JOURNAL ON

COMMUNICATIONS

VOLUME XLVIII JUNE-JULY 1997

SATELLITE COMMUNICATIONS '96

JOURNAL ON COMMUNICATIONS

A PUBLICATION OF THE SCIENTIFIC SOCIETY FOR TELECOMMUNICATIONS, HUNGARY

Editorial office
TypoTEX Ltd.
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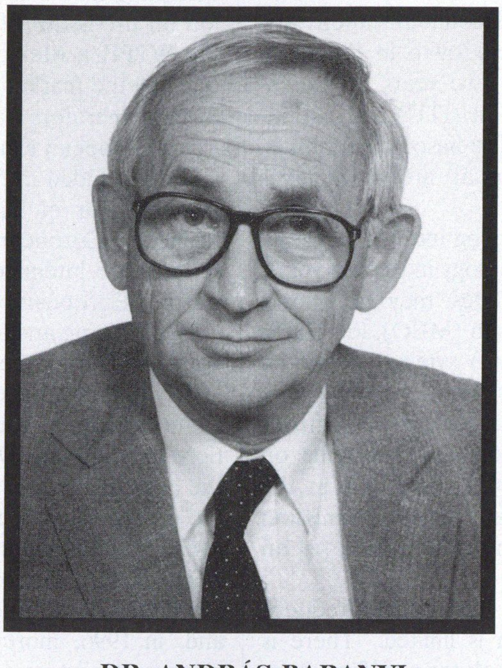
Monday–Friday 8–12 hours

Subscription rates
Hungarian subscribers
1 year, 12 issues 8100 HUF, single copies 700 HUF
Hungarian individual subscribers
1 year, 12 issues 1350 HUF, single copies 130 HUF
Foreign subscribers
12 issues 150 USD, 6 English issues 90 USD, single copies 24 USD
Transfer should be made to the Hungarian Foreign Trade Bank
Budapest, 10300002-20321411-00003285

JOURNAL ON COMMUNICATIONS is published monthly, alternately in English and Hungarian by TypoTEX Ltd. H-1024 Budapest, Retek u. 33-35. Phone/Fax: (361)316-3759. Publisher: Zsuzsa Votisky. Type-setting by TypoTEX Ltd. Printed by Dabasi Jegyzetnyomda. HU ISSN 0018-2028

FAREWELL TO OUR EDITOR-IN-CHIEF



DR. ANDRÁS BARANYI
1936 – 1997

Death is always startling, because it points to our own mortality. Much greater is the shock if a good friend, a colleague deserts us unexpectedly, catching us unprepared for the mourning, leaving unfinished the work we started together. This is how András Baranyi, our Editor-in-Chief left us with tragic suddenness. We had a talk, shortly before he passed away. As always, he was concerned about the Journal, which became under his leadership a forum to match high European standards; although it was kept strictly on a scientific level, it was still very readable, representing for the whole world Hungarian achievements in telecommunications, in the same time showing domestic readers he direction to which the world proceeds.

The Journal on Communications in its present form is his child, reflecting his spirit, shaped to the form he chose. He was the Journal's Editor-in-Chief from 1991 till his untimely death. Publishing of thematic issues, alternating Hungarian and English issues, inviting guest editors, introducing many more innovations made the Journal a recognized and respected publication. All of those were his ideas for the Journal, which meant so much to him on his course of life lined with personal tragedies and scientific successes, illnesses and decorations as well.

András Baranyi graduated in electrical engineering from the Technical University of Budapest in 1960 and received his Ph.D. from the Hungarian Academy of Sciences with his dissertation of "Problems of non-linear distortions". He spent 36 years at the Telecommunications Research Institute then he joined the Telecommunications Authority where he worked until his death. He achieved outstanding results in development of IF circuits of microwave radio relay systems, also in modeling and equalization of FM distortion. His main fields of research were the nonlinear circuit modeling and analysis, the problems of optical-microwave interactions. He was an Associate Professor at the Technical University of Budapest and he was a visiting professor in the US at the University of Maryland and at the University of California, Berkeley. He had written nearly a hundred publications on the results of his research, both in Hungarian and English languages. He was decorated with Order of Labour and Order of Eminent Inventor, he received the Virág-Pollák Prize, Tivadar Puskás Prize and the Gold Medal of the Hungarian Scientific Society for Telecommunications of which he was a member since 1961. He was a recipient of the Academy Prize from the Hungarian Academy of Sciences.

Sadly, we can no longer express our appreciation that we owe to him. He guarded and spread the professional intellectual values, served and popularized science with devotion and humbleness. He represented a good example of an engineer and researcher who was guided by the desire of the scientific cognition and the immense respect for science all through his life.

We keep his remembrance and achievements in our everyday life and will try to continue publishing the Journal following his directions, spirit and values. He devoted his work to the readers and we will follow in his footsteps.

Editorial Board of the Journal on Communications

EDITORIAL

Satellites are playing a more and more important role in the development of global telecommunications and universal services. The intense growth in the number of requests received in the last two years by the International Telecommunication Union (ITU) and the increase of investments into the satellite based communications (motivated by its market potential) are proving this growing importance.

Different new principles are emerging into the personal communications using satellite technology in the last years. Depending on the orbit of the satellites, they are known as geostationary (GSO), medium Earth (MEO), low Earth (LEO) or highly elliptic orbit (HEO) sytems, while the services they support may be either fixed or mobile type satellite services (FSS, MSS). The major service features of such systems are data transmission and messaging on less expensive small satellites (called Little LEOs in the case of low Earth systems), voice and data transmission on so-called Big LEOs, and wideband transmission (as an extension of the GII).

There is a strong competition for the possible frequencies because the available spectrum is limited. There is also a big challenge for the ITU to look for new frequency bands while ensuring the protection of existing (even non-satellite) services already in operation.

One of the results of the competition for markets and frequencies is the agreement concluded in October 1996 between Globalstar, Iridium, and Odyssey concerning the frequency use of their Big LEO systems on a global basis. It is believed this agreement will promote and simplify the regulatory procedures in the countries expected to be interested in the operation.

The agreement was signed two weeks before ITU's 1st World Telecom Policy Forum (WTPF) on the issue of the Global Mobile Personal Communications (GMPCS). The ITU has an important role in the co-ordination, licensing, and standardization procedures of global systems. Ongoing work in preparing the required amendments of the International Radio Regulations, in creating the technical standards and establishing the necessary procedures will help to implement GMPCS systems. The participants of the WTPF could exchange their opinion on the issues of policy and regulation. As a result of the WTPF, a Memorandum of Understanding (MoU) on opening the market for competition between domestic and foreign operators was completed in February 1997.

An European example for the competition is the agreement concluded in November 1996 between ORBCOMM (an operator of Little LEO system) and a consortium formed by European telco operators on the basis of which services are intended to be supplied in fourty Central and Eastern European countries (among them in Hungary).

Recognizing and appreciating the importance of satellite communications the Communication Authority, Hungary (HIF) organized the Conference of Up-to-Date Satellite Communications the fourth time already. The presentations of Mr. Hans Dodel (Daimler-Benz Aerospace) made the basis of the first such conference (organized by one of the predecessors of HIF, the Institute for Frequency Management, and held in 1993 as a result of firm organisatory work of Mr. Simon Istvn, surmounting all difficulties). Since then, the Conference is becoming increasingly noted, and, in 1996, more than 30 presentations were already given to the issues of satellite communications.

Selecting from those papers, we grouped them around four major issues in the present number of the Journal of Telecommunications. New developments in the satellite communications as well as regulatory questions are discussed in the overview. Further, mobile and fixed satellite telecommunications systems are presented. Finally the reader can get know the four Hungarian VSAT service providers.

With this special double number we intend to pay tribute to Dr. Baranyi András, former Chief Editor of the Journal of Telecommunications, the demise of whom took us as by sorrowful surprise. He was the first to have the idea to treat that topic.

I would like to express my thanks to Mr. Simon István being of great and essential assistance to me in preparing this special number.

I. BOZSÓKI

István Bozsóki is the Head of the Validation Group in the ITU-BR Space Services Department. He received his M.Sc.E.E. (1980) from the Technical University of Budapest. Sinc 1980 he has been working in the field of frequency management, specially in computerized frequency management. He was the Head of the Computer Services Department (since 1990), the Head of the International Relations Department (since 1993) and Director for Internationzal Organizations (since 1995) in the Communication Authority, Hungary. He participated in the work of several ITU-R and CEPT-ERC working groups. In November 1996 he was appointed to the chairman of the TWG-HCM of the Vienna Agreement. He is member of HTE and IEEE.

THE SATELLITE COMMUNICATIONS SCENARIO

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A wealth of new applications is bursting in the different satellite applications encopassing navigation and data transmission, personal communications, seamless digital high fidelity broadcasting to the mobile user, interactive television to the home, and general data services. At the same time, a host of new launch opportunities avails itself. This editorial surveys these current developments, tries to evalute and judge these novel evolutions of space technology. Some of these developments will be viewed at critically, and, finally, a look through the window of time ventured.

1. NAVIGATION WITH LEOs AND MEOs

The spacecraft logged as the world's first communications satellite actually was a broadcast satellite: Sputnik commenced operations on Oct. 4th, 1957 by transmitting the Communist International until its batteries were empty. This occured after only a few weeks, but during this precious time the students and staff at the Johns Hopkins University in Baltimore (USA) frantically worked to determine the secretive orbit data. They measured the Doppler of the signal from three geographically dispersed points and triangulated the satellite.

They then concluded that, if it is possible to determine an unknown orbit with the Dopplers from three locations, it should also be possible to determine a point on earth with the Dopplers of three satellites in known orbits. The Low Earth Orbiting (LEO) Transits were built by J. Hopkins and successfully sold to the United States Navy. The first satellite positioning system was born, long before the first communications satellite. So close are communications, navigation and broadcasting.

The American TRANSIT system catapulted the navigation on the high seas from the astro navigation right into the twentieth century, providing all weather positioning to a few hundred meters, worldwide. A few years later the Soviet Navy copied the system and called it Tsikada.

Then the United States Air-Force demanded far higher accuracies; to this end, atomic clocks were put on-board the NAVTAR satellites and signals installed carrying the precise time and the associated coordinates of the satellite. The user terminal determines the travel times of at least three signals, multiplies them with the speed of light, gets the distances to the satellites, and triangulates its position to within 1 meter for the military and to within 10 meters for non-military users.

A few years later the Soviet Air-Force copied this sytem of medium altitute earth orbiting (MEO) satellites and called it GLONASS. Then the US military changed NAVASTAR to withold accuracy to non-military users to some 100 metrs. And this is, where we stand today, trying to figure out, what the next generation Global Navigation Satellite System (GNSS2) should look like.

It will certainly have to provide the 1 meter accuracy to non-military users, which will only be achievable with suitable frequencies of operation, out of the ionosphere and duly coordinated with the International Telecommunications Union (ITU), optimum orbits, and suitable modulation techniques. The atomic clocks may or may not be mounted in the space segment; instead, signals could be uplinked, pre-emphasized so that they downlink as though they had been generated onboard. And the system should provide the necessary messaging services complementing the locationing for tracking and tracing: position reports and vehicle status data can be sent to fleet management bases and traffic control centers, and operational orders can be relayed back to the vehicle.

Most importantly, it will have to be run by a civil international operator, and under no circumstances should the 2nd generation navigation system GNSS2 again bypass Europe and European interests. The European Union fosters a GNSS2 system which is to produce these new qualities in positioning accuracy, service continuity and system integrity, two-way messaging and value added auxilliary services, and satisfying the fundamental institutional prerequisite.

2. LOW BIT RATE DATA SERVICES WITH LITTLE LEOs

For the operationally efficient and cost affordable transmission of all kinds of position and vehicle status data, environmental data, government records, business, commercial, and personal data, today Little LEOs are an available and efficient means increasingly resorted to.

They operate at 0.2 to 0.4 GHz and they generally store the data received from the ground and forward them when overflying the call destination. In that respect, Little LEOs — including AMSATs — are technologically more advanced than most commercial communications satellites which, in the past, did not employ on-board processing. Although the first Little LEO was launched (by the USA) in 1961, this species today has reached a relevance of considerable dimension. There are several operational systems: In Russia the GONETS and in the USA the ORBCOM. The SAFIR(D) and TEMISAT(I) were competing with ORBCOM for a while but have since joined ORBCOM so that the USA again are the global player in this race.

3. PERSONAL COMMUNICATIONS WITH BIG LEOs

In the focus of our information age there is the challenge of the personal communications service (PCS) for the individual human being. People have their personal identification number (PIN) wherever they go, worldwide, as opposed to a telephone number attached to a stationary piece of grey or black plastic. This philisophy started with the Global System for Mobile communications (GSM) and leads to the exciting proliferation of personal communications systems on the basis of the so-called Big LEOs, built to relay digitized voice and low bit rate data incl. facsimile. These systems, operating in the 1.5 to 2.3 GHz bands, are slated to commence operations in 1998 to inaugurate the new era of the mobile personal communications for the roaming user.

The LEOSs' claim to fame is the virtual absence of signal time delay, compared to the 250 ms to and from the Geostationary Earth Orbit (GEO). The backside of the coin is: LEOs need a group of satellites where a single GEO can do the job. Sorted by number of spacecraft in the constellation, there are the following LEO systems: ICO-GC (Intermediate Circular Orbits – Global Communications), a system of but 10 spacecraft flying at 10,000 km altitude, almost identical to the 10 satellite constellation of ODYSSEY. Starting in the year 2000 time frame, ICO will offer voice services as well as messaging and data transmission up to 64 kbit/s, on a worldwide basis.

The Globalstar system employs 48 satellites — flying at an altitude of 14 km — for the same services (plus a position determination component); begin of service is scheduled for 1998. Next to Courier, Globalstar is the most European system with more than 70 % of its space segment being manufactured and the spacecraft being assembled, integrated and tested in Europe.

The Courier system of Big LEOs, registered in Germany, is to consist of 64 satellites flying in circular orbits of 700 km altitude and offering the same services in the same frequency band as Globalstar and Odyssey. Sharing the frequency band between the three systems is accomplished by code division multiple access (CDMA). Gateway earth stations handle the different codes and switch the calls from and to the terrestrial public switched telephone networks.

The Iridium system, by comparison, resorts to time division multiple access (TDMA), operating in the immediatelly adjacent frequency band. It uses 66 satellites in circular orbits 790 km above the earth. The handy transmits at one instant and receives at the next, on the same radio frequency — as opposed to using separate transmit and receive frequencies, as do all other LEOs. The call switching is performed onboard the Iridium satellites; call destinations extending outside the local cell are being relayed from one satellite to the next by inter-satellite-links — if need be, halfway around the globe. In the Iridium system, links directly from handy to handy are possible, while in all other systems gateway stations need to be available in the ground cell to amplify and relay the signals back via satellite to the other handy.

Covering the entire globe, LEO systems bear the greatest of potentials for all countries which lack adequate terrestrial telephony infrastructure and are not able to build up a (generally sternly expensive) infrastructure for reasons of lacking economy. And their economy is lacking, in turn, because no communications avail themselves. By comparison, in the developed countries which in the last five years have deployed one or more GSM systems, the market place for satellite handies will be limited, while only a few years ago, there would have been fabulous synergy in the marriage of terrestrial and LEO systems: install cellular systems in urban areas where the traffic density warrants them and advantageously employ satellite in the wide rural extentions.

Today, after the nationwide deployment of GSM, some countries who have authorized GSM are refusing landing rights to Iridium and Globalstar because they feel an obligation to the business economy of these terrestrial networks (he who comes late will be punished by life-history).

All Big LEOs (except for paper systems) have been initiated and will be operated by the USA.

4. BUSINESS COMMUNICATIONS USING MEGA LEOs

In the extrapolation of the Little LEOs via the Big LEOs there are Mega LEO systems proposed:

- the Motorola's M-Star system with 72 spacecraft operating in the 40 and 50 GHz domain,
- the Teledesic network of 840 spacecraft flying at 700 km altitude using the 20 and 30 GHz frequency band (presently allocated to fixed satellite services),
- the SATIVoD of Alcatel, some 64 odd Mega LEO satellites flying at 1450 km inclined by 55° and operating at 28 GHz (feeder links) and 12/14 GHz (user links); user terminals have 40 cm dishes to receive 2 Mbit/s and to transmit up to 60 Mbit/s.

These systems serve fixed users: the computers of this world which they internet via satellite. Mega LEOs exchange data, operating at bit rates of up to 1.5 Gbit/s to the user. In addition, Teledesic caters to the business world, offering interactive multimedia conference communications. The frequencies of operations are in the Ka-band up to 50 GHz. The field trials with the US Advanced Communications Technology Satellite (ACTS) have demonstrated the vast utility of this band.

Analogous to direct video broadcast satellites delivering their products Direct to Home (DtH), Mega LEOs bring professional telecommunications Direct to Office (DtO). Businesses, government offices, educational institutions etc. are customers of these broadband "worldwide webs without wait", as well as the private user sector. Actually, it was the users' pressure demanding data links beyond voice channel bit rates, on a worldwide basis, and the national PTTs not adequately responding to this customer demand, that led to the advent of Mega LEO systems.

And these over 1000 Mega LEO satellites to carry huge potentials for the developing countries where generally half the population lives in the capital and outside the capital there are no opportunities because there are no communications. Nobody will put in a glass fiber cable to Timbuktu (anytime soon) but Mega LEOs will deliver 1.5 Gbit/s of traffic to Timbuktu too. The economics of Mega LEOs pick up where fiber drops off because intensity of usage drops off or the capital investment for fiber simply does not avail itself.

5. DIGITAL AUDIO BROADCAST WITH HEOs

A sector of increasing interest is the emerging Digital Audio Broadcast via Satellite (DAB-S) of entertainment, news and events, traffic information, business, cultural affairs, emergency & rescue messages, educational programs, program associated data (PAD) and high-rate data services, to fixed and mobile subscribers. While a wealth of these service categories will likely be free of charge, some custom type applications might be "conditional access", i.e., Pay Audio.

One possible implementation are quasi-stationary spacecraft in Highly Elliptical Orbits (HEO) — such as "mediaStar" — to provide cost effective transmission for the dissemination of innovative services in the top three economic regions of this globe, located at high latitudes, i.e., Europe, North America, and East Asia.

The multimedia programming distributed by satellite is complementary to and compatible with terrestrial DAB-T: the consumer uses the same radio fro both satellite and terrestrial; both DAB-S and DAB-T adhere to the EUREKA-147 Standard. Large coverages are achieved by DAB-S, providing seamless reception on the road, also in areas of low population density. DAB is the information highway to the up-to-date person on the move. It provides novel qualities of life for the consumer — and new opportunities for the advertisers.

6. TV AND BROADBAND SERVICES FROM STRATOSPHERIC PLATFORMS

Dating as far back as the first satellites, TV services have been provided regionally by high flying platforms — generally manned aircraft and balloons — in the USA and other selected regions of the world. Both aircraft as well as balloons consume fuel to keep their designated station.

In 1995, high flying balloons have been proposed by the US as a viable alternative to earth orbiting satellites. 250 of these Zeppelins are to fly at 50,000 meter altitude, covering zones of 1500 km in diameter beneath them. Using 48 & 47 GHz as up- and down-link frequencies and on-board processing of the signals, these platforms would serve as INTERNET/WWW access and for video conferencing and general data transmission into both stationary terminals as well as handies.

7. INTERACTIVE DIGITAL VIDEO BROADCAST FROM GEO

Digital Video Broadcast (DVB) flurishes in the US and in EU (HotBird, ASTRA) in GEO, bringing TV "direct to home" (DtH). In Europe today, Pay-TV is secondary compared to advertising paid television, whereas in the US there is a lrger share of pay-TV and pay-per-view. Over the last couple of years a number of satellite operators have established themselves:

System Name	Number of TV Programs	Begin of Service	System Cost
DirecTV/USSB	150	1994	5.5 billion US$
EchoStar/TCI	150	1996	
AlphaStar	150		
PrimeStar	150		
MCI/News	150		

In Europe, the Luxembourg operator SES has implemented 104 transponders on six co-located spacecrafts transmitting from 19.2° East longitude, and EUTELSAT's HotBird$^+$ is congregating, at 13.0° East, also in excess of one hundred transponders on a cluster of satellites. The beauty of this is that the orbital locations are so close that the DtH terminal can receive both satellites with one dual feed antenna, for a total of 208 transponders. At the same time, signals are in the process of being converted from analog to digital to allow the compression of the information so that, using the powerful MPEG algorithms, alternatively five to ten (up to 20) standard programs or two high definition (HDTV) programs can be transmitted — from GEO — in lieu of one analog program.

8. DIGITAL AUDIO BROADCAST FROM GEO

Alternatively to HEO, DAB services are broadcast from GEO. SES transmits ASTRA Digital Radio (ADR), the German Telekom sends the Digital Satellite Radio (DSR) vida KOPERNIKUS, and EUTELSAT will broadcast SARA digital audio. These Ku-broadcasts (11/14 GHz) are received with small dish antennas — limited to home reception — or directive planar antennas on mobiles.

WorldSpace — in a year or so — will provide digital radio from GEO directly into portable receivers. Employing three powerful GEOs, World Space policy is to reduce the cost of the L-band handy (1.5 GHz) to an affordable minimum for the users in the Caribean, in Africa and in Sout East Asia.

9. BUSINESS COMMUNICATIONS USING MEGA GEOs

The vantage pooint of GEOs is not limited to low rate messaging services but applies even more so to the transmission of voluminous data. Mega GEOs (after ACTS) will provide multi-media information relays. They are the next generation data systems, after the narrowband Ku-VSATs of today. The 20/30 GHz links will be operated into pizza size dishes operated by commercial and private owners, with a proliferation orders of magnitude in excess of today's VSATs.

Interactive broadcast systems are an integral part of the next generation direct broadcast providing the communications between the system and the user to let him demand videos, do home-shopping, homebanking, home-everything. Several companies have announced plans for these geostationary Ka-band (20/30 GHz) satellites, and most of these GEOs are already filed with the ITU:

- SpaceWay of Hughes'Galaxy, 20 spacecrafts to complement and extend the existing Hughes global network with broadband services (up to 6 Mbit/s, 70 cm dishes);
- GE*STAR of GE Americom, 9 spacecrafts for video enhanced telephony and data transmissions to and from 66 cm dishes (GE*Americom is the world's largest telecommunications operator, before INTELSAT and Hughes/PanAmSat);
- VoiceSpace of AT&T, 12 spacecrafts primarily for telephony and picture phone type applications; 32 kbit/s to 1.5 Mbit/s to the user; 3.2 billion US$ estimated system cost;

- CyberStar of Loral, a cluster of 3 satellites (1.1 billion US$) to relay voluminous interactive multimedia data, video telephony, enhanced videoconferences, medical & technical teleimaging. CAD/CAM, and supporting VSAT networks in the Americas, in Europe, and in Asia;
- ASTROLINK of Lockheed-Martin for high speed applications with 9 spacecrafts (3.8 billion US$), catering to medial imagery, remote expertice, distance teaching and business television;
- ECHOSTAR of Echostar Satellite Inc., two spacecrafts for 340 million US$;
- PanAmSat-Ka-band, complementing C-band (4/6 GHz) and Ku-band with 9 satellites;
- Morning Star of Morning Star Corporation, four satellites in a one billion US$ program;
- ORION-Ka-band, 8 spacecrafts, 1.5 billion US$, 2 Mbit/s into 1.8 meter dishes;
- KaStar of KaStar Comms Corp., two spacecrafts for 605 million US$;
- New Millenium of MOTOROLA/COMM Inc., the high speed geostationary (4 satellites) component complementing IRIDIUM, at a cost of 2.3 billionUS$;
- NetSat of Netsat 28 Corp., a 250 million US$ Ka-band program;
- MedSat of AeroSpatiale, France, is to serve the Mediterranean region with wideband data;
- EuroSkyWay of Alenia Spazio, Italy, a Ka-band geostationary spacecraft (Italy started Ka-band satellite transmissions in the early 1970ies);
- the geostationary component of the SATIVoD of Alcatel (64 LEOs) operating at 28 Gz (feeder links) and 12/14 GHz (user links), consisting of
- the Euro African Satellite Telecommunications (EAST) satellites of Matra, a geostationary space segment for regional fixed and mobile telephony and multi-media 250 Mbit/s services;
- the Wideband European Satellite Technology (WEST) satellites of Matra, the pendant to EAST, employing LASER Inter Satellite Links to nine spacecrafts orbiting in ICO;
- Return Path of SES/ASTRA, the GEO back channel from the user to the system, to carry programming orders ("video on demand"), home shopping orders, home banking orders, opinion polls, interactive television programs, and games — 20 satellite positions worldwide.

These Mega GEOs amounts to over 100 spacecrafts of large dimensions, considerable prime power and extended life span. What a challenge for the ITU to frequency coordinate them all.

10. PERSONAL COMMUNICATIONS SERVICES WITH BIG GEOs

Similar to DAB resorting to GEO for a cost optimum satellite constellation, SatPhone, ACeS (LM), APMT (Hughes) and future INMARSATs will provide personal communications services (PCS) via GEO satellites. One single SatPhone spacecraft covers the Arabic speaking world from Morocco to Afghanistan. One ACeS covers Indonesia, Thailand and China, etc. Since 75 % of the surface of the earth is water, LEOs are idle in 75 % of the time. GEOs can be effectively operated — with the minimum number of spacecraft — to concentrate on the populated land masses.

11. LOW BIT RATE DATA SERVICES WITH LITTLE GEOs

This philosopohy leads to data dedicated systems in GEO — without locationing — such as the worldwide Mobile Data Communicatitons (MDC) and other US systems. They cater to

- Point-of-Sales Transactions
- Tracing of Containers
- Meter Readings (electric, water, and gas)
- Catastrophy Services
- Remote Sensing Data Collections from in situ Sensors
- Credit Card Verification
- Vehicles'Position Reporting
- Emergency Communications
- Special Application

They share the necessity of being extremely economical: two GEOs covering 98 % of the inhabited earth lead to a better business plan than hundreds of LEOs. In addition to MDC type systems most of the conventional GEOs s.a. Intelsat, Intersputnik, Eutelsat etc. offer small messaging services. While in the past, these intergovernmental "authorities" have not always been overly agressive in the market place, there will be offsprings like the New Intelsat, the New Intersputnik, the New Inmarsat etc., free to approach commercial enterprises and even private customers, so that a new, tremendeous potential might be expected, being offered in GEO. Aside from the 4000 equivalent 40 MHz Ku-transponders (1996) and the new 2000 Ka-transponders, there will be 6000 additional Ku-transponders in GEO by year 2000.

