied to the SCC by four tracking, telemetry and control (TT&C) stations located at Fucino, Italy; Beijing in China; Lake Cowichan, western Canada; and Pennant Point, eastern Canada. There is also a back-up station at Eik in Norway. A call from an Inmarsat mobile terminal goes directly to the satellite overhead, which routes it back down to a gateway on the ground called a land earth station (LES). From there the call is passed into the public phone network [2].

THE INMARSAT 4 MOBILE SATELLITE SYSTEM

Three Inmarsat-4 satellites are being built by the European aerospace company Astrium. Inmarsat-4 F1 was launched from Cape Canaveral USA on 11th March 2005 at 21:42 GMT. [3] Inmarsat-4 F1 is located 36,000km above the Indian Ocean (64^0 East longitude). Inmarsat-4 F1 footprint covers Europe, Africa, the Middle East, the Indian sub-continent, most of Asia Pacific and Western Australia. The Indian Ocean Inmarsat-3 remains close to the Inmarsat-4 for a month after transition to ensure a smooth handover. It is then moved to another location to provide back-up. The vastly more powerful Inmarsat-4 will host all existing Inmarsat services except Inmarsat A, which moved to another satellite at 109^0 East on February 19 and will cease operation at the end of 2007. Regional BGAN users are scheduled to migrate to the Inmarsat-4 in July.

The Inmarsat-4 F2 is currently planned for delivery to the launch site by Q3 2005

and is going to be deployed at Inmarsat's existing AOR-West (53^0 West longitude) orbit location.

The Inmarsat-4 F3 is being developed as a ground spare, which may be launched either to replace a previous launch failure or to extend the coverage area to global, based on business and operational considerations.

Table 1: Inmarsat satellites main characteristics

	Inmarsat-2	*Inmarsat-3*	*Inmarsat-4*
No. of satellites	4	4 + 1 spare	2 + 1 spare
Coverage	Global beam	7 wide spots + global beam	228 narrow spots + 19 wide spots + global beam
Mobile link EIRP	39 dBW	49 dBW	67 dBW
Channelisation	4 channels between 4.5 and 7.3 MHz bandwidth	46 channels between 0.9 and 2.2 MHz bandwidth	630 channels at 200 kHz
Satellite dry mass	700 kg	1000 kg	3000 kg
Solar array span	14.5 m	20.7 m	48.0 m
Total launch mass	1500 kg	2050 kg	6000 kg
Navigation payload	No	Yes	Yes

Source: Piers Cunningham "Inmarsat Update & I-4 The Next Generation Digital Ship Scandinavia", March 2005

The satellites will incorporate a feeder link using C-band spectrum to ensure compatibility with existing Inmarsat ground infrastructure. The satellite transponders will provide exceptional flexibility as well as increased RF power, enabling spot beam coverage and channelisation to be reconfigured in-orbit. The satellite payload is also highly efficient in terms of spectrum utilisation, and is expected to achieve more than 20 times frequency reuse at L-band.

In addition to the forward (C to L band) and return (L to C band) transponders, the Inmarsat-4 satellites also incorporate transponders for mobile to mobile links, C to C links and also a navigation transponder providing positioning information compatible with the GPS navigation satellite system. [4]

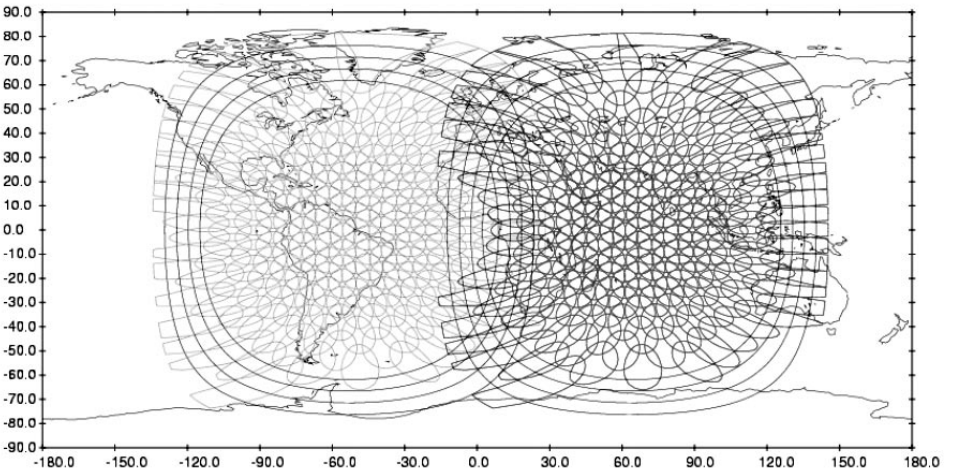
Key elements of the spacecraft such as the payload, bus, reflector, digital signal processor, antennas and solar array are skillfully combined to make the Inmarsat-4 the largest and most sophisticated commercial communications satellites ever.

