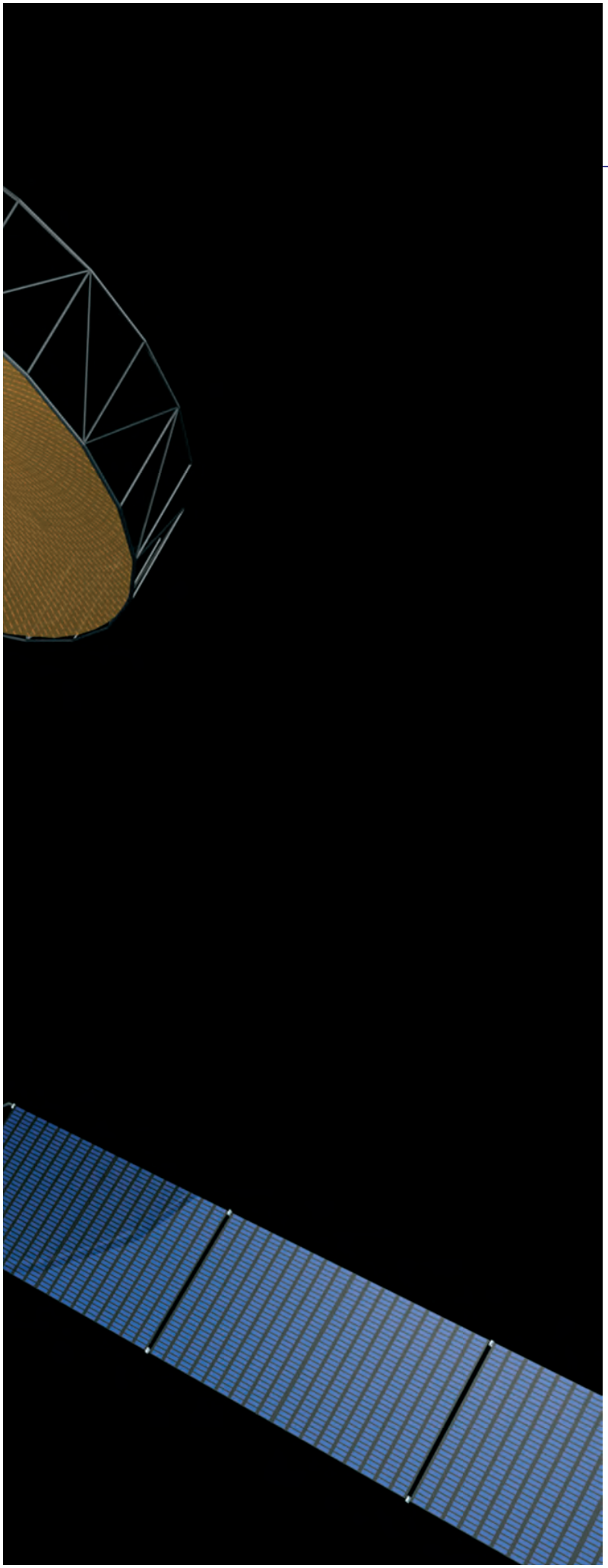
Artist's impression of an Inmarsat I-4 satellite in orbit

The BGAN Extension Programme



Juan J. Rivera
Telecommunications Department,
ESA Directorate of European Union and Industrial Programmes, ESTEC, Noordwijk, The Netherlands

Eyal Trachtman & Madhavendra Richharia
Advanced Systems Division, Inmarsat Ltd., London, UK

Mobile satellite telecommunications systems have undergone an enormous evolution in the last decades, with the interest in having advanced telecommunications services available on demand, anywhere and at any time, leading to incredible advances. The demand for broadband data is therefore rapidly gathering pace, but current solutions are finding it increasingly difficult to combine large bandwidth with ubiquitous coverage, reliability and portability. The BGAN (Broadband Global Area Network) system, designed to operate with the Inmarsat-4 satellites, provides breakthrough services that meet all of these requirements. It will enable broadband connection on the move, delivering all the key tools of the modern office.

Recognising the great impact that Inmarsat's BGAN system will have on the European satellite communications industry, and the benefits that it will bring to a wide range of European industries, in 2003 ESA initiated the 'BGAN Extension' project. Its primary goals are to provide the full range of BGAN services to truly mobile platforms, operating in aeronautical, vehicular and maritime environments, and to introduce a multicast service capability. The project is supported by the ARTES Programme which establishes a collaboration agreement between ESA, Inmarsat and a group of key industrial and academic institutions which includes EMS, Logica, Nera and the University of Surrey (UK).