In 1996, operations of geostationary telecommunications satellites led to earnings of 6.3 billion US$ worldwide; more than 2 billion US$ were earned by the seven US operators alone. And this market is still growing at a rate in excess of 10 % p.a. There are 153 commercial communications satellites in GEO today, with 63 flight models on order, all of which will have to be operated and their telecommunications services provisioned.

And in the industrial world with all its telecommunications infrastructure, GEOs have been playing an essential role in catastrophy communications, relaying messages when the terrestrial infrastructure is out of order as a result of storms of all species, floods, earth quakes and vulcano erruptions, land slides, avalanches or fires. Since our globe is experiencing an ever increasing number of natural catastrophies — the number of catastrophies and human casualties is escalating by a factor of 2.5 every ten years — this attribute is of substantial priority.

12. NAVIGATION AND OPERATIONAL MESSAGING FROM GEO

Similar to PCS going GEO, navigation is increasingly provided by geostationary space segments. The only income earning positioning systems today are all GEO: EUTELTRACS, OMNITRACS, STARFIX et al. offer locationing with increasing accuracies. EGNOS, WAAS and

MTSAT help medium altitude earth orbiting satellites improve their insufficient accuracy by providing augmentation signals from GEO. GEOs may conceivably be augmented regionally by Inclined Geo-Synchroneous Orbiting (IGSO) spacecraft (geostationary orbits inclined to the equatorial plane).

13. LAUNCHER OPPORTUNITIES AND RETRIEVAL OPTIONS

Wernher von Braun once said, the most crucial element in the space business is the availability of cost effective launchers. The multitude of space applications alluded to in the preceeding requires a new generation of launchers to make it into orbit. Since the end of the cold war, a large number of rockets have become available to commercial exploitation, and a number of East/Western joint ventures have been established to market these rockets. With no disrespect to existing launchers, the following table depicts some of them. Note the sea launch from a rig (built by Kvaerner of Norway), towed to the equator for increased launch efficiency into GEO (first launch scheduled for June, 1998, with Hughes' first HS-702 communications satellite GALAXY-11).

In addition to the launchers shown, rockets are being carried to 7000 – 10 000 meters by aircraft and then released. In the PEGASUS launch, up to 400 kg satellites are being carried by B52 aircraft to 7000 m and then dropped like air-to-ground missiles, with no vertical thrust. They then spend about half their fuel to establish vertical altitude.

Consortium	Rocket	$Payload_{LEO}$	$Cost_{LEO}$	$Payload_{GTO}$
ASA-Polyot[1]	Kosmos	0.6 to 1.5 t	8 – 18 Mio $	–
DASA-Krunichev	Rockot	up to 1.6 to	11 Mio $	ca. 0.7 t
Rockwell-Yuzhnoye[2]	Cyuclone	up to 3.6 t	25 Mio $	ca. 1.7 t
Aerospatiale-Starsem[3]	Soyus	up to 7.5 t	35 Mio $	ca. 3.5 t
Boeing-Yuzhnoye[4]	Zenit-2	up to 13.8 t	[5]	$\leq$ 6.9 t
	Zenit-3	–	[5]	$\leq$ 4.5 t
Lockheed-Martin-Krunichev[6]	Proton-K	up to 20.0 t	[5]	5.5 t
	Proton-TM	up to 22.3 to	[5]	$\leq$ 10 t

* *Payload*$_{LEO}$ is the payload mass delivered into LEO, *Payload*$_{GTO}$ is the payload mass into the Geostationary Transfer Orbit (GTO), from where the satellites reach GEO with their own apogy kick motor

1 ASA = Assured Space Access Inc., Arlington, Virginia, USA; P.O.Polyot, Omsk, Russia

2 Yuzhnoye, Dnipropetrovsk, Ukraine; proven launcher reliability of the Cyclone of 97 %

3 35 % Aerospatiale, 15 % Arianespace, 25 % Russian Space Agency, 25 % Samara State Research and Production

4 40 % Boeing Commercial Space Co., 20 % Kvaerner, Oslo, 25 % RSC-Energia, 15 % Zuyhnoye, Dnipropetrovsk, Ukraine; uses Zenit with Block DM as upper stage; Sea Launch from ship

5 market price (probably below Western niveau)

6 International Launch Services ILS, Lockheed-Martin, Krunichev, RSC-Energia

In Russia, launchers are mounted on top of the ANTONOV 225 aircraft, with stand-offs separating the missile sufficiently so that it can be ignited while still on the aircraft. The carrier then inclines up to 40° at the time of release so that the missile — of up to 275 tons — has sufficient vertical thrust to reach the desired orbit efficiently. Up to 18 t can be delivered into LEO, i.e., e.g., 48 satellites of some 400 kg each. Thus, the existing launchers in Europe, the US, China and Japan will continue to be suited well for injections into inclined orbits, the sea launch from the equator is advantageous for transports into GEO, and the air launches seem fit to shoot into LEO as well as into GEO.

The only missing link today is to bring them back, the retrieve of satellites after their useful live. Leaving them up there ad infinitum will eventually glut the useful space.

14. SUMMARY

Position determination is of paramount relevance to the European economy, and the combination of positioning and messaging in the sense of telematics will provide dramatic opportunities, the essential mobility and a series of synergetic spin-offs. Judiciously combined with vehicle observation, it very effectively can lead to conglomerate communications, navigation, and surveillance.

For the relaying of data, low eart orbiting (LEO) satellite systems are entering the market place for point-of-sales transactions, credit card verification, container tracing, vehicle position reporting, meter Readings (electric, water, and gas), emergency and catastrophy communications, remote sensing data collections from in situ sensors, and a wealth of novel and special applications.

Big LEO constellations of tens of satellites (Odyssey, ICO), and up to hundreds of spacecrafts (Iridium, Courier) have been announced. They will cater to global voice, data, fax, & paging, with the consumer demand for personal communications services being the motor of this development.

Mega LEOs serve high speed data to internet the personal computers of this world. The users' pressure demanding data links beyond voice channel bit rates, on a worldwide basis, and the national PTTs not adequately responding to this customer demand, led to the advent of Mega LEO systems, delivering Gigabits per second to the customer's home or direct to office.

Digital Audio Broadcast (DAB) has been proposed from HEO, with, e.g., a school of six satellites, three quasi-stationary positions can be established, serving the industrialized world in Europe, North America, and East Asia. Directive receive antennas tracking the satellites would be used.

Even geostationary balloons have been proposed to provide worldwide web access, video conferencing and data services, operating at extremely high frequencies just short of the second stop band at 60 GHz. Where the service has to compete with fiber quality, the stratospheric platform picks up.

By comparison, Direct Video Broadcast (DVB) has been firmly established in the geostationary earth orbit, not only in Europe and the Americas, but on a wordwide basis, in India, Asia etc., and similarly, DAB has been in GEO for more than ten years and several systems are operational today, and others have been announced, receivable with portable radios.

So, concurrent with the proliferation of low and lowest earth orbiting systems, there is a remarkable renaissance of the geostationary earth orbit (GEO) for Personal Communications Services (PCS), and — in fact — both little and big bit-rate services haved repatriated to GEO.

For high speed digital services at Mega bit rates, some 100 additional GEO spacecrafts have been announced to commence services shortly, operating at Ka-band; most all of these satellites systems are under US control and most of them on a global basis, serving all nations on this earth.

GEOs delivering Big Services (i.e., voice and date) as well as Little Services (data only) exist and will multiply; GEO comsats have been and will remain to be the workhorse of space.

US filings for Mega bit rate LEOs and GEOs add up to 1000 spacecraft at a cost of 34 billion US$.

Positioning systems have penetrated GEO — all of the present systems earning income are GEOs — and future navsats will likely be GEO/IGSO, requiring fewer satellites regionally. GEOs — possibly aided by inclined geosynchroneous orbits (IGSO) — allow new architectures readily confinable to regional coverages, so not to upset the US with intolerable accuracies and service integrities. The next generation positioning system will open up new dimensions in navigation and, at the same time, point the direction of Europe's role in the future.

And the launchers are ready to get the payloads into orbit, from land pads, from seagoing bases and from airborne carriers: Six new consortia have been incorporated to enrich the launcher market. The only element missing today is the capability to bring the spacecraft back to earth after their useful life. If we do not start soon to retrieve our satellites (particularly the hundreds of LEOs) they soon will start to obstruct each other's fields of view or worse.

In this digital era, services will merge, and there will be intelligent global networks. And in the not too distant future, totally, new products will come about: at home we will have one flat screen on the wall for our personal home station which includes the PC, the TV, the telephone, the fax, etc. On the move, we will have our hand-held personal communicator, which is a telephone, a note-book, a radio and television set, a navigator and a digital assistant. This multimedia handy will let us place telephone calls from any point on the surface of the earth, at any time, and provide us with any type of data, including entertainment, as we desire. And if the price erosion in consumer electronics continues for a while longer, these equipments and services could certainly become affordable to many of us.

The ITU has accepted the challenge of more than one thousand Ka-band filings and is responding with the most up-to-date computer aided semiautomated registration of satellites and frequencies via INTERNET. This process has been presented and field demonstrated at the 4th Budapesti Symposium on Up-to-Date Satellite Communications.

This state of the art in telecommunications has come about through consumer pressure, not only through regulatory wisdom. Europe has not exactly been the driving force and motor of these essential developments so relevant to Europe's economy. It seems to be up to industry to act and take the lead — if need be, without government subsidies. Few, if any, of the US systems conquering the globe are government supported.

Today, not the beauty of technology is what counts but the economics of technology employed to progress civilization — and affordable technology in telecommunications is here today.

Hans Dodel was educated at the Technical University of Stuttgart, the University of Kansas and the George Washington University. From 1969 through 1977 he was with the Communications Satellite Corporation (COMSAT) in Washington, where he was engaged in INTELSAT System Design and Utilization, AEROSAT System Feasibility, SBS System Definition and MARISAT System Implementation. From 1978 through 1981 he served as Communications Program Manager in the German Air and Space Administration DFVLR, and from 1981 through 1984 as Manager of the DFVLR Systems Engineering Department, responsible for satellite business systems development and field trials. In 1984 he joined MBB-ERNO Space Division as Director of the Advanced Telecommunications Satellite Systems Department. Since 1990 he is Chief Engineer with the Daimler-Benz Aerospace (DASA) Communications Satellites Division working in telecommunications operations and services.

PROCEDURAL ASPECTS OF SATELLITE NETWORK COORDINATION

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The article summarizes the international regulatory procedures which have to be followed for implementing a satellite network or a stastion of it. It describes the relevant provisions and prescriptions of the Radio Regulations in case of the advanced publication, the coordination and the notification.

1. REGULATIONS APPLYING TO THE USE OF FREQUENCIES AND ORBITS BY SATELLITE NETWORKS

The Radio Regulations provide an international regulatory framework for the orbit/frequency management of space radiocommunication services. These procedures serve to enable the ITU Member States to meet their requirements in terms of the orbit/spectrum resources, ensuring on one hand the equitable access and on the other hand efficient use of these limited resources. Fig. 1 indicates the relevant parts of the Radio Regulations applicable to the space services.

The provisions of the Radio Regulations concerning space services can be divided into two groups, as follows:

- those covering frequency bands where a Plan has been established, the so-called *planned bands and services*,
- those where the use of the band *is not planned a priori* and coordination of the use of satellite networks is required prior to bringing them into use, in order to ensure equitable access and efficient use of the spectrum and the GSO.

This paper deals with some of the major regulatory aspects with respect to non-planned bands.

2. PROCEDURES APPLYING TO NON-PLANNED BANDS

The vast majority of existing and planned space systems are not covered by the specialized regulatory provisions of Appendices 30, 30A and 30B. They are covered by the procedures of Articles 11 and 13 of the Radio Regulations or by other very similar procedures developed for particular cases. The relevant provisions involve three basic steps:

- advance publication (Section I of Article 11),
- coordination (Section II of Article 11),
- notification (Article 13).

There are four similar specialized procedures in addition to those of Articles 11 and 13, namely those contained in:

- Resolution 46 for operation in a number of bands allocated to the mobile-satellite service and to feeder links to stations in the non-geostationary satellite networks in the mobile-satellite services;
- Resolution 33 for the broadcasting-satellite service operating in bands that are not planned;
- Article 14 in cases where a footnote to the Table of Frequency Allocations requires an agreement with other administrations;
- Article 7 of Appendix 30 for the coordination of the FSS and the BSS in the 11.7–12.7 GHz band.

2.1. Advance publication procedure

The aim of the advance publication procedure prescribed under Section I of Article 11 of the Radio Regulations is to inform all administrations of any planned satellite system using a geostationary or a non-geostationary satellite and of its main characteristics. This procedure provides a formal mechanism whereby any administration can make an initial assessment of the effect that a planned satellite network is likely to have on the stations of existing or planned satellite systems, and comment accordingly.

To this end, the administration responsible for the planned satellite network should submit to the Bureau, for publication, the information stipulated in Appendix 4 of the Radio Regulations. The information should reach the Bureau not earlier than six years and preferably not later than two years prior to the planned date of bringing the network into use (RR1042). This information, when complete, is published by the Bureau in an AR11/A special section annexed to its Weekly Circular, a copy of which is sent to all administrations. At the same time, the Bureau informs all administrations by circular-telegram, drawing their attention to the contents of the pertinent special section.

The advance publication process is the obligatory first phase of the relevant regulatory procedures. It does not give the notifying administration any rights or priority; the only purpose of advance publication is to inform all administrations of the notifying administration's intention to bring a satellite network into use.

2.2. Coordination of frequency assignments to space networks

Coordination is a further step in the process heading up to notification of the frequency assignments for recording in the Master Register. It can be initiated not earlier than six months after the date of receipt by the Bureau of the complete information for advance publication (RR1058E).

* Based on the presentations given by Messrs P. Korobenkov, J. Lewis and P. Lundborg.

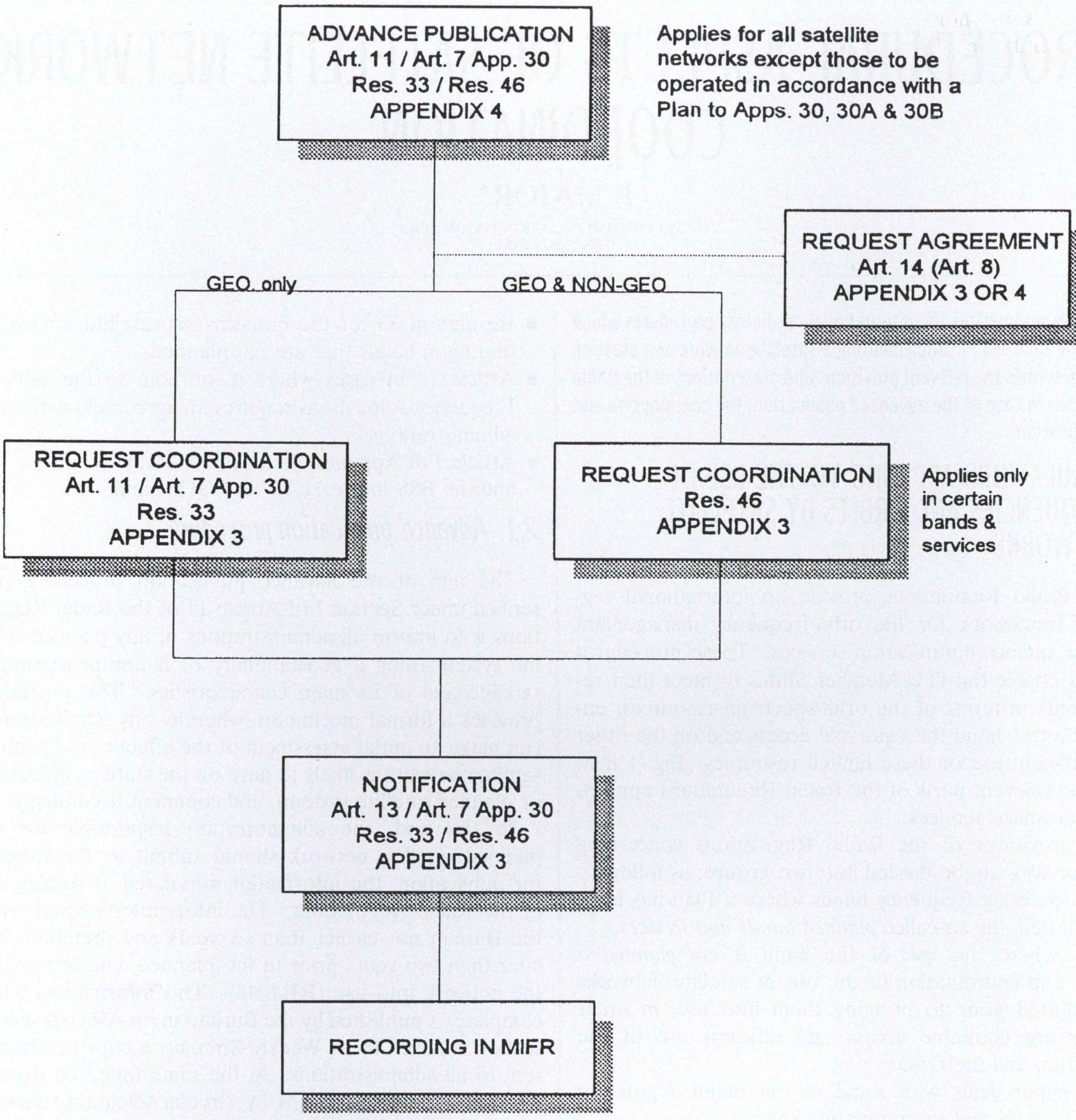


Fig. 1. Regulatory Procedures applicable to Space Services

Coordination is required for geostationary-satellite networks (although there are some exceptions) as well as for non-geostationary satellite networks which are subject to the provisions of Resolution 46.

Coordination of satellite networks under Article 11

The coordination procedure contained in Article 11 is applicable to geostationary-satellite networks. This procedure is a formal regulatory obligation both for an administration seeking to assign a frequency in its network and for an administration whose existing or planned services may be affected by that assignment. An agreement arising from this coordination confers certain rights and imposes certain obligations on the administrations concerned; as such, coordination must be effected in accordance with the relevant regulatory procedures laid down in the Radio Regulations and on the basis of technical criteria either contained therein or otherwise agreed to by the administrations concerned. The Radiocommunication Bureau is required to intervene at different stages of the process.

In accordance with the Radio Regulations, before notifying to the Bureau under RR1488/1491 a frequency assignment to a space station on a geostationary satellite or a frequency assignment to an earth station intended for communication with a geostationary satellite, an administration shall, under RR1060, effect coordination of the assignment with any other administration whose space or earth station assignments in another geostationary-satellite system are likely to be adversely affected.

In accordance with RR1060, coordination has to be effected for any frequency assignment to a space station or to an earth station. However, it should be noted that the ORB-88 Conference introduced the "network concept" in the coordination and notification procedures (Articles 11 and 13), in order to deal with a space radiocommunication network as a whole; in other words, the Conference established the possibility of coordinating space systems on a "network basis". The regulatory instruments for that approach are included in RR1060A, where it is stated that coordination of the space station may be effected on the basis of additional information concerning typical earth stations which may be located within its service area. This method is further supported by a modification to Appendix 3 to include the necessary data to allow the complete network to be considered as a whole for the coordination procedure. The possibility of individual coordination of the space and earth stations (in contrast to network coordination) was also maintained by retaining the provisions of RR1060.

The provisions of RR1066-1071 define the conditions under which no coordination is required.

Having identified the administrations with which coordination is to be effected, the responsible administration sends a request for coordination to each of them, along with the relevant information listed in Appendix 3 of the Radio Regulations and the technical criteria being proposed for the determination of interference levels. Proposals concerning these technical criteria are essential, since it is due to the increase in noise temperature exceeding the threshold value of 6 % that coordination is necessary. In this case a detailed calculation shall be carried out using the methods and techniques set out in the relevant ITU-R Reports and Recommendations, or, in the absence of such Recommendations, criteria shall be agreed upon between the administrations concerned. In short, the administration responsible for the project shall send to all administrations concerned a request for coordination. The administration requesting coordination shall at the same time send a copy of the request for coordination to the Bureau, together with all the information listed in Appendix 3 required for coordination and the names of the administrations with which coordination is sought (RR1074).

On receipt of the copy of the request for coordination under RR1060, the Bureau will check to make sure that all mandatory information listed in Appendix 3 has been furnished and that it is in conformity with the Convention, the Table of Frequency Allocations and other provisions of the Radio Regulations.

The Bureau will then examine the information received with a view to identifying any administration with which coordination under RR1060 must be effected in addition to those to which the requests for coordination have been already sent.

Finally, the Bureau will publish the information in an AR11/C special section of its Weekly Circular. As soon as the information is published in a Weekly Circular, the Bureau will duly inform all administrations by circular-telegram, drawing their attention to the contents of the Weekly Circular (RR1078) as well as to the results of its examination, its findings relating to conformity with the Radio Regulations and the date of receipt of the information, which represents the date as from the frequency assignments concerned are taken into account for coordination.

There is an obligation for the notifying administration to coordinate with any administration which has initiated the coordination process at an earlier stage. However, there is also a provision (RR1085A) stipulating that both the notifying administration and the objecting administration shall make all possible mutual efforts to overcome any difficulties which may arise in a manner acceptable to the parties concerned. The intent of this provision is to facilitate the entry of the newcomer and , even though an administration was first in line, encourage concessions to that end on the basis of mutual cooperation.

2.3. Resolution 33 procedure

This procedure is to be used for advance publication, coordination and notification of frequency assignments to stations in the broadcasting-satellite services (BSS) which are to operate in frequency bands not governed by any plan.

2.4. Article 14 procedure

The use of space services operating in certain frequency bands is governed by the procedure in Article 14, in addition to coordination under Article 11. This supplementary procedure is to be applied in cases where a footnote to the Table of Frequency Allocations requires an agreement with an administration. The proposed assignment may only be deemed to be in conformity with the Table in the context of the footnote concerned after such agreement has been reached.

Article 14 procedure provides for the identification of all administrations whose services may be affected by the use of a frequency assignment subject to such a footnote, and further provides for consultation between the administrations involved in order to reach an appropriate agreement, with the assistance of the Bureau if necessary.

The Article 14 request for agreement is published by the Bureau in an AR14/C special section as required under RR1615. A list of administrations whose services have been identified as possibly affected by the proposed assignments is included in the special section. Any administration to which a request for agreement is thus addressed, as well as any which considers that its services operating or planned to operate in accordance with the Table of Frequency Allocations might be affected, is allowed a period of four months to inform the requesting administration and the Bureau accordingly.

In the absence of a response within the four-month period, the administration will be regarded as unaffected by the proposed assignments. The results of the application of this procedure are published in an AR14/D special section.

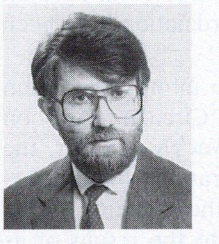
2.5. Regulatory procedure applicable to the FSS in the 11.7-12.7 GHz band

The purpose of this procedure as described in Article 7 of Appendix 30 is to coordinate the fixed-satellite service with respect to the broadcasting-satellite service in the same frequency band; this procedure should be applied in addition to that contained in Article 11.

3. WRC-95

WRC-95 adopted a simplified coordination procedure contained in Article S9. This article presents a standardized procedure for effecting "coordination" with or obtaining "agreement" from other administrations whose services may be affected by a particular proposed frequency usage. The existing procedures of Articles 11 and 14 as well as those of Resolutions 33 and 46 have many features in common, and this is why they were all integrated into a single Article S9 for application whenever the interests of potentially affected administrations have to be safeguarded prior to the notification of frequency assignments in non-planned bands.

The simplified procedure is similar to that of Article 11, with some particularities.



Péter Major graduated from Eötvös Loránd University, Budapest in physics in 1972. He had his Ph.D. in computer science in 1975. He joined Computer Application and Service Company (SZÁMALK) in Budapest, where he worked in different positions up to 1986. He early responsibilities included design and development of components of EDP systems, technological forecasts using mathematical models. From 1981 to 1985 he was head of database application division of the company. He coordinated and supervised system development activities of the division. In January 1986 he was nominated to be head of Database Management Department. In June 1986 he joined the Radiocommunication Bureau (BR former IFRB) of the International Telecommunication Union (ITU) in Geneva. His responsibilities include design, implementation and maintenance of the database for Space Network Systems of BR (SNS). Recently he developed a WWW interface to SNS.

THE TELEDESIC SATELLITE SYSTEM

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There is a significant worldwide demand for broadband communications capacity. The cost to bring modern communications to poor and remote areas is so high that many of the world's people cannot participate in our global community. Teledesic plans to address this need using a network of 924 low-Earth orbit (LEO) satellites operating in Ka-band (30/20 GHz). The Teledesic network will provide "fiber-like" service quality, including low transmission delay, high data rates, and low bit error rates, to users around the world by 2002, providing a variety of services including Internet access, multimedia conferencing, video conferencing , videotelephony, distance learning, and voice.

1. THE DEMAND FOR SWITCHED, BROADBAND SERVICES

"The Internet is the most important single development in the world of computing since the IBM PC was introduced in 1981." [1]. The emergence of the World Wide Web and network-centric computing provide a compelling model for switched, broadband services. Peer-to-peer networking, based on the ubiquity and exponential performance improvements of personal computing, is transforming the way individuals live and businesses create value. Switched broadband connections provide a variety of services including Internet access, multimedia conferencing, video conferencing, videotelephony, distance learning, and voice.

Tragically, most of the world lacks the infrastructure for even the most basic telecommunications services:

- Over half the world's population lives more than two hours from the nearest telephone.
- Manhattan has more telephones than all of Africa, where approximately 121,000 of the 151,000 villages have no telephones at all.
- 75 % of the world's telephones are located in just 9 countries.
- In India, there are 7 million telephones, clustered in a few large cities, to serve 860 million people.
- The world's telephone waiting list is large and growing, and it does not include the huge number of people who have not joined waiting lists because they have no hope of ever getting service.

Even those areas with basic voice service get access through 100-year-old technology — analog, copper networks — most of which will never be upgraded to support digital, broadband services. The developing world, which constitutes 85 % of the world's population, has less than 10 % of the computer networks.