COVERAGE

Figure 1 shows the typical narrow spot beams coverage areas of the first two satellites, which together will cover around 85 % of the earth's landmass.

Inmarsat-4 satellite generates one global beam, 19 wide beams and 228 narrow spot beams. The global and wide spot beams will be used to support some of the existing Inmarsat services, like Inmarsat C and Mini-M, and will also support call set-up procedures for the BGAN services. These spot beams have higher performance than currently provided on the Inmarsat-3 satellites, enabling higher data rates to be delivered to evolved version of the current range of user terminals. The narrow spot beams will be used by the new BGAN services and will also support the current Regional BGAN land mobile services.

Figure 1: BGAN Enhanced Coverage



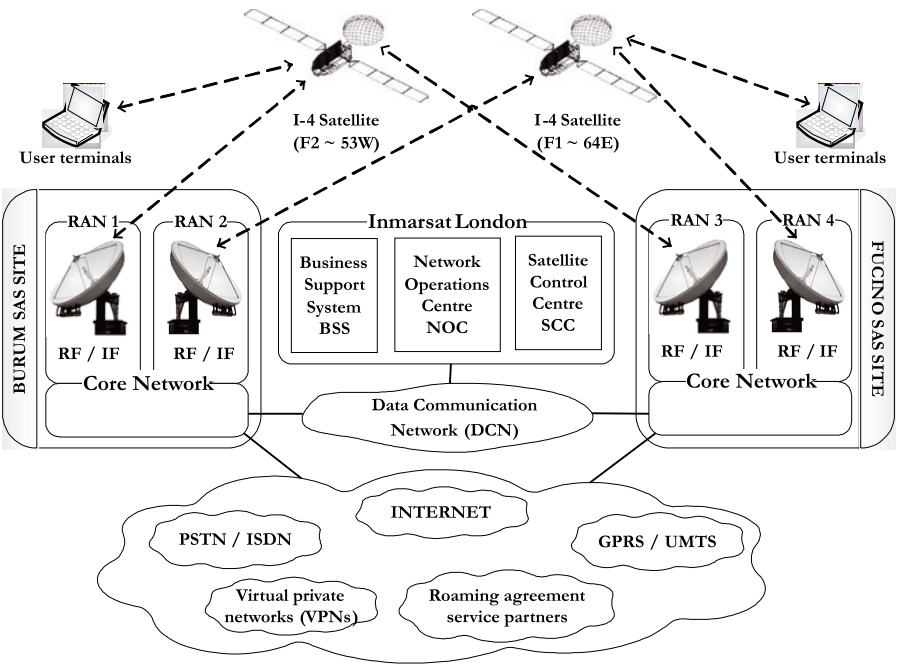
Source: BAE Systems (http://www.baesystems.com)

3. ADVANCED GROUND NETWORK

The Satellite Access Stations (SAS's) are located in Fucino, Italy and Burum, Netherlands. The first, in Burum, will be operated by Inmarsat partner Xantic, and the other, in Fucino, by another partner, Telespazio. The SAS's are interconnected by a Data Communication Network (DCN), managed bandwidth service from global network operators. Inmarsat from the Network Operation Centre (NOC) exercises the overall network control and management, while the satellites will be controlled from the Satellite Control Centre (SCC). These two systems require a sophisticated integration, especially due to the need to dynamically reconfigure and allocate channel resources to the spot beams as a function of network traffic and geographic traffic distribution. The Business Support System (BSS) is a modular system comprising a wholesale billing system, along with customer activation, customer care, fraud management modules and other functions. [5]