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Introduction

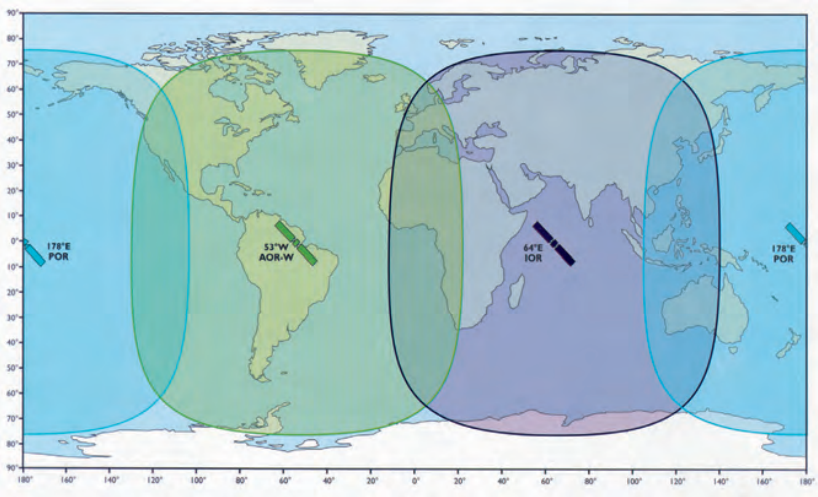
Since its creation in 1979, Inmarsat has been operating pioneering global mobile satellite communication systems. The company came into being as an intergovernmental organization to provide global safety and other communications for the maritime community. Starting with a customer base of 900 ships in the early 1980s, it grew rapidly to offer similar services to other users on land and in the air. It now supports links for phone, fax and data communications to more than 287 000 ships, vehicles, aircraft and other mobile users in every part of the World except the polar regions.

Inmarsat's current strategy is to pursue a range of new data-dissemination opportunities at the convergence of information technology, telecommunications and mobility, while continuing to serve the traditional maritime, aeronautical, land-mobile and remote-area markets. A cornerstone of this strategy is the new Inmarsat fourth generation satellite (I-4) constellation, which is expected to begin providing commercial services late in 2005. These satellites will form the backbone of Inmarsat's BGAN system.

BGAN is designed to provide a portfolio of packet-mode and circuit-mode-based services, offering speech telephony, ISDN calls and 'always-on' Internet/Intranet IP-based mobile data communications at up to 492 kbps for Internet access, mobile multimedia and many other advanced applications. Data rates and connection options provided to BGAN users are dependent on the design and class of user equipment, encompassing in its fully deployed configuration up to 12 different types of user terminals. The BGAN Mobile Satellite Service will share the scarce radio resources available in the L-band with a wide range of existing Inmarsat services, which are carried over 2nd and 3rd-generation satellites in addition to I-4s.

The agreement established between ESA and Inmarsat in 2003 on the 'BGAN Extension' Programme pursues the enhancement of the BGAN system and marks the first collaboration on system engineering activities between the two organizations. The Programme identifies two main areas of research and development:

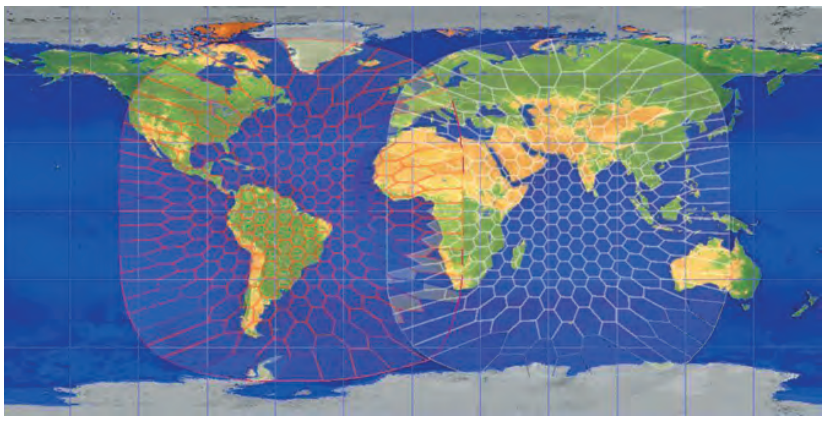
– The baseline system is optimised for static land-portable terminals. The 'BGAN Extension' Programme will extend the capabilities of the system to new directional as well as omni directional BGAN platforms and services for truly mobile maritime, aeronautical and land vehicular applications, extending the number of user-terminal classes from 3 to 12.
– The baseline system has been designed to support point-to-point tele-communica tions services. BGAN Extension also aims to diversify the service portfolio through the development of multicast service capabilities, i.e. point-to-multipoint or multipoint-to-multipoint communication services, thereby exploiting the natural strength of satellites for delivering multicast services at the global level.