While access bandwidth is growing in tiny steps, personal computer processing power, which is fuelling the demand for bandwidth, continues the exponential growth dictated by Moore's Law, resulting in a "bandwidth bottleneck", as shown in Fig. 1.

While fiber will continue to be the technology of choice for connecting countries and trunking between central offices, it will not be economical in the local loop outside of the most advanced urban areas of the developed world. Widespread broadband deployment will be expensive. PacTel has estimated the cost to upgrade California's infrastructure to support broadband capabilities at $15 billion, while NTT has projected the cost of fibering Japan at $900 billion. In Australia, which has strong public policy supporting universal access, 60 % of the $40 billion cost of broadband services — or about 2± times the cost of the Teledesic Network — would be necessary to provide service to just 30 % of the population. The deployment of fiber requires significant infrastructure and backhoes do not obey Moore's Law.

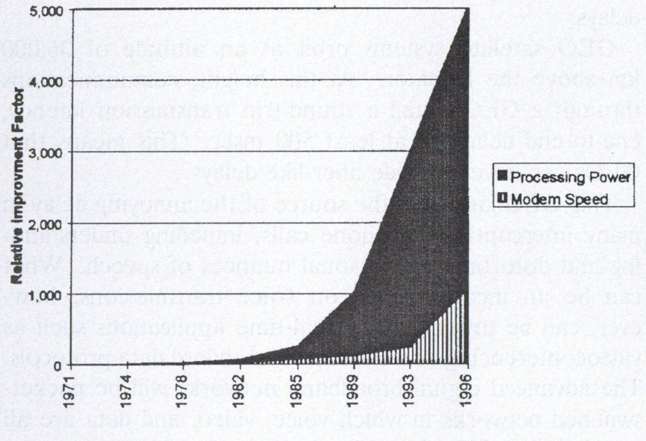

Fig. 1. Bandwidth Bottleneck [2]

2. IMPLEMENTING BROADBAND WIRELESS ACCESS

The deployment of ubiquitous, switched, broadband services will be built on the foundation of wireless economics. GEO satellites can never provide fiber-like delays to support services that are seamlessly compatible with existing terrestrial networks. By contrast, low-Earth-orbit (LEO) satellite systems allow delays comparable to fiber. Low altitude also reduces signal loss and terminal power requirements and allows the use of more compact electronics and antennas. This is the solution Teledesic has adopted.

Just as networks on the ground have evolved from centralized systems built around a single mainframe computer to distributed networks of interconnected PCs, space-based networks are evolving from centralized networks relying on a single GEO satellite to distributed networks of interconnected low-Earth-orbit satellites. In GEO networks, loss of a single satellite is catastrophic. To reduce this possibility to an acceptable level, reliability must be engineered to the point of diminishing returns where further gains in reliability are only achieved at high cost.

With a distributed network, like Teledesic's, reliability is engineered into the network rather than the individual satellites, reducing the complexity and cost of the individual satellites and enabling more streamlined, automated manufacturing processes. With its distributed architecture, dynamic routing, and robust scalability, the Teledesic Network emulates the most famous distributed network of all, the Internet, while adding the benefits of low-latency and location-insensitive access.

3. THE LATENCY FACTOR

Without knowing for certain all the applications and data protocols a broadband network will be called upon to accommodate in the 21st Century, it is reasonable to assume that those applications will be developed in the advanced urban areas of the developed world — where fiber-optics sets the standard. Satellite systems offer the capability to provide location-insensitive, switched, broadband service, extending the reach of networks and applications to anywhere on Earth. But to ensure seamless compatibility with those networks, a satellite system must be designed with the same essential characteristics as fiber networks — broadband channels, low error rates and low delays.

GEO satellite systems orbit at an altitude of 36,000 km above the Equator. At this height, communications through a GEO entail a round-trip transmission latency, end-to-end delay, of at least 500 msec. This means that GEOs can never provide fiber-like delays.

This GEO latency is the source of the annoying delay in many intercontinental phone calls, impeding understanding and distorting the personal nuances of speech. What can be an inconvenience on voice transmissions, however, can be untenable for real-time applications such as videoconferencing as well as many standard data protocols. The advanced digital broadband networks will be packet-switched networks in which voice, video, and data are all just packets of digitized bits. It is not feasible to separate out applications that can tolerate delay from those that can't. As a result, the network has to be designed for the most demanding application.

Applications are developed for prevailing terrestrial standards, not for special networks with non-standard characteristics. Companies that build networks that are not compatible with the predominant protocols and applications are taking a big business risk that their systems will be usable mainly for specialized, proprietary applications. Since telecommunications customers make purchasing decisions based on their most demanding application, GEO satellite systems represent a very risky choice for a carrier if even a relative minority of services are latency-sensitive.

In fact, it turns out that the vast majority of protocols running over the Internet and intranets are adversely affected by high-latency connections. Two of the most important standards in computing today provide examples: TCP and the World Wide Web. Both are intrinsic to the Internet and intranets, yet neither works well over GEO links.

4. INTERNET PROTOCOLS

TCP/IP is so fundamental to the operation of the Internet, that one of the best technical definitions of the Internet is "the network of interlinked computers running the TCP/IP protocol suite". TCP is a reliable data protocol; it guarantees that the data will arrive in the same form it was sent, without loss or corruption. Like most protocols, TCP splits the data into packets and then reassembles them in the same order on the other side of the link. This way, if any data is lost in transit, the missing packets can simply be re-transmitted. However, this requires that all unacknowledged packets be stored on the transmitting computer until confirmation is received that the packets arrived successfully. To confirm successful transmission, TCP utilizes acknowledgement packets. The time it takes to send some data and get an acknowledgement back is the round-trip delay, the round-trip latency, of the connection.

TCP/IP was designed on, and works quite well over, terrestrial networks with low latency. Problems arise, however, when it is used over non-standard networks with high latency, such as GEO satellite links. The issue is that most implementations of TCP allow only a small number of packets to be stored in a buffer on the transmitting computer while awaiting acknowledgement that they were received correctly on the other side of the connection. Using a small buffer wasn't just an oversight. Small buffers can improve performance in certain circumstances, such as when one machine serves many users simultaneously (e.g., a popular Web server).

For example, the default buffer size in both the Windows 95 and Windows NT implementations of TCP/IP is 64 kilobits. This means that at any given moment, only 64 kilobits can be in transit and awaiting acknowledgement. No matter how many bits the channel theoretically can transmit, it still takes at least half a second for any 64 bits to be acknowledged. So, the maximum data throughput rate is 64 kilobits per ± second, or 128 kbit/s. A very high data rate channel with latency is effectively a low throughput channel.

The World Wide Web recently overtook all other applications as the most common use of Internet bandwidth. Intranets are based on the concept of utilizing Web technologies within a corporate network. Like TCP/IP, Web technologies were developed for terrestrial networks, and encounter serious performance problems over non-standard, high-latency links.

Each part of a Web page are fetched using independent TCP transactions. The actual data delivered by each of these transactions can be quite small. In these circumstances, the overhead caused by protocol set-up quickly overwhelms any delay from actually sending data. All TCP connections, including Web transactions, require at least two round-trip delays for setting up a connection. The Web protocol will then add at least one additional round-trip delay. All of this is overhead that's separate from the time it takes to actually transmit data. With a minimum of three round-trip delays, each lasting at least 500 milliseconds, protocol set-up will take at least 1.5 seconds per Web transaction over GEO satellite links. But it gets worse.

That's because displaying any Web page can involve dozens of different transactions, each one requiring a separate protocol set-up, and each one incurring the delay penalties. When these individual 1.5 second delays are aggregated together, Web pages downloaded over a GEO satellite can take tens or hundreds of times longer than connections made over networks such as Teledesic that provide fiber-like delays. And because Web transfers are conducted over TCP, GEO customers face not just the Web protocol overhead delays but also the performance bottlenecks of TCP.

TCP/IP and the World Wide Web are representative examples of what people use over networks. But many other networking technologies have even greater problems with high latency. For example, the standard mainframe and minicomputer communications protocols — SNA and DEC LAT — generally will not work at all over high-latency links.

While it is technically feasible to modify protocols to accommodate GEO delays, the economically are not compelling. If there are no comparably-priced alternatives, high-latency broadband access is obviously better than no broadband access at all. But when economical alternatives exist — such as broadband LEO systems like Teledesic — the economic cost of ensuring compatibility with non-standard GEO networks will be difficult to justify.

It should be pointed out that the above problems caused by excessive latency only effects "lossless" protocols. However, real-time applications, such as voice telephony and videoconferencing, are precisely the applications most sensitive to unacceptable quality degradation as a result of high latency. It is difficult to conceptualize advanced, real-time applications such as collaborative visualization and engineering over a GEO link.

In fact, there is a wide consensus in telecom today that with alternatives such as subsea fiber available, GEOs are no longer suitable for the best-known real-time application — voice. Customers have grown to expect low-latency voice service, with the ability to engage in lively, interactive discussions. Echo cancellation and other new technologies can never eliminate the delay associated with GEO satellites.

5. THE TELEDESIC NETWORK

Teledesic plans to begin service by the year 2002. Teledesic does not intend to market services directly to end-users. Rather, it will provide an open network for the delivery of such services by others. The Teledesic Network will enable local telephone companies and governments in host countries to extend their networks, both in terms of geographic scope and in the kinds of services they offer. Ground-based gateways will enable service providers to offer seamless links to other wireline and wireless networks.

Teledesic uses small, "Earth-fixed" cells, both for efficient spectrum utilization and to respect nations' territorial boundaries. Within a 53 km by 53 km cell, the Network can accommodate a sustained load of over 1,800 simultaneous 16 kbit/s voice channels, 14 simultaneous E1 (2.048 Mbit/s) channels, or any comparable combination of channel bandwidths. This represents a significant system capacity, equivalent to a sustained capacity of 20,000 simultaneous E1s worldwide, with the potential for graceful growth to higher capacities. The Network offers high-capacity, "bandwidth-on-demand" through standard user terminals. Channel bandwidths are assigned dynamically and can be asymmetric. They range from a minimum of 16 kbit/s up to 2 Mbit/s on the uplink, and up to 28 Mbit/s on the downlink. Teledesic will provide a smaller number of high-rate channels at 155 Mbit/s (OC-3) to 1.2 Gbit/s (OC-24) for gateway connections and users with special needs.

It is estimated that the design, construction, and deployment of the Teledesic Network will cost $9 billion. The Teledesic Network represents the first time satellites and their associated subsystems will be designed and built in quantities large enough to be mass produced and tested. These substantial economies of scale enable a cost structure comparable to that of wireline services in advanced urban areas. To minimize launch costs and scheduling constraints, Teledesic's satellites will be compatible with more than 20 launch vehicles around the world and will be self-stacking so that several satellites can be deployed by a single launch vehicle.

6. DESIGN CONSIDERATIONS

Some of the key design drivers of the Teledesic Network are:

- High data rate (broadband) service
- Continuous global coverage
- Fiber-like delay
- Bit error rates less than 10^{-10}
- Mitigate effects of rain attenuation and blockage
- Rapid network repair
- Geodesic (mesh) network interconnect

The broadband service requirement drives Ka-band operation. As a practical matter, not enough bandwidth can be aggregated at lower frequencies to provide a new wireless broadband service on a large scale. The Teledesic satellite uplinks operate in the 30 GHz band (28.6 – 29.1 GHz) and the downlinks operate in the 20 GHz band (18.8 – 19.3 GHz).

Fiber-like delay requires a LEO constellation. GEO satellites introduce a minimum 500 msec round-trip transmission delay. Medium-Earth orbit (MEO) constellations introduce a minimum 133 msec round-trip transmission delay. The round trip transmission delay for a LEO constellation is typically less than 20 msec.

The practical altitude range for LEO constellations is 500 km to 1400 km. Below 500 km, atmospheric drag significantly shortens the satellites lifetime in orbit. Above 1400 km, the Van Allen radiation belt makes radiation hardening of the satellite prohibitively expensive.

Continuous global coverage requires a constellation with a near-polar inclination angle. Rapid network repair requires that the satellites in each orbital plane are decoupled from those in other orbital planes. This allows for the inclusion of active spare satellites in each plane. When a satellite fails, the remaining satellites in the plane spread out to close the resulting gap.

Ka-band communications links are subject to severe rain fading (Fig. 2). This effect is reduced as the Earth terminal to satellite elevation angle is increased. The Teledesic constellation is designed to operate with an Earth terminal elevation mask angle of 40°, providing a minimum rain availability of 99.9 % over much of the world.

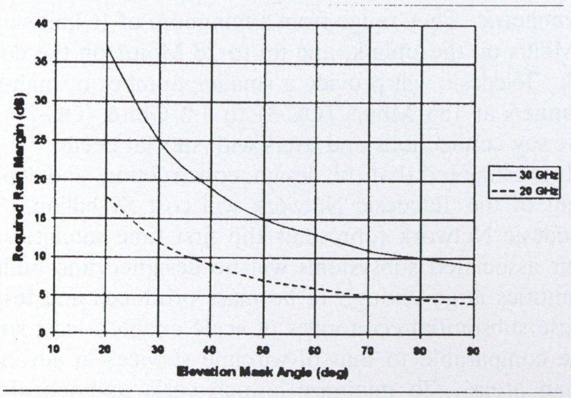

Fig. 2. Required Rain Margin (Region D2, 99.9 % Availability)

The Teledesic constellation [3] is organized into 21 circular orbit planes that are staggered in altitude between 695 and 705 km. Each plane contains a minimum of 40 operational satellites plus up to four on-orbit spares spaced evenly around the orbit. The orbit planes are at a sun-synchronous inclination (approximately 98.16°), which keeps them at a constant angle relative to the sun. The ascending nodes of adjacent orbit planes are spaced at 9.5° at the Equator.

Satellites in adjacent planes travel in the same direction except at the constellation "seams", where ascending and descending portions of the orbits overlap. The orbital parameters are shown in Table 1.

Table 1. Constellation Parameters

Total Number of Satellites	840
Number of Planes	21
Number of Satellites Per Plane	40
Satellite Altitude	695 to 705 km
Eccentricity	0.00118
Inclination Angle	98.142° to 98.182°
Inter-Plane Spacing	9.5°
Intra-Plane Satellite Spacing	9°
Inter-Plane Satellite Phasing	Random
Earth Terminal Elevation Mask Angle	40°

7. SYSTEM DESIGN

The system design is described in Teledesic's FCC [3] application. The network uses fast packet switching technology based on Asynchronous Transfer Mode (ATM) developments. Each satellite in the constellation is a node in the fast packet switch network, and has intersatellite communication links with eight neighboring satellites. This interconnection arrangement forms a non-hierarchical geodesic network that is tolerant to faults and local congestion.

All communication is treated identically within the network as streams of short fixed-length packets. Each packet contains a header that includes address and sequence information, an error-control section used to verify the integrity of the header, and a payload section that carries the digitally-encoded video, voice, or data. Conversion to and from the packet format takes place in the terminals. Fast packet switching technology is ideally suited for the dynamic nature of a LEO network.

The network uses a "connectionless" protocol. Packets of the same connection may follow different paths through the network. Each node independently routes the packet along the path that currently offers the least expected delay to its destination, see Fig. 3. The required packets are buffered, and if necessary resequenced, at the destination terminal to eliminate the effect of timing variations. Teledesic has performed extensive and detailed simulation of the network and adaptive routing algorithm to verify that they meet Teledesic's network delay and delay variability requirements.

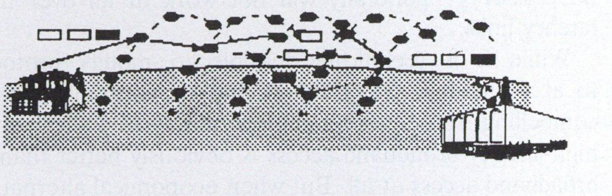

Fig. 3. Distributed Adaptive Routing Algorithm

7.1. Earth Fixed Cells

The Teledesic Network uses an Earth-fixed cell design to minimize hand-offs. The Earth's surface is mapped into a fixed grid of approximately 20,000 "supercells". Each supercell is a square 160 Km on each side and is divided into 9 cells as shown in Fig. 4.

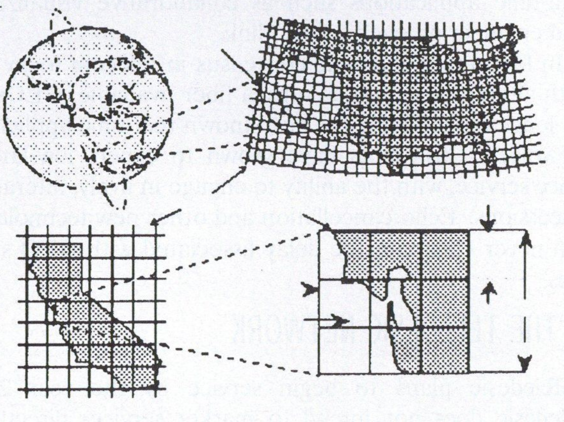

Fig. 4. Earth Fixed Cells

Supercells are arranged in bands parallel to the Equator. There are approximately 250 supercells in the band at the Equator, and the number per band decreases with increasing latitude. Since the number of supercells per band is not constant, the "north-south" supercell borders in adjacent bands are not aligned.

A satellite footprint encompasses a maximum of 64 supercells, or 576 cells. The actual number of cells for which a satellite is responsible varies by satellite with its orbital position and its distance from adjacent satellites. In general, the satellite closest to the center of a supercell has coverage responsibility. As a satellite passes over, it steers its antenna beams to the fixed cell locations within its footprint. This beam steering compensates for the satellite's motion as well as the Earth's rotation. This concept is illustrated in Fig. 5.

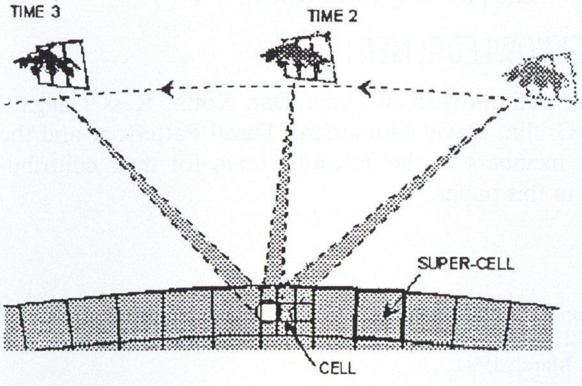

Fig. 5. Beam Steering

Channel resources (frequencies and time slots) are associated with each cell and are managed by the current "serving" satellite. As long as a terminal remains within the same Earth-fixed cell, it maintains the same channel assignment for the duration of a call, regardless of how many satellites and beams are involved. Channel reassignments become the exception rather than the normal case, thus eliminating much of the frequency management and hand-off overhead.

A database contained in each satellite defines the type of service allowed within each Earth-fixed cell. Small fixed cells allow Teledesic to avoid interference to or from specific geographic areas and to contour service areas to national boundaries. This would be difficult to accomplish with large cells or cells that move with the satellite.

7.2. Multiple Access

Teledesic uses a combination of space, time, and frequency division multiple access to ensure efficient spectrum utilization. At any instant of time each fixed supercell is served by one of 64 transmit and one of 64 receive beams on one of the Teledesic satellites. The scanning beam scans the 9 cells within the supercell with a 23.111 msec scan cycle. Each scanning beam supports 1800 16 kbit/s channels. FDMA is used for the uplinks and asynchronous TDMA (ATDMA) for the downlinks.

Satellite transmissions are timed to ensure that all supercells receives transmissions at the same time. Terminal transmissions are also timed to ensure that transmissions from the same numbered cell in all supercells in its coverage area reach that satellite at the same time. Physical separation and a checkerboard pattern of left and right circular polarization eliminate interference between cells scanned at the same time in adjacent supercells. Guard time intervals eliminate overlap between signals received from time-consecutive cells.

On the uplink, each active terminal is assigned one or more frequency slots for the call's duration and can send one packet per slot each scan period (23.111 msec). The number of slots assigned to a terminal determines its maximum available transmission rate. One slot corresponds to a Standard Terminal's or Mobile Terminal's 16 kbit/s basic channel with its associated 2 kbit/s signalling and control channel. A total of 1800 slots per cell scan interval are available.

The terminal downlink uses the packet's header rather than a fixed assignment of time slots to address terminals. During each cell's scan interval the satellite transmits a series of packets addressed to terminals within that cell. Packets are delimited by a unique bit pattern, and a terminal selects those addressed to it by examining each packet's address field. A Standard Terminal operating at 16 kbit/s requires one packet per scan interval. The downlink capacity is 1800 packets per cell per scan interval. The satellite transmits only as long as it takes to send the packets queued for a cell.

The combination of Earth-fixed cells and multiple access methods results in very efficient use of spectrum. The Teledesic network reuses its spectrum over 350 times in the continental US and 20,000 times across the Earth's surface.

8. COMMUNICATIONS LINKS AND TERMINALS

All of the Teledesic communications links transport data, video, and voice as fixed-length 512 bit packets. The links are encrypted to guard against eavesdropping. Terminals perform the encryption/decryption and conversion to and from the packet format.

The uplinks use dynamic power control of the RF transmitters so that the minimum amount of power is used to carry out the desired communication. Minimum transmit power is used for clear sky conditions; transmit power is increased to compensate for rain.

The Teledesic Network supports a family of subscriber terminals providing on-demand data rates from 16 kbit/s up to 2.048 Mbit/s (E1), and for special applications from 155.52 Mbit/s (OC-3) up to 1.24416 Gbit/s (OC-24). This allows a flexible, efficient match between system resources and subscriber requirements.

Standard Terminals include both fixed-site and transportable configurations. All configurations operate at multiples of the 16 kbit/s basic channel payload rate up to 2.048 Mbit/s (the equivalent of 128 basic channels). These terminals use antennas with diameters from 16 cm to 1.8 m as determined by the terminal's maximum transmit channel rate, climatic region, and availability requirements. Their average transmit power varies from less than 0.01 W to 4.7 W depending on antenna diameter, transmit channel rate, and climatic conditions. All data rates, up to the full 2.048 Mbit/s, can be supported with an average transmit power of 0.3 W by suitable choice of antenna size.

Within its service area each satellite can support a combination of terminals with a total throughput equivalent to over 1,000 E1s.

The Network also supports a smaller number of fixed-site GigaLink Terminals that operate at the OC-3 rate (155.52 Mbit/s) and multiples of that rate up to OC-24 (1.24416 Gbit/s). Antennas for these terminals range in size from 28 cm to 1.6 m as determined by the terminal's maximum channel rate, climatic region and availability requirements. Transmit power varies from 1 W to 49 W depending on antenna diameter, data rate, and climatic conditions. Antenna site-diversity can be used to reduce the probability of rain outage in situations where this is a problem.

GigaLink Terminals provide gateway connections to public networks and to Teledesic support and data base systems, as well as to privately owned networks and high-rate terminals. Each satellite can support up to sixteen GigaLink terminals within its service area.

Intersatellite Links (ISLs) operate in the 60 GHz band. They interconnect each satellite with its eight neighbor satellites. Each ISL operates at the OC-3 rate, and multiples of that rate up to OC-24 depending upon the instantaneous capacity requirement.

9. ACKNOWLEDGEMENTS

The authors wish to thank Dan Kohn, Russ Daggatt, Tren Griffin, David Montanaro, David Patterson, and the other members of the Teledesic team for their contributions to this paper.

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THE GLOBALSTAR SYSTEM

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The GLOBALSTAR satellite system provides low-cost personal communications to users. The system is based on 48 LEO satellites, operated by big multinational companies. The paper gives an overview on the system and on the services provided.

1. INTRODUCTION

GLOBALSTAR is a non-geostationary mobile satellite system that is interoperable with current, and future, terrestrial mobile and switched telephone networks of all types. It is designed to provide low-cost personal communications to the everyday user, with worldwide and constant coverage from a system of 48 satellites in circular low-earth orbit. The service is offered to the end user customer through single- or dual-mode terminals connected with existing terrestrial networks via satellites and gateway earth stations.

The GLOBALSTAR system is a truly global project. Its owners include: Loral Corporation, QUALCOMM, AirTouch Communications, Alcatel, Finmeccanica, DACOM, DASA, France Telecom, Hyundai and Vodafone. These companies have vast expertise in the areas of satellite design and manufacturing, space mission control systems, telecommunications equipment, network design and management, and wireless and digital transmission technologies. These owners, individually or in partnership, as well as other non-owner firms, will provide GLOBALSTAR service to end users.

The GLOBALSTAR space segment of 48 satellites provides mutiple satellite coverage, thereby ensuring high quality communications at all times. The low orbit reduces signal path delay and decreases the necessary satellite electrical power at radio frequency level. Thus, users will not experience the delay which can occur with higher orbit satellite systems. The satellites are frequency-translating or "bent pipe" design, to further reduce complexity and cost. Less complexity permits high quality, reliable communications at low cost.

The satellites operate with user links in the 1610.0–1626.5/2483.5–2500 MHz band and with feeder links in the 5091–5250/6875–7055 MHz bands. The satellites are controlled through a satellite operation control center. The GLOBALSTAR gateway earth stations operate in C-band to facilitate high quality communications even in areas with extensive rainfall. In addition, a number of ground operation control centers will be located around the world.

The following table summarizes key attributes of the GLOBALSTAR system:

GLOBALSTAR non-geostationary MSS System

Orbital Parameters:	Type of Orbit	Circular
	Altitude	14141 km
	Inclination	52°
Frequencies:	User to Satellite	1610.5 to 1626.5 MHz
	Satellite to Gateway	6875 to 7055 MHz
	Gateway to Satellite	5091 – 5250 MHz
	Satellite to User	2483.5 to 2500.0 MHz
Modulation Type	CDMA/FDMA	
Number of Gateway Earth Stations		100 – 200 Worldwide

The US-licensed space segment of GLOBALSTAR will provide telecommunications capacity to in-country service providers. These in-country service providers often will be existing telecommunications service providers, such as providers of cellular service.

Service will be provided to users through fixed and mobile user terminals which will be dual mode: The terminals will attempt to utilize terrestrial cellular or other wireless systems prior to transmitting the call to the satellite. From the satellite, calls will be routed to gateway earth stations and the public switched telephone network (PSTN).

All calls are set up and processed on the ground by the local gateway terminal. The gateway equipment consists of transmit-receive antennas, software and a packet-switched data network for operational control, and other administrative functions. The gateways provide interconnection to PSTNs. As is the case with most mobile communications today, most calls carried over the GLOBALSTAR system will either originate or terminate in the terrestrial fixed network.