The SAS itself can logically be divided in two parts: the Network Switching Subsystem (NSS) and the Radio Switching Subsystem (RSS). The Network Switching System (NSS) components are standard GSM, GPRS and UMTS components. The key elements are the Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN). The SGSN has a radio focused view, looks after mobility management and the GGSN has a terrestrial interface view. The GMPRS air interface and system and SAS architecture have been guided by a desire to ensure the NSS components can remain standard. The Radio Switching Subsystem (RSS) maps into the UMTS RAN (Radio Access Network), since it implements the necessary air interface for reliable communications over the satellite, as well as the radio frequency components of the station. Advanced modulation and coding schemes are employed in order to achieve high spectrum efficiency, while at the same time implementing an effective power efficient scheme. [6]

Figure 2: Inmarsat BGAN Ground Network



4. INMARSAT BGAN USER TERMINALS

A selection of Inmarsat terminal types is provided in table 2, beginning with existing products for maritime, aero and land markets. Existing products will continue to be supported over the I-4 global and wide spot beams, as well as over the I-3 satellites. Evolved, dual mode terminals will support enhanced services within I-4 coverage, as well as existing services within I-3 coverage, thus providing virtual global coverage for these services. Existing and evolved services will be offered via the current ground network comprising Land Earth Stations (LESs) and service providers.

New BGAN products would be capable of operation only over I-4 narrow spot beams. The BGAN user terminals will be compatible with standard IT/PC communications software, and also have integrated position determination capability using the GPS system. Their alignment with global mobile telecommunications industry allows roaming to/from terrestrial data networks by means of a standard SIM card.

Table 2: Inmarsat standards and service capabilities

Year of Adoption	*Satellite Series*	*Service Capabilities*
1982	Inmarsat A	Analog telephone (FM-SCPC) and telex
1990	Aero H & L	Aeronautical digital voice and low-speed data
1991	Inmarsat C	Low-speed data, briefcase keyboard terminals
1993	Inmarsat B	ISDN digital voice and data (64 kbps), suitcase-sized land mobile terminals
1993	Inmarsat M	Compressed digital voice, briefcase terminals
1994	Global paging	Pocket size pagers
1995	Navigational services	Variety of specialized devices
1996	Aero - H+ and I	Voice and data communications
1997	Mini-M	Notebook voice terminals and 2.4 kbps data
1999	Global Area Network (GAN)	ISDN and MPDS services (64 kbps)
2002	Swift64	ISDN and MPDS services
2002	Fleet F77 / F55 / F33	Voice, fax, Mobile ISDN and MPDS services
2003	Regional BGAN	Palmtop medium data rate modem, up to 144 kbps, Europe, North Africa, the Middle East, and southern Asia
2005	BGAN	Palmtop medium data rate modem, up to 492 kbps, global footprint using Inmarsat 4

The notebook (A4 size) with size comparable to notebook computers, measuring approximately 30 cm x 20 cm x 3 cm, and weighing around 1000 g will provide download data rates of up to 492 kbps. The pocket (A5 size) similar in size to pocket computers, measuring approximately 20 cm x 10 cm x 3 cm, and weighing around 500 g will provide download data rates of up to 384 kbps. [7]

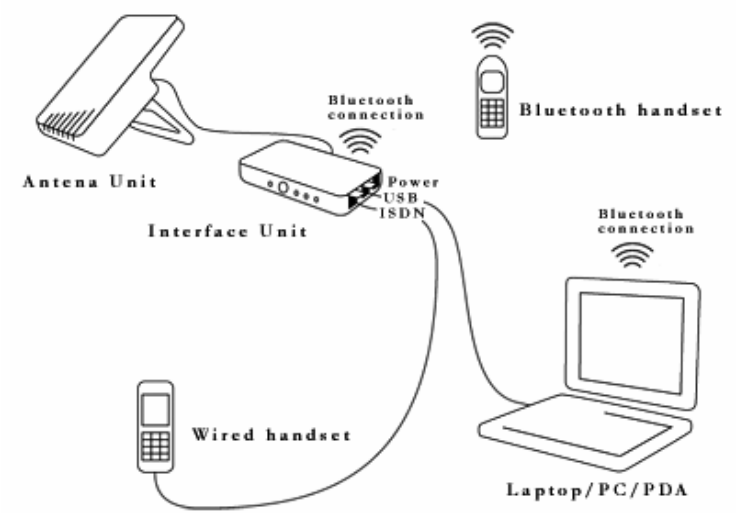
An initial range of four user terminals will be available. Manufacturers and terminals expected performance is presented in table 3. There will be two smaller, lower-bandwidth devices and two larger, higher-bandwidth devices with differing functionality and pricing to appeal to the needs of different target markets.