Inmarsat BGAN coverage

The BGAN System

The Inmarsat BGAN system is intended to form part of the satellite component of the Third Generation (3G) IMT-2000/ Universal Mobile Telecommunications System (UMTS). It constitutes the first new Inmarsat service to be launched on its geostationary I-4 satellites and will be the first mobile satellite system to deliver broadband data and voice simultaneously through one device, to almost anywhere on the planet. After the launch of the first I-4



The spot-beam coverages of the first two I-4 satellites

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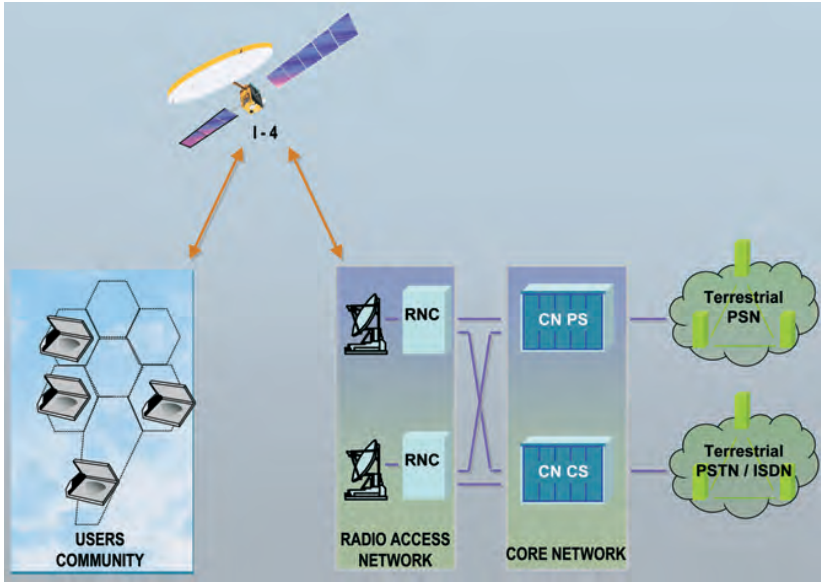


System overview

satellite, the service will initially be available across Europe, the Middle East, Africa and Asia late in 2005; it is expected to be launched in North and South America in the second quarter of 2006, after the launch of the second I-4 satellite. The future of the third satellite, which is required to provide full global coverage, will be decided after the launch and initial testing of the second satellite. The accompanying figure shows the BGAN service area after deployment of the first two satellites.

The BGAN user terminals provide a set of services that mirror those available with terrestrial UMTS. Based on IP technology, BGAN will deliver data rates of up to 492 kbps. At launch, the service will be accessible via three classes of satellite terminals: Class-1 a briefcase-like terminal, Class 2 a notebook-like terminal, or Class-3 a pocket-sized terminal. The Class-1 terminal is meant for the fixed office environment, whilst the Class-2 and -3 variants are intended to serve professional users who require packet- and circuit-switched services whilst on the move. The system architecture is shown in the accompanying figure.