The GLOBALSTAR system was designed to operate compatibly, from a technical, economic and user perspective, within the existing telecommunications infrastructure. For example, the use of local service providers preserves the existing relationships between wireless providers and customers and permits existing mechanisms to continue to be used for settlement and roaming arrangements. In addition, the use of local service providers ensures that each administration has the ability to exercise control over the operation of telecommunications systems within its national boundaries.

2. CODE DIVISION MULTIPLE ACCESS

The GLOBALSTAR system utilizes the code division multiple access (CDMA) technology developed by QUALCOMM, Incorporated. This modulation provides an excellent voice quality, relatively low RF power levels, security, reliability and capacity benefits. With CDMA, and the use of satellite diversity, permitted by the coverage of service areas by multiple satellites, continuous communication will be provided even when a path to one satellite may be blocked. CDMA also permits sharing of the user link with other satellite systems, and permits capacity limits to be exceeded when traffic requires.

3. GLOBALSTAR INTERFACE TO THE SERVICE PROVIDER AND THE PSTN

Licenses will have to be given by the national regulatory authorities to provide the service, to operate the gateways, and to interconnect the gateways and the PSTN. Consistent with local law and policy, there may be one or more than one licensee. For a public land mobile network (PLMN, the gateway may interconnect with the line side of the mobile switching center. As a result, the gateway is interoperable with multiple mobile network systems, including GSM, AMPS, and others. The gateway is also compatible with a PSTN environment which is not integrated with an existing cellular network.

4. GLOBALSTAR'S USER TERMINALS

GLOBALSTAR's dual-mode user terminals will be compatible with the GSM standard used widely throughout the world, as well as the North American PLMN standards adopted by the Telecommunications Industry Association (TIA).

5. ROAMING

International travelers will use the roaming facilities offered by the GLOBALSTAR system. The authorized service providers will participate in, and abide by, technical procedures based on use of the North American Standard AMPS (IS-41) and the European Standard GSM (MAP) protocols and Signaling System 7 (SS-7). Roaming will be available even if the service provider does not operate a terrestrial PLMN.

6. VALIDATION OF CUSTOMER AND AUTHORIZATION TO USE IN TERRITORY

The GLOBALSTAR system is designed so that calls cannot be made to and from mobile terminals within a country that has not authorized services of the system. This is accomplished through the ability of the system to locate the position of each mobile terminal when it attempts to operate. The user location is provided to the gateway when it is first registered with the gateway earth station and is updated each time service is requested from the gateway earth station.

In order to initiate a call from a mobile terminal, the mobile terminal first transmits a short packet identifying itself and its location so that the gateway earth station can verify that it is an authorized user of the system. The system verifies that the user is authorized and is within a territory where service is permitted. If the user is unauthorized, or it is within a territory where service is not permitted, the call will not be permitted to go through.

Similarly, a call to a mobile terminal can be completed only if the mobile is located within a country that has authorized service to be provided by that system. All calls are routed through gateways which perform the position location and verification functions. If the called party is not an authorized user or it is within a country which does not permit the service, the call will be blocked. In addition, subscribers will be informed as to where service is authorized, and where it is not.

7. SYSTEM ARCHITECTURE

The GLOBALSTAR system consists of a Space Segment, a User Segment, a Ground Segment, and a interconnect into the Terrestrial Network.

8. SERVICES

GLOBALSTAR offers voice, data, message, facsimile and position location services in four primary environments:

(1) Mobile users working in and/or residing in areas without terrestrial mobile coverage.
(2) Mobile users roaming into areas without terrestrial mobile coverage.
(3) Fixed terrestrial users in areas without fixed telecommunications service.
(4) Private or specialized networks.

In addition to voice service, GLOBALSTAR provides transmission at rates up to 9600 bits per second (BPS) for asynchronous message, data, and facsimile terminals. Subscribers will be able to access remote databases, send and receive electronic mail, and perform data transfer functions. Paging will also be available.

9. SUMMARY

LEO satellites are here to stay. They capitalize on digital technology and advances in the cellular industry. The economics they offer along with new services and ubiquitous wide area coverage make LEO systems a viable new and exciting technology.

GLOBALSTAR can provide an inexpensive way for mobile service providers to instantly increase their coverage area, and add new customers that desire services in areas where it is not economical to provide terrestrial services. Worldwide deployment of the system assures ubiquitous availability of telephony services, data transmission up to 2400 bit/s with bit error rates of better than 10^{-6}, locationing to better than 300 meters, and paging: You can be located and called or you can call anyone from nearly everywhere with a single device – your GLOBALSTAR handy.

GLOBALSTAR offers highly reliable, readily affordable personal communications services, via satellite, worldwide.

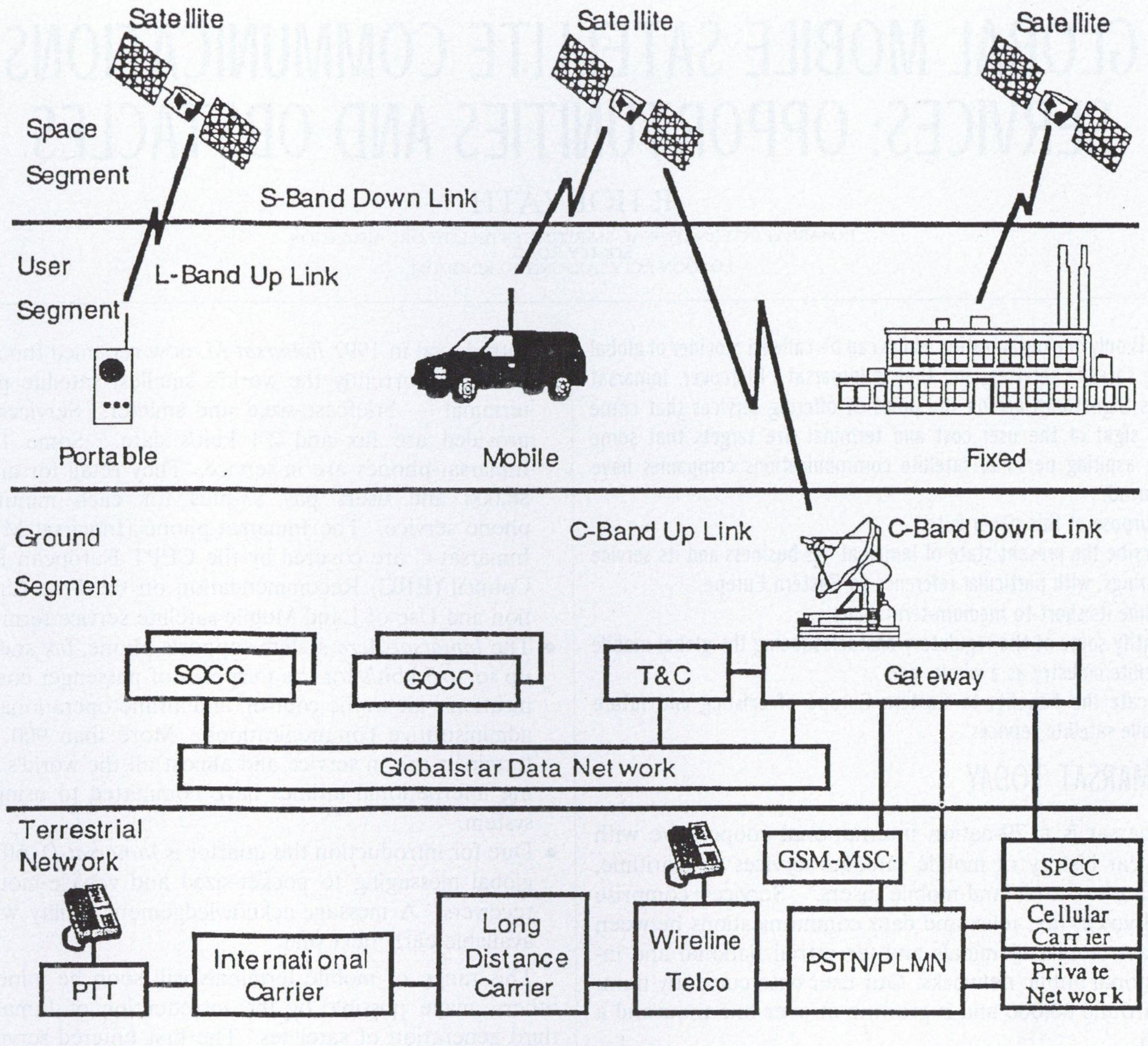

Fig. 1. The GLOBALSTAR System Architecture

GLOBAL MOBILE SATELLITE COMMUNICATIONS SERVICES: OPPORTUNITIES AND OBSTACLES

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There is only one organization which can be called a provider of global mobile satellite services, and that is Inmarsat. Moreover, Inmarsat and its Signatories are on the point of offering services that come within sight of the user cost and terminal size targets that some of the aspiring personal satellite communications companies have announced.

The purpose of this paper is to:

- describe the present state of Inmarsat, its business and its service offerings, with particular reference to Eastern Europe,
- outline its short to medium-term plans,
- identify some of the regulatory obstacles facing the global mobile satellite industry as a whole, and
- indicate the benefits to Eastern Europe of existing and future mobile satellite services.

1. INMARSAT TODAY

Inmarsat is a 79-nation international cooperative with a 15-year history of mobile satcoms services to maritime, aeronautical and land-mobile users. Services comprise global voice, fax, telex and data communications between compact mobile terminals and terrestrial national and international public networks. Our user base currently numbers around 66,000 and is growing at over one thousand a month.

Inmarsat's primary link with Eastern Europe is via its member nations. Of the current total of 79, nine come from this region. Between them they account for nearly one per cent of the organization's investment base and include Belarus, the Slovak Republic, the Czech Republic, Ukraine, Romania, Latvia, Croatia, Bulgaria, and Poland. In cooperation with other Signatories, five of the region's countries are represented on the Inmarsat Council.

2. INMARSAT'S MOBILE TERMINALS

- *Inmarsat-A* was Inmarsat's original offering. This analogue system supports phone, fax, telex and data at up to 64 kbit/s for maritime and land-mobile users. More than 25,000 Inmarsat-A terminals are in service.
- *Inmarsat-B*, launched in 1994, is the digital successor to Inmarsat-A. Because it makes more efficient use of space segment resources it permits significant reductions in user charges.
- *Inmarsat-C*, introduced in the early 1990s, supports store-and-forward data messaging at 600 bits/s to terminals that are briefcase-sized and smaller. Over 25,000 Inmarsat-C terminals are in service in maritime, land-mobile, aeronautical and remote-monitoring applications.
- Introduced in 1992 *Inmarsat-M*, now renamed Inmarsat-phone is currently the world's smallest satellite phone terminal — briefcase-sized and smaller. Services also provided are fax and 2.4 kbit/s data. Some 10,000 Inmarsat-phones are in service. They retail for around $8,000 and users pay $3-plus for each minute of phone service. The Inmarsat-phone (Inmarsat-M) and Inmarsat-C are covered by the CEPT European Radio Council (ERC) Recommendation on the Frce Circulation and Use of Land Mobile satellite service terminals.
- The *Inmarsat-Aero* system supports phone, fax and data up to 10.5 kbit/s for the purposes of passenger communications, air traffic control, and airline operational and administrative communications. More than 900 Aero terminals are in service and almost all the world's leading international airlines have committed to using the system.
- Due for introduction this quarter is *Inmarsat-D*, offering global messaging to pocket-sized and vehicle-mounted receivers. A message-acknowledgement facility will be available early next year.

This range of mobile terminals will soon be joined by others, made possible by the introduction of Inmarsat's third generation of satellites. The first entered service in May 1996 and the second was launched successfully on September 6 on a Russian Proton vehicle. With their high-power spot beams they will support even cheaper, more compact terminals, including the range of terminals and services described below:

- *Mini-M, the second member of the Inmarsat-phone family*, will deliver voice, fax and 2.4 kbit/s data services to laptop-sized terminals weighing 2.5 – 3 kg. As an indication of prices, one service provider recently announced a package combining terminals priced at less than $3,000 with a user charge of under $3 a minute. Beta-testing of Mini-M has commenced, with commercial launch scheduled for October. While offering similar functionality, Mini-M comes close to the tariffs announced by some of the personal satellite communications companies that now have systems in development — but Mini-M will be available this year, not 1998 or at the turn of the century.
- The *Aero-I* intermediate-gain system will make it possible for aircraft ftying within spot-beam coverage to obtain current levels of service — voice, fax, 10.5 kbit/s data — through smaller, cheaper terminals. Flight trials were successfully completed in March, first terminal type approval is scheduled for December, and the service will be introduced next year.

- *Spot-beam Inmarsat-C* will exploit spot-beam power to deliver improved- quality, more flexible Inmarsat-C service to terminals weighing about 0.5 kg.
- Dedicated *navigation transponders* carried by the Inmarsat-3s will relay ground- generated signals designed to enhance the accuracy, integrity and availability of the positioning provided by satellite navigation systems such as GPS. Various groupings of Inmarsat Signatories as ground network operators will act as service providers to Air Traffic Control organizations such as the the US Federal Aviation Administration. Further Inmarsat involvement in satellite navigation services is under study.

3. TOWARDS A NEW INMARSAT

The established services have generally delivered healthy growth in revenues throughout Inmarsat's history, and this is being repeated in the year to date. The new Inmarsat-3 services will lead the organization beyond its present highly specialized markets and into the domain of personal satellite communications, with its potential for greatly inereased user numbers.

Inmarsat continues to be a very successful enterprise. But it has been clear for some time that the changes in the telecommunications industry generally and in mobile satellite communications in particular require Inmarsat to become more market-focused and responsive. As a result, we have just completed an internal reorganization designed to sharpen our market reflexes. We are driving down our costs and raising user perceptions of Inmarsat as a service wholesaler. We are streamlining our customer interface, introducing improved service activation procedures. We have launched a major quality-of-service effort. And we have been mandated to develop an institutional structure yielding greater flexibility of management and investment.

Our current financial and governance structure was developed sixteen years ago. It worked well in its time but the changes to our business environment mean that it is now inappropriate, locking some of our owners into investments to which they may no longer be committed, and consequently impeding the flow of funds into new projects. In similar fashion, our governance process — with its complex and cumbersome procedures — is no longer equal to the demands of an inereasingly competitive and fast-moving marketplace.

These constraints have been recognized for some time, and the Inmarsat Directorate has been working with Signatory shareholders and member governments to develop proposals for structural reform. The objective is a structure that will ensure Inmarsat continues to be an attractive investment vehicle with increased financial and investment flexibility, with faster, market-oriented management processes, with the ability to form strategic partnerships, and so on — in effect, a more "commercially normal" corporate structure.

In February the Inmarsat Assembly, bringing together our member governments, laid down five basic principles to be respected in any new structure:

- continued provision of maritime, distress and safety services, and support of the Global Maritime Distress and Safety System;
- non-discrimination among customers on basis of nationality;
- Inmarsat must continue to be used for peaceful purposes only;
- should seek to serve all areas where there is a need for mobile satellite communications; and
- should compete fairly.

The Assembly also recommended a number of essential elements. A reformed Inmarsat should remain intergovernmental in nature, with the Assembly retaining oversight of the public-service obligations defined in the basic principles. There should be broad ownership, and the importance of developing-country markets should be recognised. Investment should be open and voluntary, and the liability of investors should be limited.

The governing board should be fiduciary — that is, its members should have a duty in law to act in the best interests of the organization rather than in those of the shareholders they represent. The responsibilities of the board and other senior management should conform to commercially normal practice. And there should be a properly managed and phased transition from the present structure to the new one. The last requirement concerns matters such as the gradual shedding of the privileges and immunities currently held by Inmarsat, due to its current intergovernmental status.

For detailed development, the Inmarsat Council selected a national law company structure, now called New Inmarsat. Registered under national law, such an organization would be a commercialized entity with limited liability and improved financial and governance flexibility. The Assembly would still have a role, via a small Inmarsat Intergovernmental Organization (IGO) — but only in relation to public-service obligations. The New Inmarsat's fiduciary board would have ultimate responsibility for purely commercial activities.

Work is under way to develop the model fully, and define the necessary amendments to the Inmarsat Convention and Operating Agreement. Our ambitious schedule calls for these changes to be considered this year, with an extraordinary Assembly in April of next year to agree the amendments.

The business push behind this timetable is the need to have the new structure in place in time to facilitate investment in the fourth-generation space segment currently being defined by our Project Horizons.

4. INMARSAT'S HORIZONS

Project Horizons are being driven by the market, *not* the mechanics of satellite communications. Inmarsat has in the past been falsely accused of being an engineering-led organization, delivering technical excellence in its own time. Technology obviously *will* have a bearing on what we offer in the next century. But nothing will enter development unless we are first completely satisfied that it will meet real-world requirements at a price that the real world will pay, and that it will give us a real-world return for our money and effort.

The task of the Horizons team is to:

- identify business opportunities in the first decade of the next century;
- select the most promising;
- identify the most effective technical and commercial means of delivering these services;
- plan for their introduction and for the space segment needed to support them;
- promote timely implementation.

At this point a number of business areas are emerging as candidates. Inmarsat is already active to some degree in most of them — building on our existing strengths is the strategy.

One of the areas under study is rural and remote communications. Another is the relationship with ICO Global Communications (ICO), in which Inmarsat has a 10 per cent share. ICO will offer services to hand-held terminals from the year 2000. Inmarsat has exclusive rights to market ICO services for non-hand-held terminals in the aeronautical and maritime markets, and we are currently studying markets and terminal designs. ICO has emerged as one of the favourites to succeed in the hand-held satcoms market of early next century — that can only be good news for Inmarsat.

A third business area under investigation is broadband services. There seems little doubt that mobile satellite operators will be called on to support much higher data rates than are the norm at present. The world is now seeing an explosion in the take-up of increasingly sophisticated and data-hungry on-line services in the fixed telecoms environment. In the coming years a valuable proportion of that demand will assuredly come from mobile users who roam internationally and in areas not served by terrestrial systems. Last year's rush to the US Federal Communications Commission to register systems capable of delivering global broadband services next century is a clear indication that satellites will play a major role in the high-bandwidth markets of the future. Inmarsat is as ready as anyone to participate and to succeed.

5. FREE TO COMPETE, FREE TO SERVE

A large obstacle to the achievement of the aims outlined above is not technological or even economic but the widespread existence of policy and regulatory barriers. They make it more complicated and more expensive for users to carry their equipment across borders and use it. For service providers the result is lost opportunities, lost traffic and lost revenue. Potential users are being denied a valuable communications capability, often when there are no alternatives. And the nations implementing barriers lose most of all, since good telecoms is now widely acknowledged as a powerful engine for economic growth.

Inmarsat has been working for many years to promote a global regulatory environment that is more benign for all mobile satellite services and their providers. The advent of new global providers in the coming years offers an opportunity for the mobile satellite industry as a whole to make a concerted effort to solve this problem.

Many countries limit usage by imposing high licence fees and customs duties and demanding local type-approval of terminals. Several nations levy annual licence fees of several thousand dollars for a single terminal: one charges $12,000, two or three times the price of an Inmarsat-C or Inmarsat-M. Import duties of 60 – 70 per cent of the cost of the equipment are not unusual; one nation charges 108 per cent. Some countries prohibit the use of mobile satellite terminals altogether, with the possible exception of their use for disaster relief.

There is a variety of motives for these practices:

- Concern that use of Inmarsat services will result in users bypassing the national terrestrial infrastructure, thus depriving the national operator of revenue. This reason is sometimes cited even when the infrastructure in remote and rural areas is inadequate or even absent entirely.
- Fears of a threat to national security.
- A desire for close bureaucratic control or for maximum revenue from licence fees.
- Simple lack of the necessary national policies and regulations.
- Existing use of Inmarsat frequency bands for other services such as microwave point-to-point.
- A desire to protect a domestic mobile satellite operator which competes directly with Inmarsat or, in the future, the global operators currently in development.

Of these, fear of the potential bypass of terrestrial networks is the most powerful factor. But Inmarsat believes that the operators should not see bypass as a serious problem, for several reasons:

- Mobile terminals are generally employed where local facilities either do not exist or are incapable of meeting the user's needs.
- Users will tend to select the cheapest solution, and that is usually the local one.
- Calls to or from mobile terminals often go part of the way via the national terrestrial network. For the local operator this is revenue-generating traffic that might not exist if the use of mobile satellite services were barred.

Instead of trying to block mobile satellite services, policymakers and regulatory authorities should consider their social and economic benefits, especially in areas where there are no alternative means. They should then work to create an environment conductive to the availability of mobile satellite services and to facilitate the earning of revenues by local service providers.

The global tendency towards more open telecommunications markets is helping in this respect, with the current World Trade Organization talks on telecommunications liberalization working to lower the barriers to trade in services. Inmarsat does not believe that satellite services should be excluded from any global agreement that may emerge from the WTO talks. However, it is clear that many trade negotiators are not familiar with the particular characteristics of satellite-provided telecommunications services.

6. OTHER INSTITUTIONAL BARRIERS: PRACTICAL SOLUTIONS

6.1. *Licensing*

In Europe arrangements have been made so that a satellite terminal licensed in one country can be accepted for use in another without any further licensing requirement. Such terminals are distinguished by a special mark and the user may also carry a "circulation card" listing the countries which require no further licensing. As mentioned above, Inmarsat-phone and Inmarsat-C are included in the ERC free circulation recommendation for mobile terminals.

It could well take several years to achieve similar levels of mutual recognition worldwide. In the meantime, it may prove necessary for the International Telecommunication Union (ITU) to maintain a register of all countries which agree to waive additional licensing requirements. As national regulatory authorities inform the ITU of their decisions to recognise the licences of other countries listed in the register, the ITU could update the list and circulate it to national regulators. It could also be made available to users.

National policies on the waiving of licence fees for visiting users may be influenced by the possible reaction of domestic users who have had to pay the country's standard licence fee. Thus if visitors are exempted, it may have to be for a limited period only. A model transborder agreement drafted by Imnarsat has suggested a maximum of two months.

At the request of several of its member countries, Inmarsat has suggested a standard structure under which the visiting user would pay about five per cent of the total value of the equipment for the right to use it after the two-month deadline.

6.2. *Type approval*

This is the certification by an acknowledged authority that a mobile terminal design is technically fit for its purpose. Many countries require radio equipment to be type- approved before it can be used on their territory. In such cases Inmarsat type approval is widely, though not universally accepted, resulting in a need for some mutual recognition of type approvals. As with licences, the ITU could maintain a register of countries agreeing to mutual recognition.

Each country's regulator would need to keep its customs authority provided with a list of mobile terminal equipments exempted from national type-approval requirements. Following the CEPT ERC recommendation, such equipment could be marked or the user could carry a circulation card.

Whether they originate with Inmarsat or at national level, type approvals should conform to international standards set by the ITU or by other bodies. As the mobile satellite industry expands, particularly following the introduction of the global personal satellite communications systems, the standard-setting bodies will come under increasing pressure to speed up the development of standards covering broad classes of terminal and focusing only on essential requirements.

6.3. *Customs duties*

Early results from an Inmarsat survey currently under way show that customs duties on mobile terminals range from zero to 70 per cent or more of the value of the equipment. We believe this is a serious issue, for at least two reasons:

- A traveller visiting a number countries in succession may be required to pay duties several times over. Even if the individual sums are modest, the cumulative total could be significant enough to deter the user from travelling with his mobile terminal.
- Because mobile terminals are becoming smaller all the time — some Inmarsat-phones, for example, are not much bigger than a laptop computer — the user may be tempted not to make a declaration to customs. If — as will be the case with Inmarsat's Mini-M and the forthcoming hand-held terminals — the unit differs little in appearance from a laptop or a cellphone respectively, the temptation will be all the greater. Adding to the pressure to evade will be the possibility of a demand for, say, 10 per cent of the cost of a $5,000 terminal to permit its use during a visit lasting just days or even hours.

There appears to be a clear need for the ITU, on behalf of existing and future users of mobile satellite services, to examine this issue more closely and raise it with the World Trade Organization (WTO), the aim being to eliminate duties or reduce them to a nominal level. The case for such reform should be built on the ability of mobile satellite terminals to provide communications where no other means exists, to assist in national economic development, and to support humanitarian applications such as disaster relief, emergency communications, telemedicine and environmental protection.

Meanwhile, there remains an urgent need to ensure that customs officials can recognise mobile terminals for what they are and that they are instructed to waive licence fees and duties whenever the necessary agreements are in place.

7. BRINGING DOWN THE BARRIERS: THE INMARSAT CONTRIBUTION

Inmarsat is pursuing a number of initiatives designed to encourage the dismantling of regulatory barriers.

One takes the form of cooperation with individual countries so that they better understand mobile satellite services and go on to obtain the benefits. This effort — supported by our regional directors, and in future by regional offices — is beginning to bear fruit: one country recently reduced its licence fee from $10,000 to $500 a year.

The organization has also acted at the regional and global levels. For example, Inmarsat worked closely with developing countries for the adoption of Resolutions 7 and 35 at the World Telecommunication Development Conference (WTDC) in Buenos Aires in March 1994 and the ITU Plenipotentiary Conference in Kyoto in September 1994. The resolutions called on countries to remove or reduce regulatory barriers to the use of telecoms equipment for disaster relief.

Inmarsat has been in the forefront of the campaign to eliminate multiple type approval and licensing of mobile terminals. Following an Inmarsat proposal, the European Radiocommunications Committee (ERC) agreed on a mechanism under which Europe's CEPT and non-CEPT countries would recognise one another's licences. The ERC's list of countries agreeing to mutual recognition will be made available to customs officials and mobile satellite users. The latter will present the list at border crossings to indicate to customs that their tenninals are exempt from national licensing requirements.

Another Inmarsat initiative is a model agreement aimed at facilitating transborder use within regions. This is being implemented in the Gulf Cooperation Council (GCC) countries and is under study elsewhere.

Much remains to be done, however, and Inmarsat has two further specific measures to propose:

- Following the World Telecommunication Policy Forum in Geneva this autumn, the ITU should circulate to all its members a proposed policy and regulatory framework covering the transborder use of mobile satellite terminals.
- The European Radiocommunications Committee's *Recommendation on Free Circulation of Land Mobile Satellite Service Terminals* is a practical mechanism that should be actively promulgated.

At the general level, Inmarsat and the aspiring personal satellite communications operators must clearly show national policymakers, regulators and service providers why freer movement and use of mobile satellite terminals is in their own interest. This effort might benefit from the example of the GSM digital cellular standard. Transborder roaming arrangements have been reached successfully within Europe and outside, so that GSM users can use their cellular phones easily and without restriction in many countries around the world. The same arrangements could be applied to mobile satellite terminals.