Table 3: Inmarsat BGAN user terminals expected performance

Manufacturers	*Downlink*	*Uplink*
Hughes Network Systems	Up to 492 kbps	Up to 492 kbps
Thrane & Thrane	Up to 464 kbps	Up to 448 kbps
Add Value Technologies	Up to 384 kbps	Up to 240 kbps
Nera	Up to 384 kbps	Up to 240 kbps

The Inmarsat BGAN user terminal is based on the concept of satellite modem, connected to a personal computer or PDA. It comprises a directional flat antenna and has a built-in software to assist the user to correctly point it to a satellite. Although the emphasis is on portable land terminals, maritime and aeronautical versions are also planned.

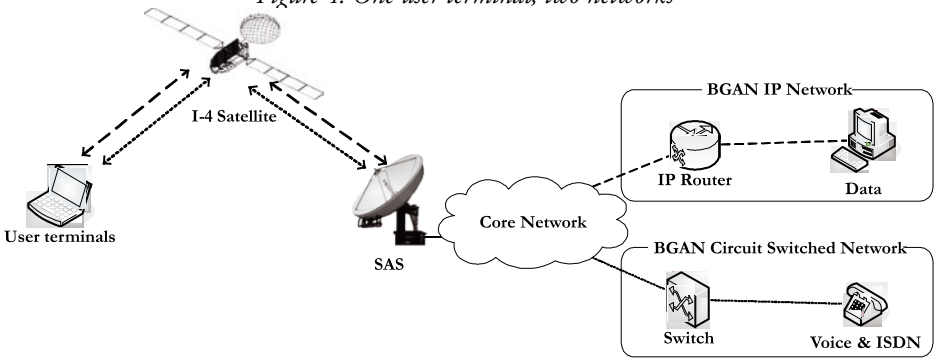
Figure 3: Broadband satellite user terminal



Source: Nera SatCom AS (http://www.nera.no)

The BGAN will support voice capability, both traditional and Bluetooth handset technology, and would be suitable for simultaneous use with high-speed data services. Both services can be delivered concurrently via the same terminal, or the user can choose to make use of BGAN either as a data "modem" or for telephony.

Figure 4: One user terminal, two networks



5. COMMUNICATIONS SERVICES

The standard IP data service will offer variable rates up to 492 kbps, always-on connection and performance enhanced by TCP/IP accelerator to compensate for satellite delay. The standard IP data service will offer public or private IP address with static or dynamic allocation. Users will send e-mails, transfer files and access the Internet and will only pay for data sent and received.

The streaming IP data service, available on selected BGAN terminals, will offer streaming class IP, guaranteed bit rate over the satellite and bandwidth on demand, enabling live video applications with charges based on duration of connection.

Voice telephony will offer direct dial voice service, with land-line quality speech using cutting edge voice compression technology (4 kbps), to and from terrestrial fixed-line and mobile networks and emergency call service.

In addition, the voice service will include all standard enhanced features offered by terrestrial fixed-line and mobile networks, such as voicemail, caller line ID, call forwarding, call waiting, conference calling and call barring.

Other services will include text messaging, SMS to and from terrestrial mobile phones, on-bound roaming, with 3G and GPRS SIM cards, and prepay / post pay charging via Inmarsat Distribution Partners. [8]

COMMUNICATIONS COST

Inmarsat is currently defining its tariff structures and pricing levels for BGAN. It has already renegotiated its agreements with its land earth station operators (LESOs) and replacing the “LESO agreement” with a “Commercial Framework Agreement”. Although Inmarsat will not sell airtime to the customer directly, it is now at liberty to sign up any new distributor provider which would be able to buy airtime from Inmarsat thus getting better rates compared to those of another LESO.