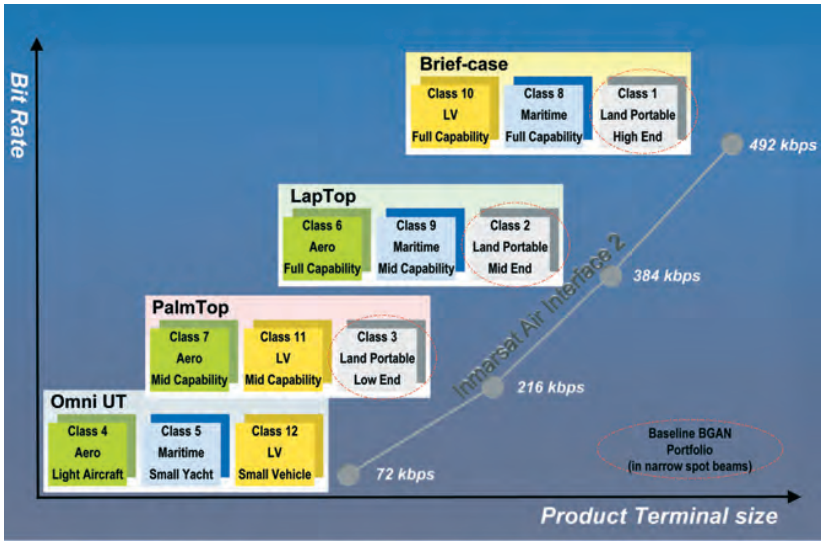
The BGAN Core Network is a suite of UMTS network nodes. It is aligned with a so-called 3GPP release-4 architecture, having separate packet- and circuit-switched domains. Media Gateway/MSC Server nodes (for user and control plane transmission, respectively) are provided for circuit-switched communication, including ISDN. GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN) services are provided for Internet Protocol (IP) packet-switched communications.

The Services

The 21st century office is increasingly dependent on the availability of high-speed communications. Mobility is an intrinsic part of working life for many people and expectations are now higher regarding what can be done whilst on the move. The demand for broadband data 'anytime, anywhere' is gathering pace, but current solutions don't always hit the mark in combining high bandwidth with ubiquitous coverage, reliability and portability. BGAN is the breakthrough system that can meet all of these requirements, by enabling broadband on the move, delivering all the key tools that the modern office needs.

In some locations, BGAN may be the user's only means of connectivity with the rest of the world, and so must be totally dependable. The 16-fold increase in network capacity that the new Inmarsat-4 satellites bring will ensure that, and customers will be able to choose from a range of robust mobile satellite terminals designed to cater for different application needs.

BGAN will support innovative packet-switched IP-based services as well as traditional circuit-switched voice telephony and ISDN data via SIM-card-associated telephone numbers. In addition, the voice service will include all the standard enhanced features offered by terrestrial fixed-line and mobile networks,



Long-term vision towards BGAN platform extensions

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The Inmarsat I-4 Satellites

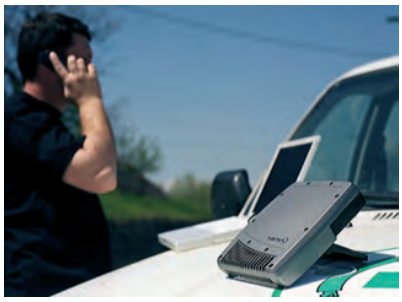
This new generation of super-satellites will usher in an era of vastly enhanced broadband mobile satellite services. Built by an international team of space engineers from the United Kingdom, France, Germany, the USA and Canada, the I-4's are the biggest and most powerful commercial communications spacecraft ever built. The body of the satellite approaches the size of a double-decker bus, its solar panels span an immense 45 m, and it has a 9 m antenna reflector that unfurls in orbit. The I-4's solar cells efficiently combine silicon technology with advanced gallium-arsenide cells. Its thrusters employ both chemical and plasma-ion technologies.

An Inmarsat I-4 satellite being made ready for testing at Astrium's factory in Toulouse, France

The I-4's can provide a 16-fold increase in the traffic-bearing capacity of the Inmarsat network, with each I-4 capable of generating hundreds of high-power spot beams. These beams can quickly be reconfigured and focused anywhere on the Earth to provide extra capacity where needed. Each satellite can generate 19 wide spot beams and more than 200 narrow spot beams, compared with the seven wide spot beams available on Inmarsat-3. It also illuminates the Earth with a single global beam, which provides an initial signalling link for all services.

EADS Astrium is the industrial prime contractor entrusted with building the three spacecraft, using its tried-and-trusted Eurostar spacecraft bus as the basis.

such as voice mail, caller ID, call forwarding, call waiting, conference calling and call barring. The Standard IP data service will offer variable rates up to 492 kbps, typically used for transferring files, accessing e-mail, the Internet or corporate network applications.