INTELSAT SATELLITES AND DIGITAL SERVICE APPLICATIONS

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This paper presents information on the INTELSAT organization, evolution of its satellites and provides detailed information on digitalization of its services. Since its creation in 1964 as a global commercial cooperative, INTELSAT has become the leading global satellite telecommunication provider with over 20 geosynchronous satellites, range of services and has generated an annual operating revenue in excess of US Dollars 910 million in 1996. Today 141 nations are members of INTELSAT and INTELSAT serves the international, regional and domestic telecommunication requirements of more than 180 countries and territories.

1. INTRODUCTION

The headquarters of the INTELSAT organization is located in Washington, D.C./USA. INTELSAT opened Regional Sales Centers in London/England, Mumbai/India and Singapore in order to better serve the growing markets of Europe and Asia/Pacific. The INTELSAT system today consists of IS-5, IS-6, IS-7 and IS-8 series of satellites. In addition, an all Ku-band satellite (IS-K) is currently operated at the 338.5 degrees East longitude serving the video broadcast requirements of the Atlantic Ocean Region customers. INTELSAT has under contract two IS-9 series of satellites to replace some of the IS-6s and one all Ku-band satellite (K/TV) will be stationed at the 95 degrees East longitude to serve the video requirements of the Asia/Pacific community.

INTELSAT has encouraged digitalization of its services over the past ten years and today more than 90 percent of the services are digital. One of fastest growing areas have been the expansion of all digital Private Networks consisting of IBS, Intelnet/VSAT, Thin Route-On-Demand DAMA, Business TV and Internet. This paper provides detailed information on these services and particularly on DAMA and Internet which are expected to be fastest growing offerings in the system over the coming years.

2. BRIEF HISTORY OF INTELSAT

INTELSAT was established in 1964 as a global commercial cooperative. Ever since that time, INTELSAT has provided technologically advanced, global satellite telecommunication services to all countries of the World on a non-discriminatory and cooperative basis. The main principles of services provision have been:

- Develop a single global commercial satellite system based on cooperative principles to meet all telecommunication requirements,
- Provide services to all areas of the World which will contribute to World peace and understanding,
- Provide the most advanced technology available, along with the most economical and efficient facilities possible,
- Permit access to all people, and those states who are members of the ITU so wishing to invest in the system with consequent participation in the design, development, construction, and provision of the equipment including establishment, operation, maintenance and ownership of the system.

INTELSAT's daily activities are handled by INTELSAT Management located at its headquarters building in Washington, D.C./USA. The chart shown in Fig. 1 displays the Organization of INTELSAT. INTELSAT Management headed by the Director General reports to the Board of Governors formed from the member Signatory representatives who are the owners of the Organization. The highest level of authority lies with the Assembly of Parties whose delegates are the representatives of member nations. The Technical, Planning and Budget/Audit Committees operate in advisory category and report directly to the Board of Governors.

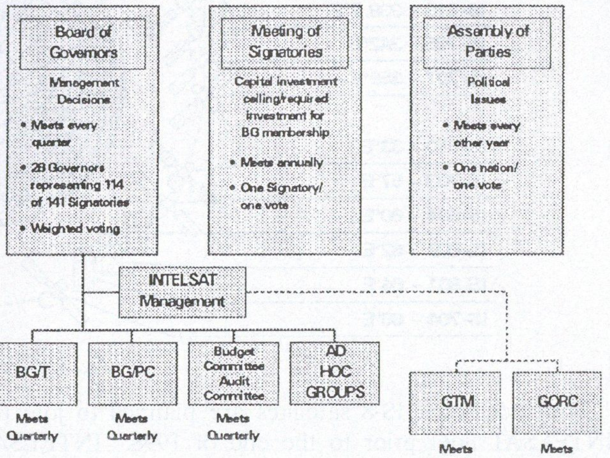

Fig. 1. INTELSAT Organization

3. INTELSAT TODAY

Today, through its global satellite network of more than 20 geosynchronous satellites, INTELSAT serves the international, regional and domestic telecommunication requirements of more than 180 countries and territories. The system connectivity extends among more than 2,200 earth station links. INTELSAT is owned by 141 member nations whose investment in the organization varies from a minimum of 0.05 percent. In 1996 INTELSAT's operating revenues were in excess of US Dollars 910 million.

The total staff of INTELSAT is less than 700 professionals and almost all of them are located in Washington, D.C./USA. In addition, there are Regional Sales Centers located in London- England, Mumbai-India and Singapore. Rather than opening a fourth Regional Sales Center in Africa, which was earlier planned, INTELSAT signed an agreement with RASCOM Organization located in Abidjan, Cote d'Ivoire, for RASCOM to promote its interests in Africa.

As a leading global satellite provider with 32 years of experience, INTELSAT offers a system reliability of 99.999 percent. INTELSAT prices are very competitive and flexible where services are offered from a minimum duration of 10 minutes up to a long term commitment of 15 years. To better serve its customers and in order to facilitate efficient utilization of its resources, INTELSAT provides free-of-charge technical assistance and training. The technical assistance program is known as IADP and to date more than 120 countries and organizations have benefited from IADP assistance.

To meet the challenges of competition and telecommunications market growth, the Assembly of Parties of INTELSAT decided in April of this year to progress with the restructuring on INTELSAT. Specifically, the Assembly affirmed its intention to authorize the establishment of a commercial affiliate (INC) and selected the Netherlands as its jurisdiction of incorporation.

4. EVOLUTION OF INTELSAT SATELLITES

Fig. 2 shows the current INTELSAT capacity in orbit. In addition to IS-6, IS-7 and IS-8 series of satellites, the system is still served by some of the ageing IS-5 series of satellites. The first IS-8 (IS-801) satellite is currently located at the 62 degrees East longitude and later will be relocated to the 64 degrees East longitude enabling 2 degree satellite spacing in the Indian Ocean Region (IOR). The second IS-8 was launched in June and it will be stationed at the 174 degrees East longitude towards the end of August following the in-orbit testing.

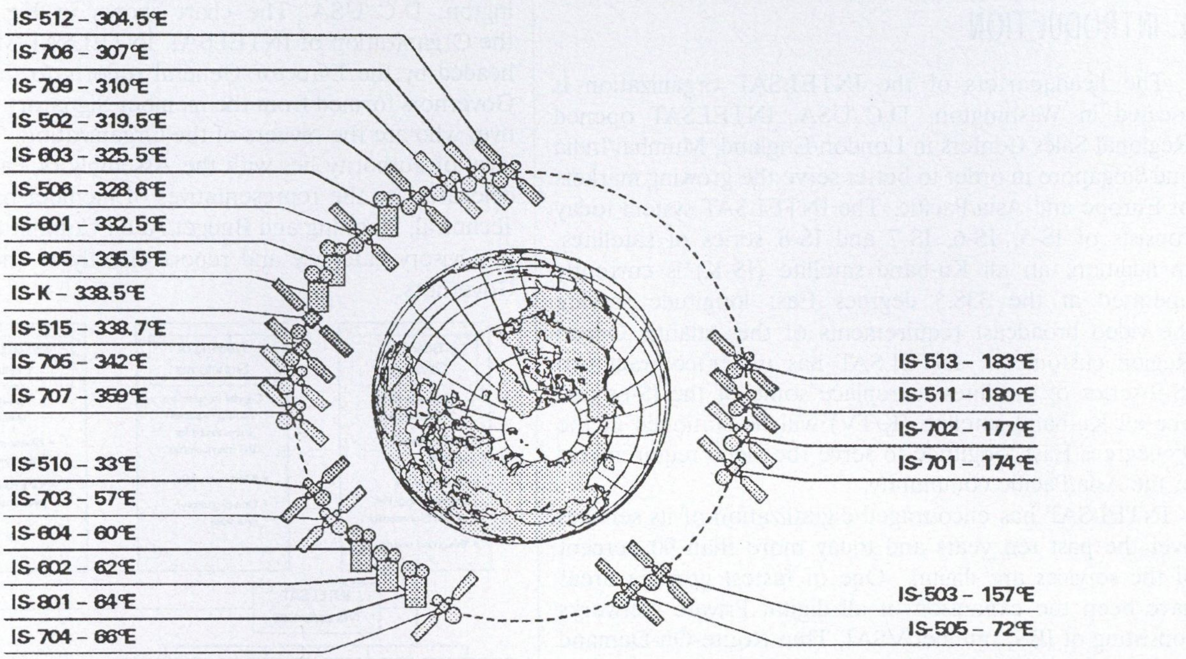

Fig. 2. Current Capacity in Orbit

Four additional IS-8 satellites are planned to join the INTELSAT fleet prior to the end of 1998. INTELSAT has under contract an all Ku-band satellite, IS-K/TV, to be operational at 95 degrees East longitude in the Asia-Pacific region in early 1999 and two additional IS-9 series of satellites are under construction to replace some of the IS-6 satellites by the turn of the century.

Table 1 displays a comparison of IS-5 through IS-9 satellites including IS-K/TV. The downlink e.i.r.p. of C-band transponders have increased by at least 5 dB while the downlink e.i.r.p. for Ku-band transponders have gone up by at least 3 dB. The IS-6 satellites were the largest commercial satellites ever built with 38 C-band and 10 Ku-band transponders. Although IS-7/7A satellites were smaller than IS-6, they offered added flexibility at Ku-band with three Ku-band antennas which can be pointed anywhere within the field-of-view.

Table 1. INTELSAT Spacecraft Performance Comparison (beam edge e.i.r.p. in dBW)

Coverage	IS-5	IS-6	IS-V7	IS-7A	IS-8	IS-9	K-TV
C-band Hemi/ /Zone	29	31	33	33	34.5/ /36*	37	–
C-band global	23.5	26.5	26	29	29	31	–
C-band spot	32.5	n/a	33	36	n/a	–	–
Ku-band spot*	41/44	44/47	44.5/47	47	44/47	45/47	43 to 51**
Number of C-band transponders	26	38	26	26	38	44	–
Number of Ku-band transponders	6	10	10	14	6	12	30

* e.i.r.p. levels for both outer and inner coverages provided.

** Outer edge e.i.r.p. levels for different beams.

In addition to higher downlink e.i.r.p. capability, IS-8 series of satellites offer much larger C-band capacity than IS-7s with a total of 38 C-band transponders. The IS-9 satellites will provide even larger capacity than IS-8s with a total of 56 transponders.

5. DIGITALIZATION OF SERVICES

As shown in Fig. 3, INTELSAT services can be grouped into the following categories:

a) Public Switched Telecommunication Networks (PSTN) consist of analog (FDM/FM, CFDM/FM and VISTA) and digital (IDR, TDMA, SCPC, VISTA and DAMA) service offerings.

b) The Private Network services (IBS, Intelnet/VSAT, DAMA) are offered digital and are non-PSTN.

c) Under the Transponder Lease offerings it is possible to establish services for both domestic and international telecommunication requirements for voice, data and video applications.

d) Within the Broadcast group of services INTELSAT offers point-to-point and point-to-multi point video and radio program distribution. These are lease services and the Occasional-Use TV service is offered on a per minute usage basis.

e) The last group is the Cable Restoration services offered on a transponder lease as well as channel basis on designated Inclined Orbit Operation (IOO) and station-kept satellites. The cable operators, however, prefer to operate on IOO satellite capacity to minimize restoration charges.

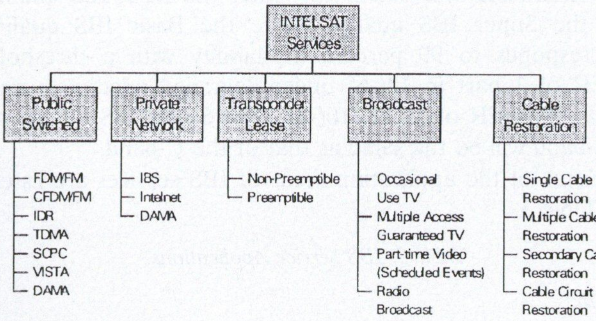

Fig. 3. INTELSAT Services

INTELSAT has been encouraging digitalization of its services for the past 10 years in order to improve system efficiency. In 1996 only 7.2 percent of the total revenues were generated from analog PSTN services while the revenues generated from digital PSTN services constituted nearly 35 percent of the total revenue. Although, majority of TV services, either full-time or occasional-use, are still broadcast as analog, there is considerable work towards digitalization of video services. Last year INTELSAT issued an open invitation to manufacturers of digitally compressed video equipment to participate in an independent interoperability testing at INTELSAT facilities. These studies were concluded to a report, which was issued showing a wide range of compatibility between various manufacturers MPEG-2 encoding equipment.

Table 2. INTELSAT Gateways

Type	Earth Station standard	Antenna size (m)	Minimum G/T (dB/K)	Service	Frequncy Bands (GHz)
Large	A	15 – 32	36.0	Telephony, Data, TV, IBS	6/4
Country	B	11-30	37.0	Telephony, Data, TV, IBS	14/11 and 12
	C	11-13	31.7	Telephony, Data, TV, IBS	6/4
Intermediate	F-3	9 – 10	29.0	Telephony, Data, TV, IBS	6/4
(teleport)	E-3	8 – 10	34.0	Telephony, Data, TV, IBS	14/11 and 12
	F-2	7 – 8	27.0	Telephony, Data, TV, IBS	6/4
	E-2	5 – 7	29.0	Telephony, Data, TV, IBS	14/11 and 12
Small	F-1	4.5 – 5	22.7	IBS, TV	6/4
(business)	E-1	3.5	25.0	IBS, TV	14/11 and 12
	D-1	4.5 – 5.5	22.7	VISTA	6/4
VSAT	G	0.6 – 2.4	5.5	INTELNET	6/4; 14/11 and 12
TVRO				TV	6/4; 14/11 and 12

6. INTELSAT PRIVATE NETWORK DIGITAL SERVICES

One of the fastest growing services of INTELSAT has been all digital private networks. These consist of IBS, Intelnet/VSAT, Thin-Route-On-Demand (also known as DAMA), Business TV and Internet. Table 2 presents the characteristics of the whole spectrum of earth stations that can be used in connection with INTELSAT services.

6.1. IBS

IBS is offered either as a carrier-based or as a lease service. The carrier-based offering can vary from a minimum of 64 kbit/s up to 8.448 Mbit/s or even higher rate. IBS can also be leased from a minimum of 100 kHz up to a full transponder bandwidth. The INTELSAT system accommodated 1,200 IBS carriers with an equivalent 13,000 64 kbit/s channels. The total capacity dedicated for IBS is approximately 48 units of 36 MHz.

The technical features of IBS are defined in the INTELSAT Earth Station Standards document (IESS-309). The service is offered either as open or a closed network with QPSK modulation with Forward Error Correction (FEC) rates of 1/2 and 3/4 FEC. The service is protocol transparent and selection of the protocol is up to the user.

This service is offered at C-band with an availability of 99.96 percent of an average year with a threshold Bit Error

Rate (BER) of 1 part in 10(-3) under degraded conditions and a clear-sky BER better than 1 part 10(-8). At Ku-band operation the user can select either the Basic IBS quality or the Super IBS quality where the Basic IBS quality corresponds to 99 percent availability with a threshold BER of 1 part in 10(-6) under degraded conditions and clear-sky BER of 1 part 10(-8). The Super IBS quality at Ku-band will be the same as that of the C-band.

Some of the application areas of IBS services are listed in Table 3.

Table 3. IBS Service Applications

Data:
Dedicated Private Line Networks
Interconnection of Mainframe Computers
Interconnection of LAN, WAN, MAN
Electronic Data Interchange (EDI)
Electronic Mail
Document Distribution
Facsimile Transmission
Internet
Telex
Voice:
Digital Voice
Interconnection of PABX
Dedicated Private Line Networks
High Quality Audio Distribution
Internet
Video:
Video Conferencing
Business TV

6.2. Intelnet/VSAT

Intelnet is INTELSAT's VSAT service and it is offered as lease allotment from a minimum resource of 100 kHz up to a full 36/72 MHz transponder. There are no restrictions on the antenna size, modulation technique, FEC coding or the access technique. Intelnet networks are operated either in a star or a mesh configurations with a large hub earth station as a network control center and smaller remote terminals. There are numerous applications of Intelnet/VSAT services in the INTELSAT system. Some of the widely used applications are news distribution, point-of-sale for inventory and credit/check verification, reservations for hotels/motels, airlines and car rental agencies, data collection and distribution, financial transactions, environmental data transmission, etc. There are 130 Intelnet leases operational in the INTELSAT system occupying 10 units of 36 MHz.

6.3. Thin Route-On-Demand

INTELSAT's Thin Route-On-Demand DAMA service is usage-based and it is charged on a per minute basis. The service offers state-of-the-art digital solution for many PSTN applications. It can provide thin route operators instant dial-up with a global connectivity and rapid implementation. The service offering is 16 kbit/s (LD CELP) telephony for speech, fax, and voiceband data applications. It provides internationally accepted voice quality and supports facsimile and voiceband data at speeds of up to 14.4 kbit/s.

This service is supported by a wide range of earth stations, from a large gateway (Standard A or Standard B) down to a VSAT as small as 1.8 meter in diameter. The terminal equipment for DAMA is modular in design, can be sized according to the customer's projected traffic, and can also be expanded in single channel increments. A typical DAMA network architecture is displayed in Fig. 4. The network is a virtual switch in the sky and allocates space segment resources from a pool of available channels on demand. The resource allocation is managed by the Network Control Management Center (NMCC) and satellite circuit connections are automatically established by allocating a pair of available satellite channels. When a call is completed, the channels are returned to the common pool for reassignment.

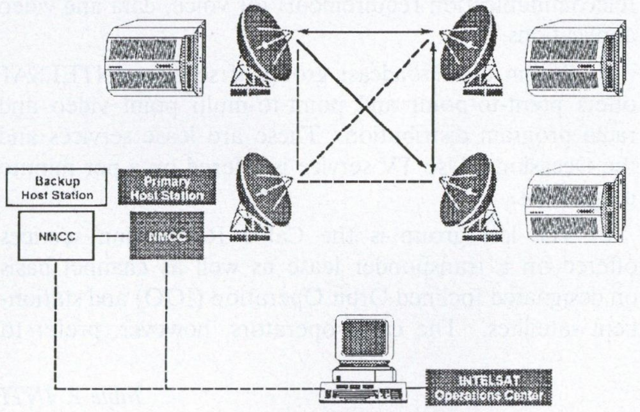

Fig. 4. DAMA Network Architecture

The Thin Route-On-Demand DAMA service is offered in global transponders at the 335.5E longitude in the AOR, the 60E degrees longitude in the IOR and the 174E degrees longitude in the POR. The AOR network was the first one to offer service starting in April 1996 following the opening of the Primary and the Backup NMCCs.

6.4. Video Broadcast Services and DTH

INTELSAT offers television services on a long term, short term and occasional-use basis in order to meet a range of requirements of our customers for both analog and digital video transmissions. INTELSAT satellite resources, at both C- and Ku-band, are capable of providing capacity for various television program contribution and distribution, Satellite News Gathering (SNG), Direct-To-Home (DTH) applications, High Definition TV (HDTV), business TV and multimedia applications. In addition to capacity used for long and short term video leases, INTELSAT has dedicated seven 41 MHz global transponders at C-band for occasional use applications. This capacity can be booked with a short advance notice and it provides global connectivity among more than 700 sites. Some of the major events broadcast through these transponders are:

i) fast breaking news coverage using fly-away or transportable terminals (Bosnia, Rwanda, Gulf),

ii) major scheduled events (Olympics, World Cup, Political Summits, Sports),

iii) feeds from remote locations (sea, mountain climbing expeditions).

One of the markets that is most affected by recent advances in digital video compression technology is the SNG applications. Through combination of digital compression and high power satellites, INTELSAT can now offer SNG not only in Ku-band, but also in C-band with truly global coverage reaching the most remote sites of the World enabling use of small (1.5 to 2.4 meter diameter) fly-away terminals.

INTELSAT today offers DTH applications for video broadcasting resulting from evolution of its satellites with high power Ku-band capability. DTH applications enable home reception of the video transmission using a dish size of less than 1 meter in diameter. Today on the INTELSAT system Orbit Communications, for example, is using high-power Ku-band spot beams on the IS-703 and IS-705 satellites at 57E and 342E, respectively, for its DTH broadcasting. This network was the first in the World as a fully digital, multi-channel, multilingual pay television DTH service. Another example would be the DTH network introduced by Telenor of Norway on the IS-707 satellite at 359E. Telenor provides service to more than 1.4 million subscribers, including 80 percent of the Nordic households using private satellite dish receivers. Both companies have plans to continue to work with INTELSAT to expand their networks even further.

6.5. Internet

Through its global connectivity and range of digital service offerings, INTELSAT can provide access to the Internet networks anywhere in the World. INTELSAT has shown by live tests and demonstrations that the satellite connectivity for Internet works and it is the fastest method of providing access to the World-Wide-Web (WWW). It should further be noted that satellites are ideal for broadcast and multicast data applications, and are perfect for thin-route information transmission allowing growth as markets develop. Since satellites can support asymmetric network architectures, they are very flexible and cost-effective solutions for Internet Service Providers (ISP).

@intelsat is INTELSAT's Internet service offering and provides global Internet access with a wide variety of earth station sizes and service offerings. Fig. 5 shows the relationship of the *@intelsat* products to the Internet access environment. This connectivity enables backbone providers to link regions with already well developed communications services (*@intelsat.backbone*). ISPs can establish access to a backbone network as shown in Fig. 6 and provide a distance-insensitive solution to quickly implement Internet services in areas with rapidly expanding customer demand (*@intelsat.access*). Corporations can establish a connection to an ISP or another corporate location for Intranet and Extranet expansion (*@intelsat.enterprise*) as shown in Fig. 7.

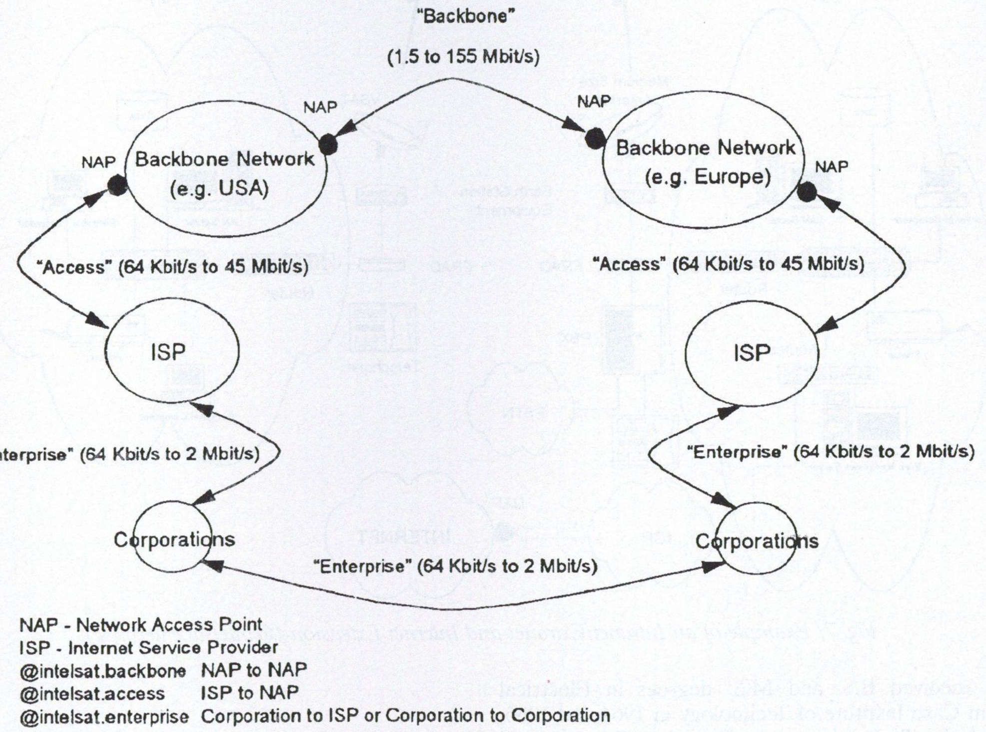

Fig. 5. The @intelsat Product Suite

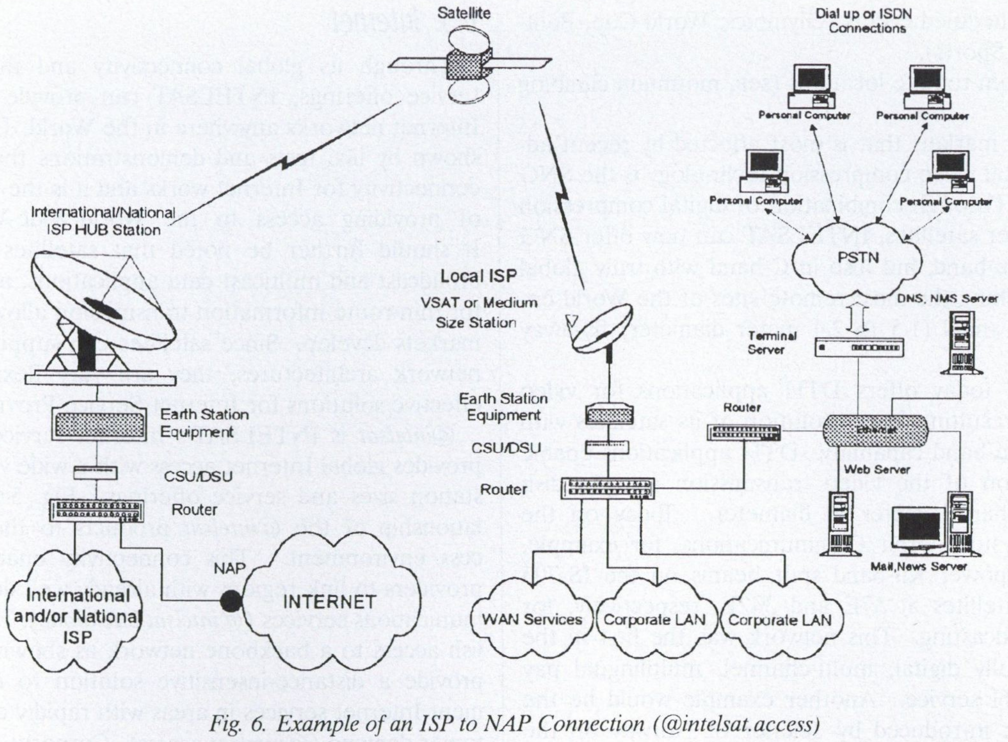

Fig. 6. Example of an ISP to NAP Connection (@intelsat.access)

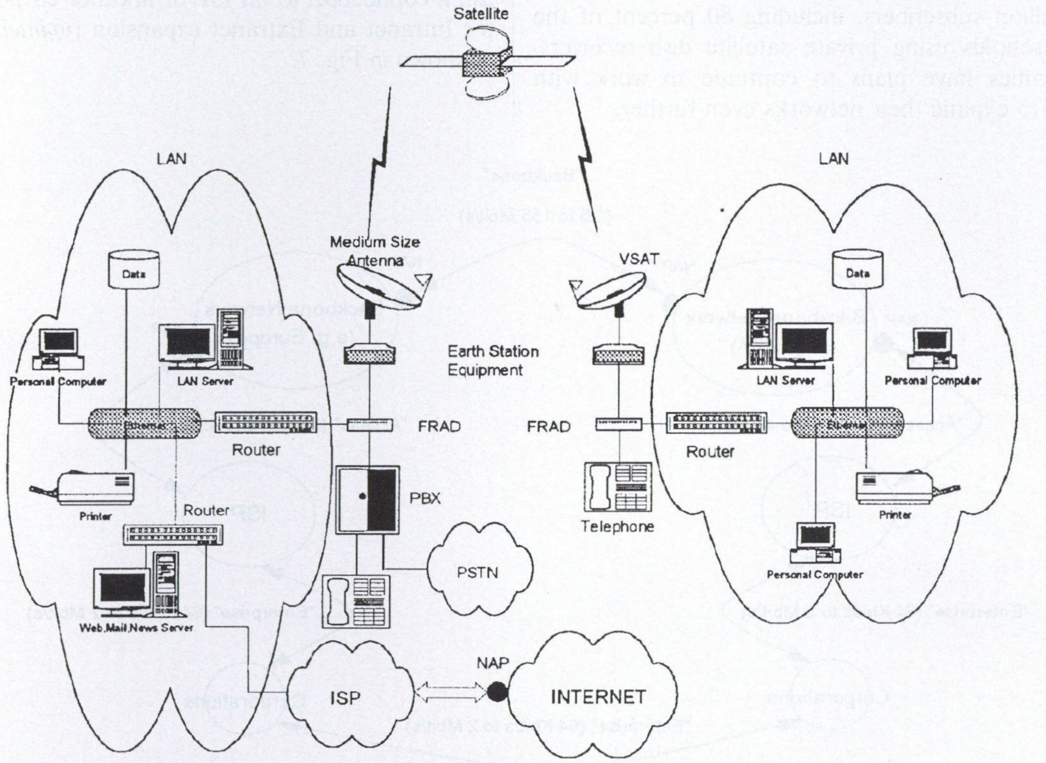

Fig. 7. Example of an Intranet/Extranet and Internet Extension (@intelsat.enterprise)

A. Tuna Alper received B.S. and M.S. degrees in Electrical Engineering from Case Institute of Technology in 1964 and 1966, respectively, and the Ph.D. degree in Electrical Sciences and Applied Physics from Case Western Reserve University in 1969 in Cleveland, Ohio/USA. 1969 Through 1970 he was a Member of the Technical Staff of Bell Telephone Laboratories in Holmdel, New Jersey/USA. From 1970 to 1975 he held a post as a Principal Scientist within the Electronics Unit of the Marmara Research Institute in Gebze, Kocaeli/Turkey. Dr. Alper joined the Communications Division of SHAPE Technical Centre in 1975 where he worked on military satellite communication systems. He has been with INTELSAT since 1982 and he is currently the Regional Sales Director with responsibility for Eastern Europe and the NIS counties. Prior to this, he served as the Manager of INTELSAT's Lease and Private Network services supervising marketing of INTELSAT's IBS, Intelnet/VSAT and Domestic Network service offerings.