6. INMARSAT BGAN FOR MARITIME USERS

Inmarsat's maritime customers will benefit, in addition to current coverage, from extended spot beam coverage in the Indian Ocean Region (IOR) followed by the Atlantic Ocean Region West (AOR-W) shortly after the launch of the second Inmarsat-4 satellite.

Within these extended areas, mini-M users will be able to use their terminals in voice, fax and data modes. Fleet F33 and F55 users will also be able to use their terminals in fax and data modes, while voice will continue to be available on a global basis. Upgraded Fleet F77 users will also benefit from access to higher data rates at 128 kbps within the enhanced coverage areas. Maritime users will subsequently be able to upgrade to broadband services and new terminals as they become available. [9]

Inmarsat BGAN for maritime users is still in development. Development includes propagation studies, physical layer specifications, proof of concept technology, final air interface definition and platform extension for all product types. Inmarsat is also determining requirements for a BGAN safety service and assessing the application of safety services on all new products. [10]

7. CONCLUSION

New Inmarsat-4 satellite constellation will provide a significant enhancement to Inmarsat's space segment, and their ability to provide more powerful and efficient services, to support both current Inmarsat services, as well as the planned new services. The first new service to be launched on the Inmarsat-4 satellites will be Inmarsat BGAN. Inmarsat BGAN will be the first mobile satellite communications solution to offer global coverage with voice and high-speed data services up to 492 kbps. Initially developed for land-based markets, maritime and aero versions of Inmarsat BGAN are currently planned for commercial launch in 2007.

A range of terminals will be supported, that will align with mobile telecoms standards, ranging from small personal devices linking up with handheld and notebook PCs, aeronautical and maritime vehicular installations linking up with on-board entertainment and communications systems, to remote base stations linking up with local area networks.

Inmarsat BGAN services will leverage the constantly increasing demand for high-speed communications, combined with wide coverage, reliability and portability, across all markets.

REFERENCES

[1] http://countdown.inmarsat.com/solutions/introducing_bgan.aspx , May 2005
[2] http://about.inmarsat.com/satellites.aspx , May 2005
[3] Piers Cunningham "Inmarsat Update & I-4 The Next Generation Digital Ship Scandinavia", March 2005
[4] A. Franchi, A. Howell, J. Sengupta "Broadband Mobile Satellite: Inmarsat BGAN", HF Journal, 3/2000
[5] A. Franchi, J. Sengupta "Technology Trends and Market Drivers for Broadband Mobile via Satellite: Inmarsat BGAN", DSP 2001, October 2001, Sesimbra, Portugal
[6] T. Eagling, A. Franchi, T. Noerpel, H.K. Wong "Inmarsat project BGAN-R", DSP 2001, October 2001, Sesimbra, Portugal
[7] Frank August "Inmarsat Broadband Global Area Network", SSPI Update, 2004
[8] Douglas Watson "Inmarsat's Commitment to The Maritime Industry", Norwegian Maritime IT Forum, 2004
[9] http://countdown.inmarsat.com/solutions/land_sea_air.aspx , May 2005
[10] http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=11369, May 2005

Sažetak

INMARSAT - ŠIROKOPOJASNA GLOBALNA MREŽA

Dostupna preko Inmarsat I-4 satelitskog sustava, Inmarsat BGAN bit će prva globalna, visoko propusna mobilna mreža za prijenos podataka koja će omogućiti brzi i pouzdan pristup Internetu te korporativnim mrežama s brzinom čak do 492 kbps. Inmarsat BGAN ponudit će prijenos glasa, podataka i „streaming" te cijeli niz mogućnosti za buduće korisnike. Inmarsat BGAN, za komercijalnu uporabu planiran krajem 2005, prvenstveno će biti namijenjen za korisnike na kopnu, a zatim nakon 2007. za korisnike u pomorstvu i zrakoplovstvu.

Ključne riječi: Inmarsat BGAN, I-4 sateliti, multimedija

Pomorski fakultet u Rijeci
Rijeka, Studentska 2
Croatia