A BGAN terminal (courtesy of Nera)

The Streaming IP data service, available on selected BGAN terminals, will offer guaranteed bandwidth on demand, enabling live video applications like video conferencing or video streaming. On the other hand, non-real-time video can also be transmitted based on store-and-forward mechanism, thereby making efficient use of available capacity.

In making a voice call, users will have a choice between using wired and wireless connections, including standard fixed-line telephones and Bluetooth headsets or handsets, depending on the satellite terminal being used. The BGAN system will serve both native BGAN users and roaming customers, provided there is the necessary roaming agreement between their home network and Inmarsat.

Other available services include: short messaging services (SMS), multimedia messaging services (MMS), and UMTS location-based services offering maps, local travel information, etc. Other chargeable content and applications services may be built on top of these many BGAN telecommunications services using Industry-standard toolkits.

The Users

BGAN can greatly extend the boundaries of the 'broadband mobile office', which emerging 3G services have only just started to deliver. Its performance and versatility will appeal to a diverse range of industries with vastly different operational needs, but who all share a need for reliable mobile communications. Key customers for existing Inmarsat services who are expected to be core users of BGAN include:

- Media companies, who use mobile satellite services to file their reports from disaster-hit areas, war zones, sports events and remote regions. Here BGAN can offer high speed, portability and easy to use means of communication, which will enable journalists, broadcasters and photographers to respond even more rapidly and with greater flexibility.
- Governments and the military, who require time-critical communications with an exceptional level of reliability, availability and security. The significant increase in network capacity that the I-4 satellites bring will ensure that BGAN meets these requirements, whilst also offering a high-speed, flexible alternative for voice and data communications on the move.
- Aid agencies and Non-Governmental Organisations (NGOs), who typically create 'temporary offices' for small teams of aid workers in areas of desperate need, which must be quick to set up and dismantle. BGAN can offer small, lightweight terminals that are simple to use, either for basic voice and e-mail communications or life-saving video applications such as telemedicine.
- Oil and gas companies, who usually require mobile satellite services during the initial exploration phase, before a

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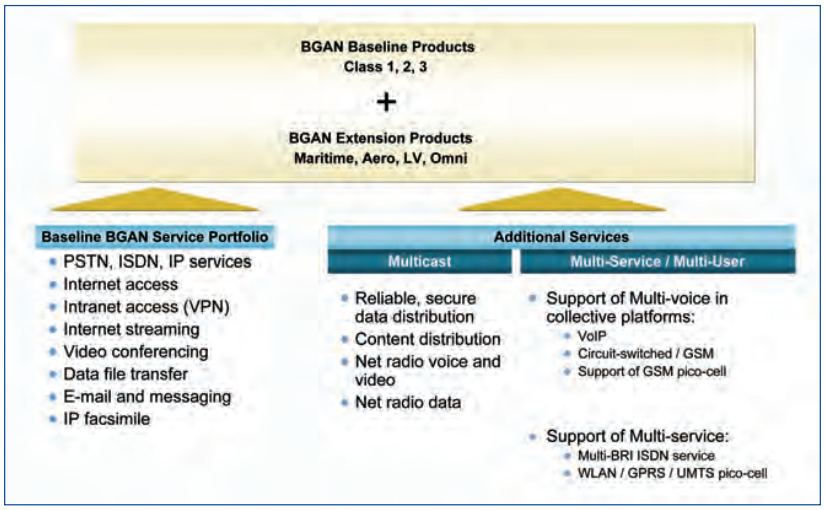

Scope of follow-on BGAN Extension activities

permanent extraction site is established. Exploration teams, together with those conducting oil-well and pipeline maintenance, will benefit from more portable BGAN terminals that are easier to use, with network coverage across most of the World's land mass.

- Construction companies, who need connectivity during 'rolling' construction projects involving pipelines, power lines, roads and railways, where the team is constantly on the move. Increased bandwidth will enable project teams to send more comprehensive progress reports that also include photographs and video.

The BGAN Extension Programme

Air-Interface and Platform Extension

The BGAN baseline system was optimized for a land-portable channel, which is relatively time-invariant while the truly mobile User Terminals have to operate under dynamically varying channel conditions depending on the specific environment. The baseline portfolio of BGAN terminals will therefore be complemented by three classes – Aeronautical, Maritime and Mobile Vehicular – embracing high-gain, intermediate-gain, and omni-directional terminals.