EUTELSAT

M. CHABROL

EUTELSAT EUROPEAN TELE SATELLITE ORGANIZATION
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Wishing to continue the establishment of the telecommunications satellites for the development of relations between nations and according to their economies, and their desire to strenghthen their cooperation in this field, EUTELSAT was created in 1977 and formally established in 1985. The initial membership of 17 countries now stands at 45. Applications to join by Estonia, Kayakhstan and Slovenia are being finalized.

1. INTRODUCTION

EUTELSAT's Signatories use the satellites as part of their domestic and international networks and also lease capacity to other users. Their shareholding is determined annually according to use of capacity. Minimum share is 0.05 per cent.

Non-Signatory service providers in some EUTELSAT member countries have also been licensed to operate national and international networks. In non-member countries, service providers can be granted governmental authorization to access EUTELSAT capacity.

In January 1996, EUTELSAT's Assembly of Parties approved an amendment to the Organization's founding treaty, the Convention, permitting the designation of more than one Signatory per EUTELSAT member-country, which means that new entities such as telecommunications operators or broadcasters may invest in the Organization's satellite system and have direct access to it, in the same way as current Signatories.

The procedure for amending the Convention provides for a ratification period of approximately 18 months. In the interim, new shareholders may be admitted alongside Signatories under national arrangements granting them the status of Non-Signatory-Entities (NSE), with the same rights and obligations as Signatories but without the right to vote. They will subsequently have the option to become Signatories once the relevant amendments to the EUTELSAT Convention have entered into force.

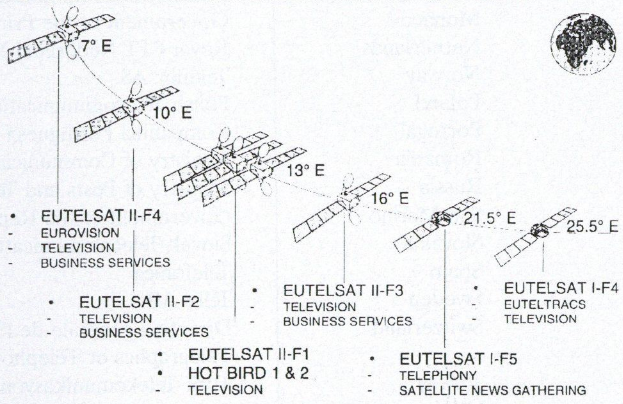

Fig. 1. The EUTELSAT System in January 1997

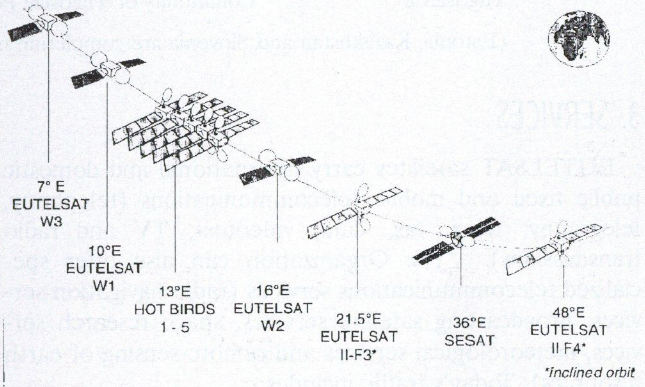

Fig. 2. The EUTELSAT System in 2001

2. EUTELSAT INVESTMENT SHARES

Country	*Signatory*	*%*
Albania	Albanian Telecommunications Enterprise	0.296210
Andorra	Servei de Télécommunications d'Andorra	0.050000
Armenia	Ministry of Telecommunications	0.050000
Austria	Austrian Administration of Posts and Telegraphs	0.538638
Azerbaijan	Ministry of Communications	0.050000
Belaros	Ministry of Posts, Telecommunications and Informatics	0.050000
Belgium	Belgacom	6.541550
Bosnia-Herzegovina	Public Enterprise of PTT Transport	0.079113
Bulgaria	Bulgarian Telecommunications Company Ltd	0.050000
Croatia	Ministry of Maritime Affairs, Transport and Communications	0.558416
Cyprus	Cyprus Telecommunications Authority	0.856989
Czech Republic	Ceske Radiokomunikace a.s.	0.266929
Denmark	Tele Danmark Ltd	0.728174
Finland	Telecom Finland Ltd	0.169677
France	France Telecom	15.375334
Georgia	Ministry of Communications of the Republic of Georgia	0.050000

Germany	Deutsche Telekom AG	8.096564
Greece	Hellenic Telecommunications Organization (OTE)	1.358104
Hungary	Hunsat	2.070325
Iceland	Post and Telecommunications Administration of Iceland	0.050000
Ireland	Telecom Eireann	0.110536
Italy	Telecom Italia Spa	12.742020
Latvia	Lattelekom	0.059493
Liechtenstein	Government of the Principality of Liechtenstein	0.054787
Lithuania	Ministry of Communications and Informatics	0.050000
Luxembourg	Administration des Postes et Télécommunications	2.592771
Malta	Government of the Republic of Malta	0.050000
Moldova	Ministry of Communications and Informatics	0.050000
Monaco	Government of the Principality of Monaco	0.050000
Netherlands	Royal PTT Nederland NV (KPN)	8.859155
Norway	Telenor AS	0.250950
Poland	Polish Telecommunications S.A.	3.190733
Portugal	Companhia Portuguesa Radio Marconi (CPRM)	1.700000
Romania	Ministry of Communications	0.211283
Russia	Ministry of Posts and Telecommunications	0.722516
San Marino	Government of the Republic of San Marino	0.050000
Slovakia	Slovak Telecommunications	1.154647
Spain	Telefonica	4.179359
Sweden	Telia AB	1.497153
Switzerland	Direction générale de l'Entreprise des Postes, Télégraphes et Téléphones Suisses	0.771758
Turkey	Türk Telekomunikasyon AS	0.698140
Ukraine	Concern of Broadcasting, Radiocommunications and Television	0.054787
United Kingdom	British Telecommunications p.l.c.	22.589739
Vatican City	Governorate of the Holy See	0.050000
Yugoslavia	Community of Yugoslav Posts, Telegraphs and Telephones	0.974150

(Estonia, Kazakhstan and Slovenia are completing membership procedures.)

3. SERVICES

EUTELSAT satellites carry international and domestic public fixed and mobile telecommunications (telephony, telegraphy, telex, fax, data, videotext, TV and radio transmissions). The Organization can also offer specialized telecommunications services (radio-navigation services, broadcasting satellite services, space research services, meteorological services and remote-sensing of earth resources). Today's traffic includes:

1. Analogue and digital TV and radio channels for DTH, cable and community reception
2. EBU Eurovision and Euroradio exchanges
3. Satellite newsgathering
4. Domestic and international trunk and thin route telephony
5. Business communications
6. Land and maritime mobile communications (EUTELTRACS)
7. Multimedia services (Internet, etc.)

1. TV and radio channels for DTH, cable and community reception

Both analogue and digital television and radio channels generally access capacity on a full-time lease basis. Over 60 million homes equipped with DTH antennas or connected to cable and community networks receive channels from the Hot Bird position at 13 degrees East.

2. EBU Eurovision and Euroradio networks

The EBU has been using EUTELSAT since 1984 for its daily Eurovision exchanges, and added a Euroradio service in 1989.

Its programme exchange network is routed via five Widebeam transponders on EUTELSAT II-F4. The extended Widebeam coverage on EUTELSAT II-F4 enables the EBU with one satellite to reach its 62 active members in 48 countries in Europe, North Africa and the Middle East.

3. Satellite newsgathering (SNG)

Capacity on EUTELSAT transponders is used by TV broadcasters for satellite newsgathering via transportable stations. EUTELSAT's booking office coordinates part-time use of SNG capacity.

4. Domestic and international telephony

Public switched digital telephony is carried on four EUTELSAT transponders via a network of 19 earth stations serving 22 countries, most recently Russia with the entry into service of a new station in Moscow in December 1996. This network is being extended further in eastern Europe.

5. Business services (SMS)

A total of 15 transponders (six on EUTELSAT II-F2, eight on EUTELSAT II-F4 and one on EUTELSAT II-F3) carry traffic for EUTELSAT's Satellite Multiservices System (SMS). SMS applications include remote-printing, videoconferencing, data transmission, civil protection, computer interconnection etc. Users connect to SMS either through a shared antenna (for example at a teleport) or through individual on-site antennas.

6. Mobile communications – EUTELTRACS

EUTELTRACS, the two-way message-exchange and position-reporting service for land and maritime mobiles, operates via EUTELSAT capacity in Europe, North Africa and the Middle East. Over 14,000 terminals are currently operational in the road transport sector, and more than 1.00 fishing vessels in four European Union countries are already equipped with EUTELTRACS.

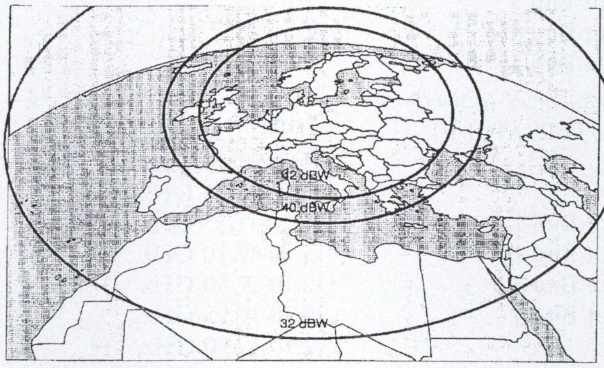

Fig. 3. EUTELTRACS Coverage

EUTELSAT manages the satellite links of EUTELTRACS via an earth station at Rambouillet, near Paris. National and regional service providers market the system to end-users. Software and terminals are distributed by the joint venture company Alcatel Qualcomm.

3.1. EUTELSAT II

The initial contract in 1986 for the EUTELSAT II series called for three satellites with an option for five additional satellites. A fourth satellite was ordered in June 1987, a fifth in March 1989 and a sixth in September 1990. The fourth and fifth EUTELSAT II satellites were modified to extend their Widebeam coverage as far as Moscow and surrounding area (EUTELSAT II-F5 was lost at launch). EUTELSAT II-F6 (Hot Bird 1) was modified for collocation with EUTELSAT II-F1 at 13 degrees East.

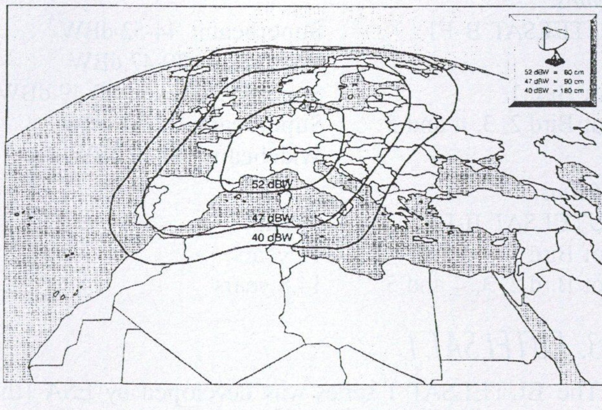

Fig. 4. EUTELSAT II Superbeam Coverage

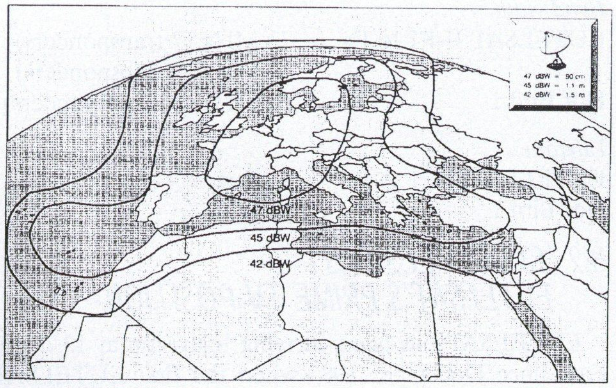

Fig. 5. Widebeam Coverage

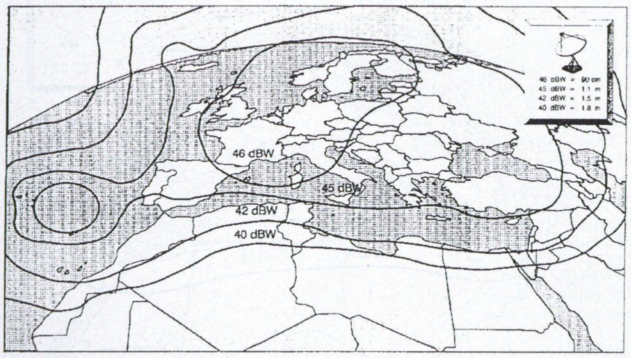

Fig. 6. EUTELSAT II-F4 Coverage

Launches:	
EUTELSAT II-F1	30.08.90, Ariane V38
EUTELSAT II-F2	15.01.91, Ariane V41
EUTELSAT II-F3	07.12.91, Atlas II, AC-102
EUTELSAT II-F4	09.07.92, Ariane V51
EUTELSAT II-F5	24.01.94, Ariane V63 (launch failure)
Hot Bird 1 (EUTELSAT II-F6)	28.03.95, Ariane V71
Locations:	
EUTELSAT II-F1	13° E
EUTELSAT II-F2	10° E
EUTELSAT II-F3	16° E
EUTELSAT II-F4	7° E
Hot Bird 1	13° E
Transponders:	
16 (plus 8 back-up)	50 Watt TWTAs on EUTELSAT II-F1-F4 70 Watt on Hot Bird 1
Frequencies (downlink):	
EUTELSAT II-F1-F4	10.95-11.20 GHz, 11.45-11.70 GHz, 12.50-12.75 GHz,
Hot Bird 1	11.20-11.55 GHz
Power:	
EUTELSAT II-F1 to F4	Superbeam: EIRP 44-52 dBW
EUTELSAT II-F1 to F4	Widebeam: EIRP 39-47 dBW
Hot Bird 1	Super-Widebeam: EIRP 4O-49 dBW

Bandwidth:

EUTELSAT II-F1 to F4	72 MHz (7 transponders)
	36 MHz (9 transponders)
Hot Bird 1	36 MHz (16 transponders)

Lifetime:

EUTELSAT II-F1 to F4	9 years
Hot Bird 1	11 years

3.2. 13 DEGREES EAST EUTELSAT'S PRIME TV POSITION

EUTELSAT has been carrying television at 13 degrees East since December 1983 when the first EUTELSAT I satellite went into service. In September 1990 the first EUTELSAT II satellite took over at this slot.

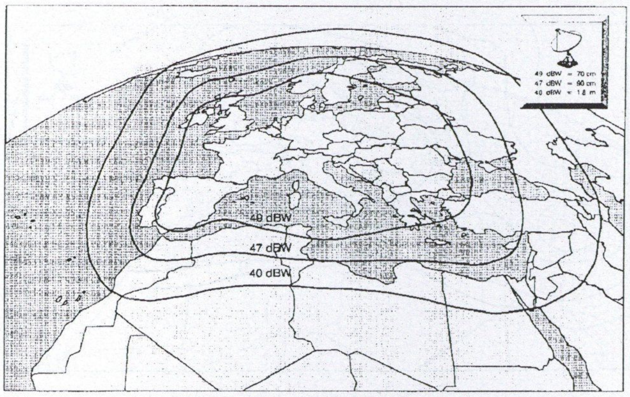

Fig. 7. Hot Bird 1 Coverage

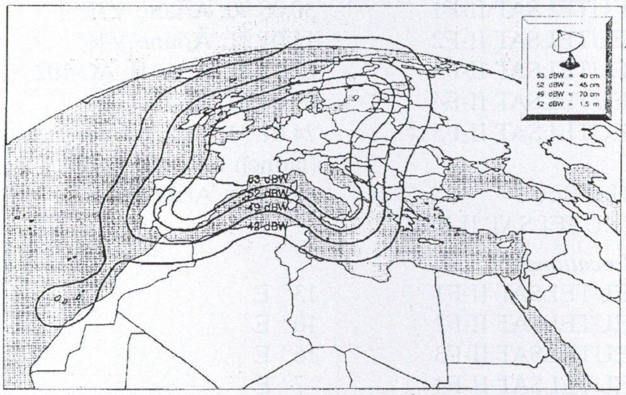

Fig. 8. Hot Bird 2, 3, 4 and 5 Superbeam Coverage

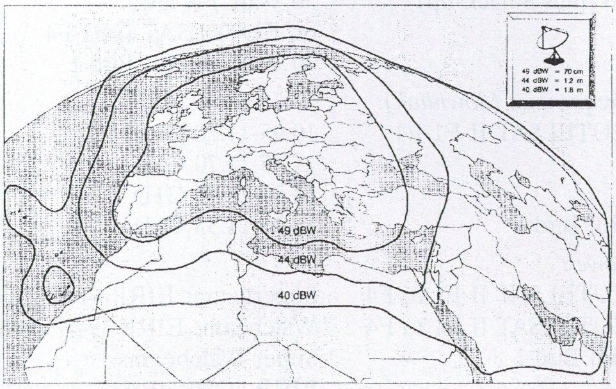

Fig. 9. Hot Bird 2, 3, 4 and 5 Widebeam Coverage

In March 1995 EUTELSAT launched a second television satellite for 13 degrees East, called Hot Bird 1, followed in November 1996 by Hot Bird 2. The three satellites will be joined in 1997 by Hot Bird 3 and Hot Bird 4, and in 1998 by Hot Bird 5 which will replace EUTELSAT II-F1.

Transponders:

EUTELSAT II F1	16
Hot Bird 1	16
Hot Bird 2	20
Hot Bird 3	20
Hot Bird 4	20
Hot Bird 5	22

Frequencies (downlink):

EUTELSAT II-F1	10.95-11.20 GHz, 11.55-11.70 GHz, 12.50-12.75 GHz
Hot Bird 1	11.20-11.55 GHz
Hot Bird 2	11.70-12.10 GHz
Hot Bird 3	12.10-12.50 GHz
Hot Bird 4	10.70-10.95 GHz, 12.10-12.50 GHz, 12.50-12.75 GHz
Hot Bird 5	10.95-11.20 GHz, 11.55-11.70 GHz, 12.50-12.75 GHz

Bandwidth:

EUTELSAT B-F1	72 MHz (7 transponders)
	36 MHz (9 transponders)
Hot Bird 1	36 MHz
Hot Bird 2	33 MHz (36 MHz, 72 MHz)
Hot Bird 3	33 MHz (72 MHz, 60 MHz, 49.5 MHz)
Hot Bird 4	33 MHz, 46.5 MHz, 36 MHz
Hot Bird 5	33 MHz, 36 MHz, 72 MHz

Power:

EUTELSAT B F1	50 Watt
Hot Bird 1	70 Watt
Hot Bird 2 and 3	115 Watt
Hot Bird 4	135 Watt
Hot Bird 5	135 Watt

Beams:

EUTELSAT B-F1	Superbeam: 44-52 dBW
	Widebeam: 39-47 dBW
Hot Bird 1	Super-Widebeam: 40-49 dBW
Hot Bird 2, 3, 4 and 5	Superbeam: 42-53 dBW
	Widebeam: 40-49 dBW

Lifetime:

EUTELSAT II-F1	9 years
Hot Bird 1	11 years
Hot Bird 2, 3, 4 and 5	14.5 years

3.3. EUTELSAT I

The EUTELSAT I series was developed by ESA (the European Space Agency) as part of the ECS (European Communications Satellite) programme. Once launched and checked out in orbit each satellite was handed to EUTELSAT for commercial operations. The satellites are maintained by ESA from its Redu earth station in Belgium.

Four EUTELSAT I satellites were successfully launched between 1983–88. EUTELSAT I-F4 and -F5 are still operating.

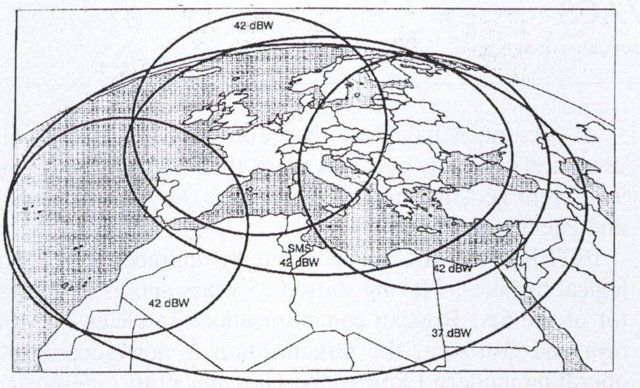

Fig. 10. EUTELSAT I Coverage

Launches:

EUTELSAT I-F1	17.06.83, Ariane L6
EUTELSAT I-F2	04.08.84, Ariane V10
EUTELSAT I-F3	12.09.85, Ariane V15 (launch failure)
EUTELSAT I-F4	16.09.87, Ariane V19
EUTELSAT I-F5	21.07.88, Ariane V24

Locations:

EUTELSAT I-F4	25.5° E
EUTELSAT I-F5	21.5°E

Transponders:
10 (plus two back-up); 20 Watt TWTAs

Frequencies (downlink):
10.95-11.2 GHz, 11.45-11.7 GHz, 12.5-12.75 GHz

Power:

Atlantic, West and East spots:	EIRP 40.8-46.0 dBW
Eurobeam:	EIRP 34.8-41.0 dBW
SMS beam:	EIRP 39.8-43.5 dBW

Bandwidth:
72 MHz

Design life:
7 years

3.4. W Series

In July 1995 EUTELSAT ordered three satellites from an international consortium headed by Aerospatiale to provide telecommunications services primarily over Europe. The contract also provides for an optional purchase of up to four additional satellites. Called the W series the new satellites, will start to replace the EUTELSAT II generation at 10, 7 and 16 degrees East in early 1998.

Launches:	W1 – December 1997 W2 – third quarter 1998 W3 – first quarter 1999
Orbital positions:	W1 – 10 degrees East W2 – 16 degrees East W3 – 7 degrees East
Transponders:	24
Frequency bands (downlink):	10.95-11.70 GHz, 12.50-12.75 GHz
Bandwidth:	72 MHz, 36 MHz
Power:	90 Watt
Beams	Fixed beam 47-49 dBW; steerable beam 52 dBW
Lifetime:	12 years

2.5. SESAT

In August 1995 EUTELSAT ordered a satellite to meet telecommunications needs in central and eastern Europe.

Called SESAT (*S*iberia *E*urope *Sat*ellite) and due for delivery in orbit in December 1998 it is designed to provide 18 channels for a minimum operational lifetime of 10 years. SESAT is being built by NPO-PM of Russia together with Alcatel Espace of France.

Delivery:	December 1998
Orbital position:	36 degrees East
Transponders:	18
Frequencies (downlink):	10.95-11.20 GHz, 11.45-11.70 GHz, 12.50-12.75 GHz
Power:	95 Watt
Bandwidth:	72 MHz
Beams:	Widebeam: 47 dBW, Steerable beam: 49 dBW
Lifetime:	10 years

INTERSPUTNIK JUMPS AHEAD

I. KOVÁCS

LOCKHEED MARTIN INTERSPUTNIK LTD.

The paper introduces the INTERSPUTNIK organization, which is turning from intergovernmental organization to a business oriented organization. INTERSPUTNIK has substantially upgraded its technological facilities using the most powerful DBS series in the world today.

INTERSPUTNIK, the International Organization of Space Communications, is an intergovernmental satellite telecommunications organization similar to Intelsat and Eutelsat. INTERSPUTNIK has 22 member-countries and more than 25 years of experience. It was created as the Soviet bloc's organization in opposition to Intelsat. All the countries in the Soviet sphere were members.

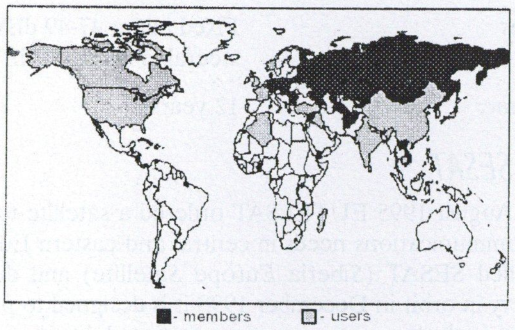

Fig. 1. The INTERSPUTNIK organization

When the deregulation of politics came to the socialist countries bloc, there was no reason to have a rival satellite organization anymore, so it became more of a coimmercial organization. Despite of this it still maintains intergovernmental characteristics — the headquarters are in Moscow, it has observer status at the UN asnd ITU and the Supreme Body is the Assembly of Parties comprised of one representative from each member country. However, it is worth saying that INTERSPUTNIK differs from other intergovernmental satellite organizations in terms that the direct access to the satellites is permitted, that is to say, you do not have to book the capacity through one of the signatory countries.

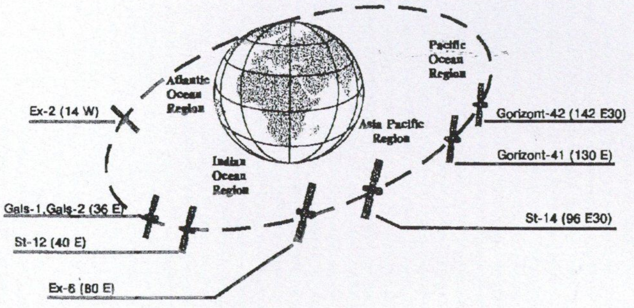

Fig. 2. INTERSPUTNIK satellite system

At present, it has more than 100 state-run and private users and currently operates more than 36 transponder on 9 different geostationary satellites over the Atlantic, Indian and Pacific Oceans.

INTERSPUTNIK has substantially upgraded its technological facilities. Having started 25 years ago as an operator of the first Russian communications satellites — Molniya and Gorizont, the Organization is now successfully operating modern Express and Gals spaceraft.

The Gals satellites are the most powerful DBS series in the world today. Since 1994 the Gals direct broadcast satellites are being used in the system. These satellites are designed to provide direct-to-home television. The first Gals-series satellite was put into orbit in January 1994 and another one in November 1995. Their maximum beam-center EIRP is 57 dBW making it possible to use 60 cm receive dishes.

The Express satellites feature better characteristics and more capacity. These satellites have improved the system's performance, service quality and cost efficiency. Since 1994 the Gals direct broadcast satellites have been used in the system. The Express-2 satellite began operations at 14W00 in 1995 and the Express-6 satellite in November of 1996.

INTERSPUTNIK earth stations use state-of-the-art radio equipment available on the world market. They provide all kinds of high quality services with a high degree of reliability.

Over the last five years, INTERSPUTNIK has grown quite considerably. In 1991, it was using 16 transponders, and now it is up to 36. Internal forecast indicate that by the year 2000 it could go up to 170 transponders for all regions of the world.

The growth of traffic has been quite considerable. TV traffic has grown five and a half times in the last five years. Voice traffic has grown six times.

In order to meet this demand INTERSPUTNIK realized it can no longer link its future development with Russian masnufacturing industry which unfortunately faces problems related to credits and financing.

It was the XXIVth Session of the Board held in October of 1995 which approved the formation of a new joint venture stock company to operate a fleet of non-Russian satellites.

The main objectives of this historic decision are that INTERSPUTNIK will have its own orbital slots, offer the usual and new range of telecommunication and broadcasting services, expand its activities and become more of a global satellite operator.

In this framework, Lockheed Martin's Space & Strategic Missiles Sector and the INTERSPUTNIK International Organization of Space Communications announced at Asia Telecom 97 in Singapore the formation of a joint venture company to provide worldwide communications services.

The new company, *Lockheed Martin INTERSPUTNIK Ltd.*, or *LMI*, will be headquarted in London with a marketing office in Moscow.

LMI will draw upon the expertise and capabilities of both companies to provide a full range of world-class satellite products and services. The substantial experience of INTERSPUTNIK as a global satellite service provider will be combined with Lockheed Martin's extensive satellite, launch and ground systems capabilities.

The first satellite deployed will be Lockheed Martin's A2100 on a Proton launch vehicle in late 1998 over the Indian Ocean region. An other satellite is expected to be deployed in later 1999 and two additional in 2000 due to market's demand and requirements. This venture will expand to as globalservice provider that will generate between \$300 – 500 million in annual revenues by 2001.

Ininitially, LMI will provide broadcast, fixed telecommunications and Very Small Aperture Terminal (VSAT) services to customers in Eastern Europe, South Asia, Africa and the Community of Independent States. These services will expand to include direct-to-home video and audio, and mobile services to customers worldwide.

The first satellite will carry 28 C-band transponders of 36 MHz and 16 Ku-band transponders of 27 MHz.

C-band transponders are planned to be used for establishing regional and domestic communications networks and TV exchange networks. The satellite EIRP in this band will allowed customers to use 2.4 m antennas at the earth stations in TV and broadcasting networks.

Ku-band transponders are planned to be used to establish regional and domestic communications networks, TV and audio broadcasting networks and business networks. The satellite EIRP in this band will allow customers to use 0.9 m receive terminals in TV and audio broadcasting networks.

To deploy the new satellites, INTERSPUTNIK has filed for 15 orbital slots with the ITU through the administrations of Belarus and Cuba. Some of these positions – 83W00, 97W00, 59E30 and 75E00 are currently under coordination.

The new comapny will provide state-of-the-art solutions to the customers' communications needs. The joint venture will pursue excellence and growth through cooperation, continues improvement and innovation.

FORECAST FOR FUTURE OF COMMERCIAL SATELLITES

L. R. DEST and M. CAYLOR

HUGHES SPACE AND COMMUNICATIONS INTERNATIONAL, INC.
P.O. BOX 9712 LONG BEACH
CA 90810, USA

Over the past several years, the commercial satellite industry has seen an explosion of new applications. Although sales of traditional geosynchronous, bent pipe communications satellites continue to grow, non-traditional applications using alternate orbital configurations, previously unused frequency bands, and advanced signal processing have become more prevalent. This expansion of applications and implementation has been fostered not only by advances in technology, but also by the increasing scarcity of available C- and Ku-band spectrum and increasing competition in the telecommunications services industry. This paper addresses changes in the commercial satellite industry with a five-year forecast showing the projected evolution in satellite applications and capabilities. The paper also describes the satellite technology development efforts at Hughes Space and Communications International to meet the evolving market requirements.

1. FIVE-YEAR FORECAST

The commercial satellite forecast is driven by a number of technical and business factors, foremost of which is the evolution in telecommunications services and applications that satellites enable. Other factors considered in the forecast are the capability to operate in non-geosynchronous orbital configurations, increase in the number of launch vehicle providers and their capabilities, and optimization of spacecraft/launcher system performance.

1.1. Evolution in Services and Applications

The five-year forecast for satellite applications and services (summarized in Table 1) points to a consolidation of systems in the traditional geosynchronous C- and Ku-band fixed satellite services and analog broadcast satellite services. Though few new systems will be developed, the need for satellite resources will continue to replenish existing telecommunications systems. Growth is also anticipated in developing regional markets that are underserved by C- and Ku-band satellite communications services. Digital direct-to-home television services are expected to continue growing over the next five years, with introduction and development of services in the Ka-band frequencies. These developments are strongly driven by the lack of available spectrum and the difficulties of coordination in the traditional Ku-band FSS and BSS frequencies.

Personal mobile communications services will play a prominent role in satellite applications over the coming five-year period. These services include the growth of existing vehicular mobile services, plus the development and introduction of satellite-based regional and global hand-held mobile communications systems. Such technologies will also support fixed mobile services to remote regions where terrestrial telephony is not practical. Fig. 1 shows the expected distribution of, and growth in, mobile systems revenue to the year 2010.

Table 1. Services and Applications Forecast

Services and applications	Forecast next 5 years
Fixed satellite service utilizing C- and K-band frequencies General telecommunications, telephony, data and analog TV disribution	Consolidation of systems Some growth in regional markets Replenishment of some systems Limited new applications
Broadcast satellite service (BSS) utilizing Ku- and Ka-band frequencies Digital TV, primarily direct-to-home (DTH) at Ku-band	Growth and consolidation of Ku-BSS Development and growth of Ka-BSS
Mobile satellite services (MSS) utilizing L- and S-band frequencies Vehicular mobile communications at L-band	Development and growth at both L-band and S-band for personal mobile communications, as well as fixed MSS applications
Broadband multimedia services utilizing Ka-band frequencies	Development and introduction of interactive multimedia applications
Cyberstar Few services at Ka-, L-, S-, and X-band frequencies In conceptual stages for navigation, air traffic control, environmental, etc.	Development of applications

Numerous administrations have recently filed with the ITU for Ka-band spectrum, and the forecast predicts a period of rapid development in broadband and interactive multimedia applications utilizing these frequencies. Satellites supporting these applications will generally be processor-based and have a high degree of flexibility, permitting "bandwidth on demand" services to both institutional and individual users, with such diverse applications as rural telephony, direct-to-home television, telemedicine, video conferencing, and internet connectivity. The deployment of highly flexible bandwidth on demand satellite services is also expected to catalyze the development of new media types, thus further increasing the demand for such satellite capabilities.

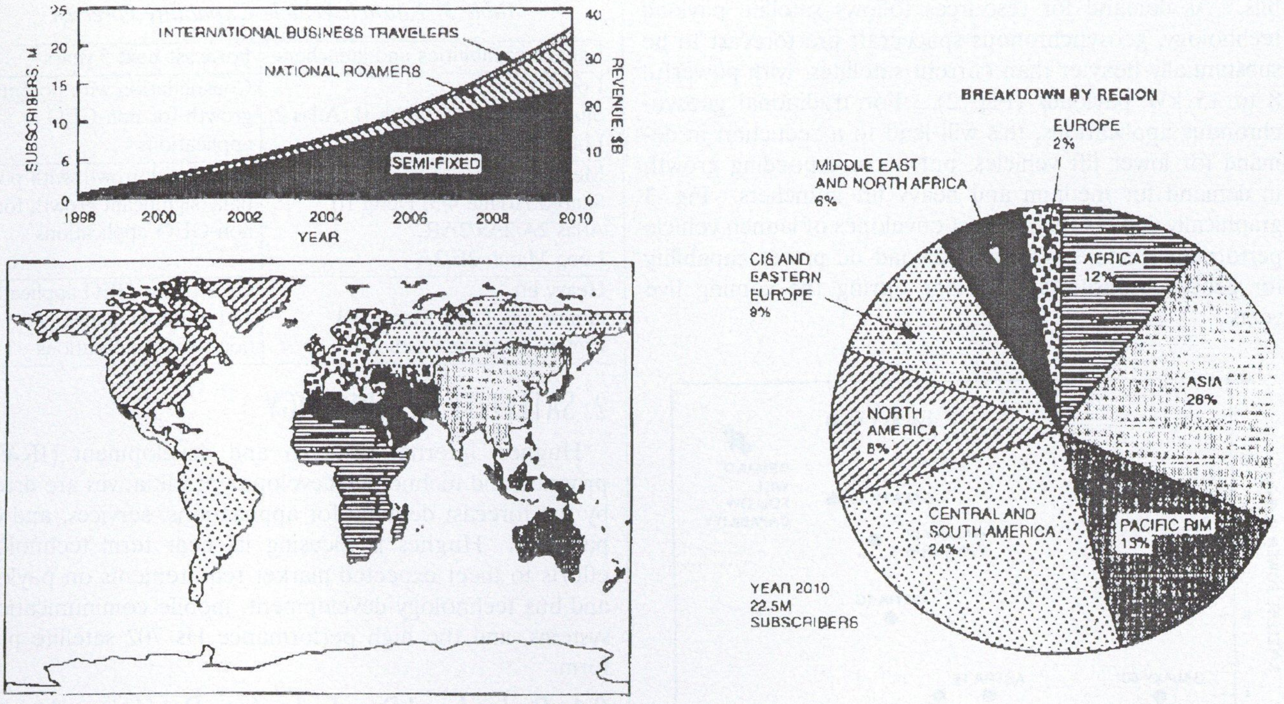

Fig. 1. Mobile Systems Projected Demand and Revenue Worldwide

The advent of high power processor-based satellite payloads is expected to also foster commercial applications in non-traditional frequency bands notably, L-, S-, X-, and Ka-bands. Applications currently in conceptual stages that will be introduced within the next five years include commercial remote sensing and environmental services, satellite-based precision navigation, and air traffic control.

1.2. Multiple Orbit Operation

In terms of orbit utilization, the five-year forecast shows expansion of commercial applications to orbits other than geosynchronous, particularly to orbits at lower altitudes (Table 2). Satellites in geosynchronous earth orbit (GEO) will continue to provide the bulk of traditional telecommunications and broadcast services, and will also support developing interactive multimedia and regional personal (handheld) mobile communications. For those mobile applications, which use omnidirectional terrestrial antennas, inclined geosynchronous orbit operation throughout the spacecraft life will be utilized to minimize onboard propellant requirements.

Over the coming five years, medium earth orbit (MEO) satellites will support global personal mobile communications services as well as interactive multimedia applications. MEO orbits will also continue to support the US Government's GPS navigation system, as well as potential commercial systems (most likely sharing satellite resources with communications payloads). This orbit offers advantages over geosynchronous orbit in terms of shorter range to user terminals (thus, smaller time delay), lower required launch capability to inject into orbit, and coverage of the earth's polar regions. The major disadvantage of MEO communications satellites is the need for a relatively large number of satellites (typically > 10) provide continuous coverage.

Table 2. Orbit Utilization Forecast

Orbits and applications	Forecast next 5 years
Geosynchronous earth orbit (GEO) General telecommunications, video distribution, mobile, meteorological	Consolidation – new applications as multimedia interactive developed and introduced
Medium earth orbit (MEO) Development stage for mobile, navigation and multimedia interactive services	Development of mobile and navigation (ICO, Odyssey) and multimedia applications
Low earth orbit (LEO) Navigation, meteorological, and environmental with development of mobile services (Iridium, Globalsar), and multimedia interactive (Teledesic)	Development and growth of mobile, multimedia and navigation Advanced development for environmental and meteorological

Low earth orbits (LEOs) have traditionally been used for remote sensing and scientific applications, and, with Iridium and Globalstar, will also support handheld mobile communications services. For communications applications, the relative advantages and disadvantages of LEOs are similar to those of MEOs, with the number of satellites required for continuous global coverage increasing to more than 50. Also, due to the restricted field of view of the earth from each satellite, LEO systems typically require extensive use of intersatellite links. Commercial applications of LEO remote sensing capability is expected to develop and grow before the turn of the century.

1.3. Launch Vehicle Options and Spacecraft Optimization to Launchers

As spacecraft complexity and capability grows, so grows spacecraft mass — thus placing greater demands on launch vehicle performance to inject satellites in their desired orbits. As demand for resources follows satellite payload technology, geosynchronous spacecraft are forecast to be substantially heavier than current satellites, with powerful 8 to 15 kW payloads (Fig. 2). For traditional geosynchronous applications, this will lead to a reduction in demand for lower lift vehicles, but a corresponding growth in demand for medium and heavy lift launchers. Fig. 3 graphically depicts the forecast envelopes of launch vehicle performance and spacecraft payload dc power capability for geosynchronous applications during the coming five years.

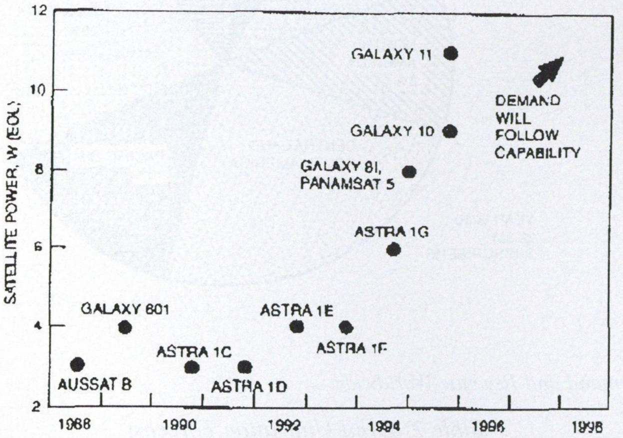

Fig. 2. Commercial Satellite Power Demand

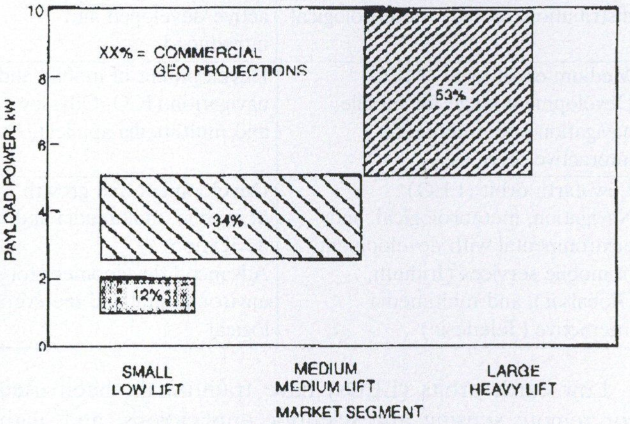

Fig. 3. Commercial Satellite Market Projection

Significant growth is anticipated in LEO and MEO launch applications, especially with the low and medium lift capability vehicles. MEO satellites will be approximately the same mass as current GEO satellites, with agile payloads in the 4 to 6 kW range. LEO spacecraft are forecast to be efficient designs with advanced payloads in the 2 kW dc power class. Table 3 summarizes the five-year launch vehicle capability forecast.

Multiple satellite launch using a single booster to all orbits will become more prevalent with the medium and heavy lift vehicles, and the advent of Delta III and Sea Launch in 1998 will dramatically increase the availability of commercial launch opportunities. Both of these trends suggest an easing of the currently impacted launch market.

Table 3. Launch Vehicle Capability Forecast

Launch capabilities and launchers	Forecast next 5 years
Low lift Shared Ariane 4, Delta II, Atlas 2, Long March 3	Consolidation with potential growth for non-GEO applications
Medium lift Shared Ariane 4/5, Delta III, Atlas 2A/2AS/2AR, Long March 2E/3A	Continued growth with potentially significant growth for non-GEO applications
Heavy lift Ariane 4/5, Long March 3B, Proton, Zenit Sea Launch	Growth for GEO applications and multiple launch non-GEO applications

2. SATELLITE TECHNOLOGY

Hughes' internal research and development (IR&D) program and technology development initiatives are driven by the forecast demand for applications, services, and capabilities. Hughes is focusing its near term technology efforts to meet expected market requirements on payload and bus technology development, mobile communications systems, and the high performance Hs 702 satellite platform.

2.1. Payload and Bus Technology Development

The capability to provide advanced satellite services is contingent upon advances in spacecraft technologies. Foremost among the new technologies to be implemented within the next five years is the processor-based communications payload. Digital payload processors provide the levels of power allocation flexibility and signal switching necessary to make handheld mobile and interactive multimedia services efficient and practical. Hughes Space and Communications, International's (HSCI) digital signal processor technology is a relatively mature design — with heritage from the UHF/EHF satellite program for the US Navy — that makes use of application specific integrated circuits (ASICs) for reduced power consumption. Hughes' geosynchronous mobile, ICO, and Spaceway programs incorporate advanced digital payload processors.

Flexibility is a key attribute of the payload processor and is also the motivation behind the development of on-orbit reconfigurable antennas. When procuring a satellite, commercial service providers must define antenna coverage patterns relatively early in the manufacturing cycle — often as much as two years before service begins — and, thus, must anticipate their early market requirements. Furthermore, once the spacecraft is launched, a conventional antenna pattern is obviously fixed for the ten to fifteen year mission duration. As the commercial market is becoming more and more dynamic, the capability to modify antenna coverage on orbit is becoming essential. This capability is being introduced using both mechanically steerable conventional antennas and electrically steerable phased array antennas.

Satellite platform technology advances are keeping up with the resource demands of the advanced communications payloads. High efficiency electric propulsion is replacing conventional chemical propulsion to support the high-mass and long-life requirements of modern satellites.

Hughes' xenon ion propulsion system (XIPS) thrusters ionize xenon gas by electron bombardment and accelerate the ions through a potential of approximately 1000 volts. The ions produce thrust as they exit the thruster at roughly 40 km/s. This method of propulsion results in a factor of ten improvement in efficiency relative to chemical propulsion systems. The first spacecraft to utilize XIPS for stationkeeping will be launched in 1997.

Along with mass, electrical power is a precious resource on communications satellites. Technology development in this area focuses not only on power generation — through higher efficiency solar cells using gallium arsenide and solar concentrator technology — but also on electronical power storage during periods of eclipse. Conventional batteries are typically the heaviest part of the spacecraft bus, and they consume a large amount of the volume available on the spacecraft. Technology development is looking at advanced chemical battery technologies to drastically increase specific energy capacity, as well as alternative secondary power methodologies, including flywheel energy storage.

2.2. Mobile Communications with Satellites

Hughes has implemented a variety of mobile satellite systems on its satellites, including the dedicated AMSC-1 satellite for North American vehicular mobile services, as well as mobile co-payloads on Solidaridad and Optus spacecraft for regional service to Mexico and Australia, respectively. Hughes is now introducing a high capacity, processor-based geosynchronous mobile satellite system for APMT, as well as a MEO based global mobile system for ICO.

The geosynchronous mobile satellite communication system is a turnkey implementation for regional applications that consists of a space segment (satellite), a fixed ground segment, and a user segment (various mobile telephone types). Fig. 4 illustrates the key elements of the system, which will begin service in 1998. The design merges the cell geometry concept of land-mobile telephony with the unique digital beamforming capability of the Hughes digital processor. Mobile services include voice, message, fax, and data transmission. The satellite accommodates 16,000 simultaneous phone calls, for which, at industry standard call rates, a user subscribership of more than a million can be supported.

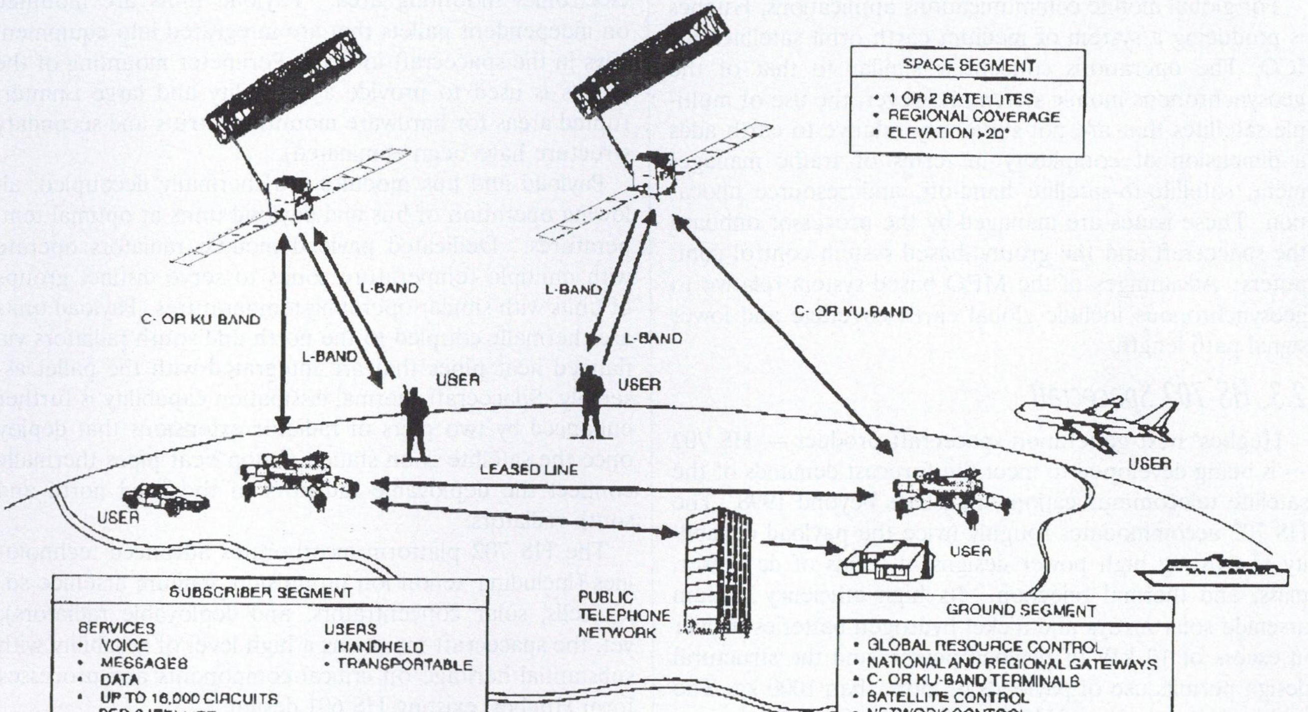

Fig. 4. GEO Mobile System Overview

The space segment consists of a satellite at geosynchronous altitude with a large aperture L-band antenna and a shaped small aperture Ku-band antenna. The L-band antenna projects a pattern of more than 200 parallel beams over the desired coverage region. The ground segment transmits to and receives traffic signals from the satellite at Ku-band, and the user segment transmits and receives at L-band.