As these new classes of terminals will have to operate under very different dynamic conditions, careful investigation was required, which involved developing a set of representative propagation models from established databases and theory, and extensive computer simulations of typical environments of each mobile category. The modifications required on the aeronautical channel have proved especially challenging due to the frequency-selective fading that occurs. In addition, numerous changes were needed to the upper protocol layers for handover support, definition of new user terminal classes, management of new bearer types, user-terminal fade recovery mechanisms, management of initial acquisition of omni-terminals, etc.

The evolved specifications and solutions are currently being implemented by Inmarsat and its BGAN Extension programme partners, EMS Technologies and Nera, in the radio access network and the mobile satellite user terminals.

Multicast Service Extension

The BGAN baseline system has been designed to support point-to-point telecommunication services. The BGAN Extension aims to provide a multicast service capability, to exploit the inherent strength of satellites for delivering such services at the global level. Multicast has also been identified as a primary requirement for government and security operations in the field. The BGAN multicast service will support mobile operations in a more efficient manner and with much lower airtime cost for the end-user than today's unicast mode. It is also seen as an attractive proposition for the development of new applications and business opportunities for value-adding resellers.

The BGAN Multicast Service will support both real-time and non-real-time applications. It will be scalable and rely on IP-based standard protocols for interfacing to the end users and content providers, who can be connected to the BGAN System through the Internet. It will be capable of supporting reliable and secure multicast transport protocols ensuring quality of service for individual multicast flows.

The end user will also experience a high degree of flexibility, being able to receive multiple multicast flows simultaneously. Additional functionality provided to the service provider or network operator will enable them to authenticate the user's identity prior to authorising the reception of the multicast content, based on such criteria as membership status, geographical location, user status, mobile capabilities, and network resources.

Future Extensions

The scope of the work covered by the ARTES 'BGAN Extension' programme may be extended in the future to include other attractive features. For instance, the multi-service and multi-user detection capability can build on the complementary role of Mobile Satellite by seamlessly extending GSM, UMTS and WLAN services to users of terrestrial mobile networks when operating out of reach of cellular coverage.

The BGAN System can be extended with multi-service and multi-user support capabilities to provide a reliable means of communication for nomadic and mobile collective platforms like trains, planes or ships, by allowing seamless inter-working between the BGAN mobile satellite communication system and terrestrial wireless access technologies. The multi-user service enhancement will also allow the collective platform users to access the full range of BGAN services via the BGAN mobile terminal serving that platform.

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Despite the considerable spectrum-utilisation efficiency offered by the Inmarsat I-4 narrow-spot-beam technology, the growing demand for spectrum arising from ever-increasing multimedia applications may still outstrip the spectrum pool. Narrow-band multi-user detection (MUD) technology has emerged as a promising candidate to alleviate such a scenario, but is very demanding in terms of processing power. Inmarsat therefore intends to prototype an MUD unit in the framework of the BGAN Extension programme to demonstrate the improvements in spectrum utilisation efficiency. In addition to spectrum savings of up to 30% on the return link, the BGAN omni-directional prototype demonstrator may also pave the way for new technology central to the next generation of highly efficient, broadband, mobile user terminals.

Open Standard Approach

The BGAN Extension programme has adopted an open standard approach and intends to standardise the BGAN system and air interface as a satellite component of the UMTS. The range of BGAN design specifications are expected to produce significant inputs to various European and International standardisation bodies, which are involved with air-interface and signal-in-space definition, protocol optimisation for mobile satellite operation, and spectrum allocation and sharing recommendations.

Conclusion

Enabled by the state-of-art Inmarsat-4 satellites, BGAN will usher in the next generation of mobile satellite communications services, which will provide ubiquitous wideband access beyond the reach of the latest terrestrial telecommunications. As the initial services approach role-out by the end of 2005, the BGAN service portfolio is already being enhanced under the auspices of ESA's ARTES Programme. The BGAN extended capabilities provided by the new platforms to the aeronautical, maritime and land-mobile environments, together with the service extension to multicast, will be ready for service at the end of 2006 and early 2007. These new services aim to serve a wide range of user communi-ties, including governmental and non-governmental organizations, aid agencies, the military sector and private companies.

The BGAN Extension Programme therefore responds to the key strategic objective of ESA's Telecommunications Long-Term Plan by contributing to maintaining the competitiveness of both the European Industry and Satellite Operators, and ensuring Inmarsat and its partners a leading position in the global market.

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