The ground segment provides the mobile caller with a satellite interface to the public switched telephone network (PSTN) through gateway stations. The ground system comprises these gateway earth stations, a network control center (NCC), and a customer management information system (CMIS). Each gateway interfaces with the local phone system PSTN. The gateway switches a signal received from the satellite to the PSTN and provides information to the NCC for billing and management by the CMIS. The NCC provides carrier assignments to the gateways for signal transmission to the satellite. Signal interfaces between gateways and to and from the NCC are at Ku-band. Each country served by the system can have a dedicated gateway, or two or more countries can share a gateway station.

The user segment consists of fixed, handheld, and vehicle mounted phone terminals. The performance requirements of the entire mobile communication system are driven by the relatively low RF power and G/T characteristics of the handheld terminal. A mobile user communicates to the public phone system with a signal up to the spacecraft at L-band and down to a gateway at Ku-band. In the Hughes design, mobile user-to-mobile user communication is accomplished on a single hop to and from the spacecraft at L-band.

For the regional mobile communications applications, this geo-mobile system has significant advantages over mobile systems at other orbital altitudes. Since service can be provided with just one operating satellite, initial system costs and operating costs are expected to be lower than those of the multi-satellite LEO and MEO mobile systems. For regional markets, the geo-mobile design provides a relatively low cost, flexible option for mobile communication providers.

For global mobile communications applications, Hughes is producing a system of medium earth orbit satellites for ICO. The operations concept is similar to that of the geosynchronous mobile system; however, the use of multiple satellites that are not stationary relative to earth adds a dimension of complexity in terms of traffic management, satellite-to-satellite hand-off, and resource allocation. These issues are managed by the processor onboard the spacecraft and the ground-based system control computers. Advantages of the MEO based system relative to geosynchronous include global earth coverage and lower signal path length.

2.3. HS 702 Spacecraft

Hughes' next generation spacecraft product — HS 702 — is being developed to meet the forecast demands of the satellite telecommunications industries beyond 1998. The HS 702 accommodates roughly twice the payload capability of existing high power designs in terms of dc power, mass, and thermal rejection. Its high efficiency gallium arsenide solar arrays and nickel hydrogen batteries deliver in excess of 10 kW of payload power, and the structural design permits use of payloads of more than 1000 kg. The multi-mission design of HS 702 offers the flexibility to support a wide range of commercial geosynchronous applications, including telephony, television distribution, personal mobile communications, and interactive multimedia. Fig. 5 illustrates the HS 702 performance envelope in comparison with Hughes' spin stabilized HS 376 satellite, and its higher power, three-axis stabilized HS 601/601HP family.

HS 702's high performance and spacious antenna mounting area ideally suits it for multiple-payload applications. In such a configuration, a single spacecraft platform can economically support individual communications payloads for separate regional operators, offering significant reductions in operating expenses and startup costs relative to the use of dedicated satellites.

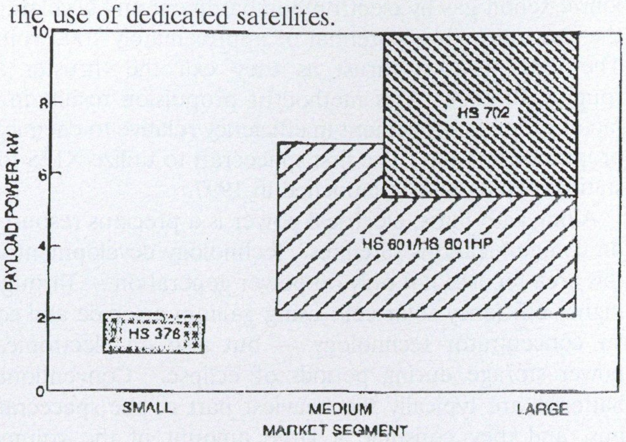

Fig. 5. Hughes Spacecraft Applications

The HS 702 development primary goal is production of high performance spacecraft with low total system costs and relatively quick delivery schedules. Designed for producibility, HS 702 features fully modular bus and payload electronics, ample room for mounting a wide variety of antenna configurations, and a large, unobstructed payload electronics mounting area. Payload units are mounted on independent pallets that are integrated into equipment bays in the spacecraft interior. Perimeter mounting of the pallets is used to provide accessibility and large uninterrupted areas for hardware mounting (struts and secondary structure have been eliminated).

Payload and bus modules are thermally decoupled, allowing operation of bus and payload units at optimal temperatures. Dedicated payload module radiators operate with multiple temperature zones to serve distinct groups of units with similar operating temperatures. Payload units are thermally coupled to the north and south radiators via flanged heat pipes that are integrated with the pallet assembly. Spacecraft thermal dissipation capability is further enhanced by two pairs of radiator extensions that deploy once the satellite is on station. Loop heat pipes thermally connect the deployable radiators to the fixed north and south radiators.

The HS 702 platform incorporates advanced technologies (including xenon ion propulsion, gallium arsenide solar cells, solar concentrators, and deployable radiators); yet, the spacecraft maintains a high level of reliability with substantial heritage on critical components and processes form Hughes' existing HS 601 design.

3. CONCLUSION

The forecast for the future of commercial satellites over the next five years shows growing payload power requirements, increasing payload complexity, expansion to non-traditional commercial communications frequency bands, and the exploitation of alternatives to geostationary orbit. These changes are driven by numerous new telecommunications services and applications and will be supported through technological development by leaders in the satellite and launch vehicle industries.

EXAMINING THE SES/ASTRA APPROACH TO DIGITAL DTH DELIVERY

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The paper provides a detailed overview on DTH satellite TV reception in Europe in general and on the ASTRA based SES system in details. The author examines the European TV broadcasting market shared among the terrestrial, cable and DTH satellite broadcasters. Finally, the author presents the SES' strategy for the digital future and enlists the advantages of DTH networks against other broadcasting services.

1. INTRODUCTION

It was in the early 1980's that a small group of political and financial leaders in Luxembourg came together with a common vision. The initial impulse had been given by Mr. Pierre Werner, the then Prime Minister of Luxembourg and today the honorary-chairman of the Board of Directors of SES. They foresaw that in the future, satellites would deliver audiovisual services directly to individual homes.

- ▲ **Privately held Luxembourg Company**
- ▲ **1995 revenue: approx. MLUF 10'300**
- ▲ **Approx. 180 employees of about 15 nationalities**
- ▲ **Mission: Direct-To-Home (DTH) broadcasting of TV and Radio programmes via satellite to a european audience**
- ▲ **System marketed under ASTRA brand name: The ASTRA Satellite System**
- ▲ **Direct customers: private and public broadcasters**
- ▲ **Active marketing strategy**
- ▲ **Web site is http:/www.astra.lu**

Fig. 1. SES Company profile

When SES was founded and incorporated in Luxembourg, in March 1985 to set up the first privately owned satellite in Europe, it focused on the needs of the European television viewers and the TV broadcasters. In other words, the ASTRA satellites contribute to satisfying both the demand for a broader choice of television programming for the viewer as well as providing easy access to millions of TV households for the broadcasters, thus allowing them to achieve profitability.

In early 1989, with the launch of ASTRA 1A, SES introduced its new approach to satellite television and began to operate as a service and market oriented company. Its aim was and still is to provide the necessary satellite infrastructure that enables SES' customers to deliver entertaining high quality TV and radio programming to the different European language markets, made available to the consumer on attractively priced and easy to install reception equipment. This infrastructure consists of 'State-of-the-art' satellite technology as well as of an active marketing support targeting equipment manufacturers, trade and retail.

SES operates under a franchise agreement of the Grand Duchy of Luxembourg. The franchise runs until the year 2010, with the possibility for extension, and covers audiovisual services as well as possible new business applications. The Grand Duchy holds a 20 % interest in SES through two public financial institutions, whilst the rest of the equity capital comes from private international entities.

The company's staff today numbers over 190 people from 15 different nations and cultural backgrounds, who devote their talents to highly specialized jobs at the forefront of satellite technology and the commercialization of satellite television.

SES' sales revenues (approx. 235 mill. GBP or 350 mill. USD in 1995) are derived from leases of satellite capacity to television and radio broadcasters. Most leases cover periods of ten years and thus provide planning security to both the broadcasters and SES.

Today, the ASTRA Satellite System is considered by many players in the audiovisual as well as the satellite industry to be the leading European satellite platform, supporting the transition from analogue to digital transmission.

The implementation of the digital compression technology on the ASTRA Satellite System will allow the various European linguistic regions and markets to further develop and progress towards a modern Information Society.

2. EUROPEAN SATELLITE MARKET SITUATION

When questioning a leading European satellite operator about its approach for digital satellite you may not be surprised to hear that we foresee a good business case for digital transmissions via satellite.

In order to scrutinize the seriousness of such prospects, let us first take a look at the current satellite market situation.

In this context, it is important to emphasize that SES is a private and independent satellite infrastructure provider, not forming part of any vertically integrated company structure, and thus, not being under the influence of any particular satellite industry player or any program provider, i.e. dedicating its competence and efforts to create a successful business.

Looking at the shares each transmission mode is occupying today:

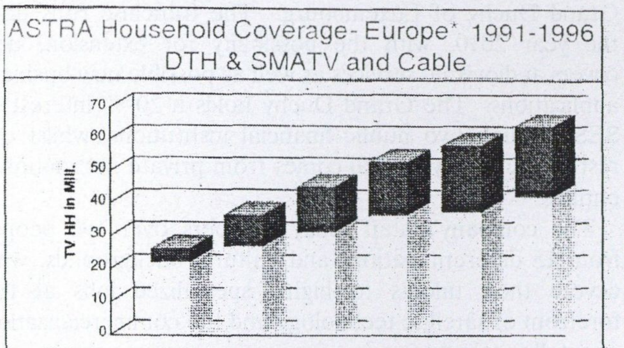
- 15.4 % or more than 24.93 million households throughout Europe are already receiving their programming services in DTH mode,

- 27 % or almost 44 million homes receive their programming via cable networks

we should bear in mind that the European TV market is still dominated by terrestrial transmission:

- 57 % out of the 162 million Western and Central European households receive terrestrial TV only.

Taking into account that DTH-reception technology for small sized dishes has only been in existence for slightly longer than 7 years, it indicates the enormous potential for the further development of its market share, once the enhanced offer of digitally compressed linguistic program and service bouquets are commercially available for mass-consumption all across Europe.



Mid Year	1991	1992	1993	1994	1995	1996
DTH & SMATV	4.06	9.77	13.87	16.71	21.43	22.03
Cable	22.13	26.89	31.33	36.44	37.49	41.97
Total	26.19	36.65	45.21	53.15	58.92	64.00

SES ASTRA Satellite Monitors, Spring 1996 — *based on 22 European countries within the ASTRA footprint

Fig. 2. European ASTRA Penetration Growth (Mid Year 1996)

Satellite distribution technology has developed over the last decade to be the most convenient and most economical distribution means for international broadcasters. Now, with digital transmission techniques, it is getting ready to provide its advantages to thematic service providers, business to business applications as well as to other electronic narrowcast activities.

Satellite can deliver a "quasi unlimited" content offer and is not restricted to the size and the transmission capacity of a particular network as it is the case for cable and terrestrial distribution. As a matter of fact, hundreds of services will be available to each consumer in each of the main European markets.

In this context one should point out that Europe is not one single TV market.

Each of the markets is defined by a different language and therefore by a different TV programming offer. In some countries, such as Germany most satellite TV services, are available "in the clear" today and are financed through advertising. This situation is very different to the one in the UK, where the majority of the analogue satellite services are encrypted pay television.

With the arrival of digital transmission, broadcasters can offer a wide range of new services, based on time convenience, exclusiveness of events, thematic and "quasi" tailor-made/personalized program content. These services will require encrypted transmission, due to their acquisition costs and rights issues and thus can only be made available on a subscription basis.

As the introduction of digital technology in Europe will primarily promote pay TV program packages, the economic success will mainly depend on their acceptance in the largest linguistic domains, i.e. the distinct line-up of services offered.

The opportunities for digital pay TV via satellite can be best evaluated by the combination of two criteria: the total population by linguistic market as well as the per capita income.

When applying these demographic and economic measuring instruments, five markets clearly stand out: Germany, France, Italy, the UK and Spain.

With the exception of Germany, four out of these large and wealthy countries have low cable and satellite penetration, 23 % in the UK with DTH being in a strong position, 15 % in France, 10 % in Spain and 3 % in Italy. These four markets certainly represent the highest growth potential entering the digital age. We expect those geographic markets to be the most promising for digital satellite services, together with Scandinavia and Benelux.

This potential is confirmed by SES' European satellite and cable penetration forecast for the next 10 years. Our study comes to the conclusion that cable may grow at abouf 3 % per year, while satellite DTH will grow twice as fast, that's to say at 6 % per year.

- In the somewhat more developed DTH markets (Germany, Nordic Countries and the UK), the cable industry will find itself facing a large base of satellite dishes mostly pointed to the ASTRA Satellite System.
- In the less developed cable and satellite markets (France, Italy and Spain) the speed of development of DTH compared to cable will be even faster once the consumers find that the digital packages provide added value.

Satellite distribution will thus take a large stake in the growth of the Western European TV market over the next 5 to 10 years.

According to SES' forecasts, analogue and digital transmissions will co-exist for some time, say 5 to 10 years.

Based on the experience gathered throughout the past 7 years of marketing analogue DTH, SES is confident it is in a good starting position for digital DTH.

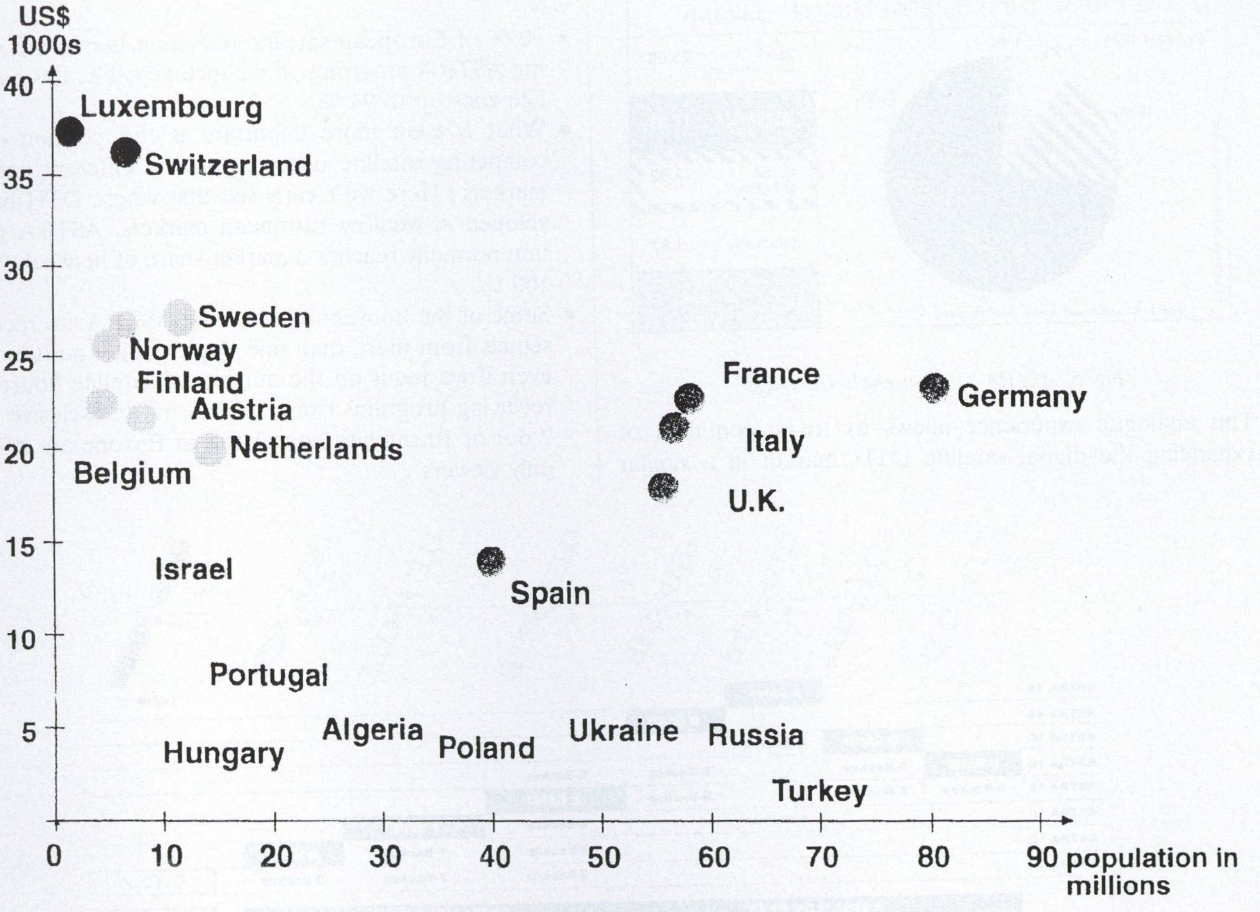


Fig. 3. Per Capita Income x Total Population

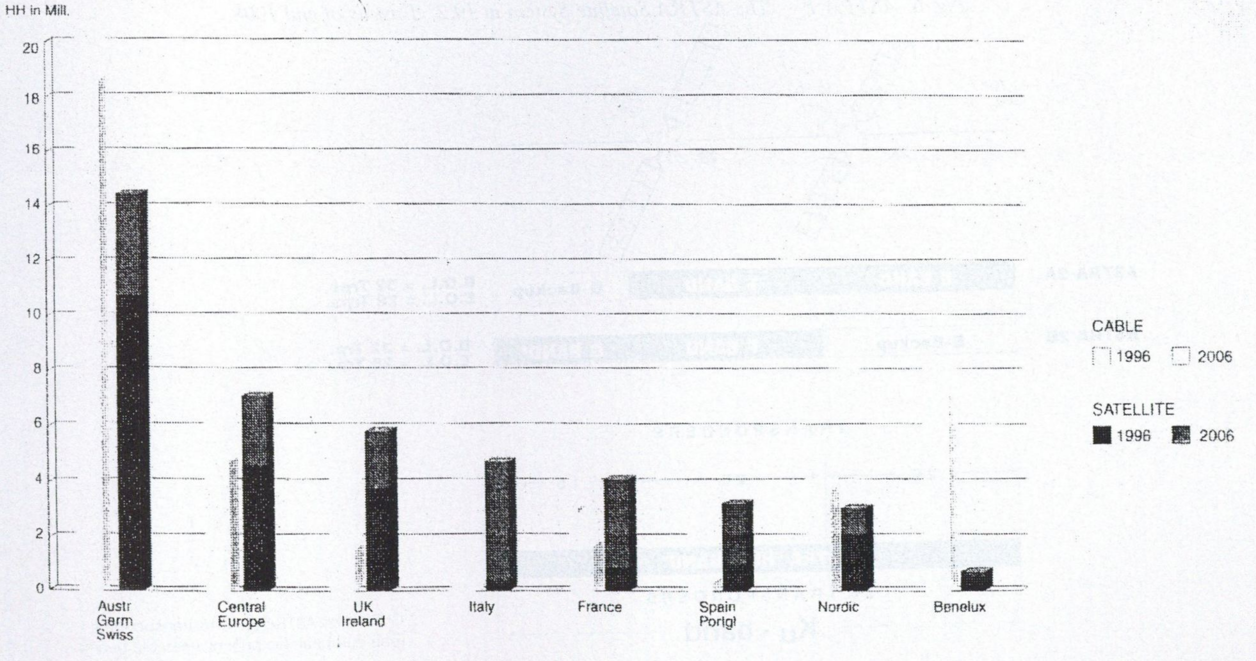


Fig. 4. Forecast European Satellite & Cable Penetration (1996–2006)

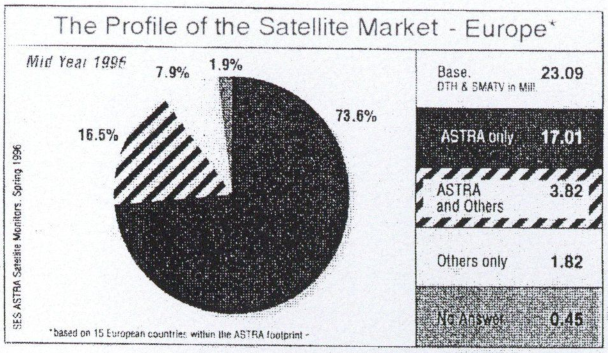


Fig. 5. ASTRA TV Household Coverage

This analogue experience allows us to be confident of expanding the digital satellite DTH market in a similar way:

- 90 % of European satellite television homes are receiving ASTRA programs. If we include cable, this percentage goes up to 94 %.
- What is even more important is the position of the competing satellite operators in the different linguistic markets. Here we clearly see that where DTH has developed in wealthy European markets, ASTRA reception normally reaches a market share of between 95 and 100 %.
- Some of the households receiving ASTRA are receiving signals from more than one single orbital position. But even if we focus on the number of satellite households receiving programs from ASTRA on an exclusive basis, 7 out of 10 satellite households in Europe are ASTRA only viewers.

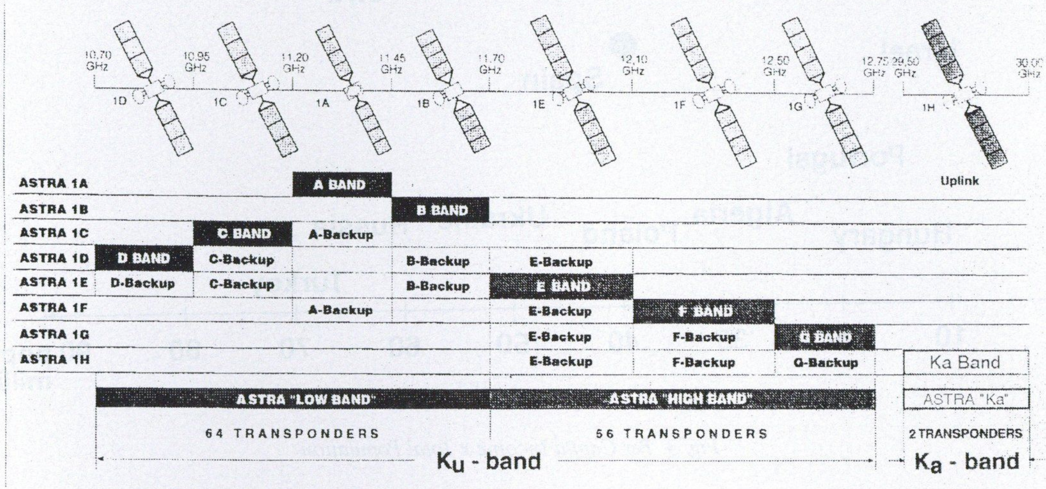


Fig. 6. ASTRA 1 — The ASTRA Satellite System at 19.2° East as of end 1998

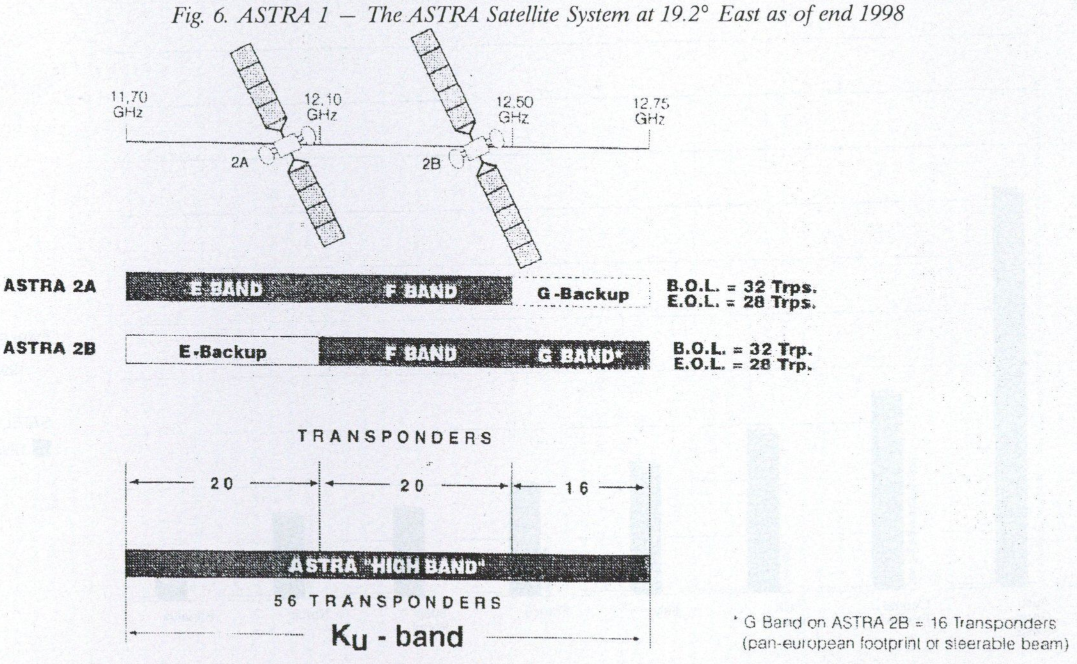


Fig. 7. ASTRA 2 — The ASTRA Satellite System at 28.2° East as of end 1998

3. SES' STRATEGY FOR THE DIGITAL FUTURE

1996 is seeing SES pioneering the launch of fully digital services Europe-wide. The preconditions for this launch were set already three years ago, at a time when Europe was still debating other transmission standards.

During that time we took the decision to invest in future transmission capacity and to adhere DVB as a founder member and thus became a leading satellite infrastructure provider in the digital age. Today the ASTRA Satellite System consists of 6 satellites co-located at the orbital position of 19.2 degrees East:

- ASTRA 1A to 1D deliver analogue audio/visual services to Europe on 64 transponders in the low Ku-band (10.70 – 11.70 (GHz)).
- ASTRA 1E and 1F, launched in October 1995 and April 1996 respectively, already offer 40 transponders in the high Ku-Band (11.70 – 12.50 GHz), operational for digital transmissions and will distribute program bouquets very soon to the different language markets.
- By June '97, another 16 transponders for digital transmissions will be co-located, bringing the total number of transponders on the orbital position of 19.2 degrees East up to 120.
- A back up satellite, ASTRA 1H, will not only complete the first ASTRA position in 1998. It will also carry two transponders, operating in the Ka-Frequency Band and thus providing a direct return path via satellite to the system:
  19.70 – 20.20 uplink,
  29.50 – 30 downlink.

This concentration of satellite transmission capacity, allowing broadcasters and service providers to allocate their products at one single orbital position is considered to be the primary factor in developing the impressive digital DTH market potential in Europe. But technology was never an aim in itself, it always was and it continues to be a mean to deliver distinct bouquets of attractive audiovisual services to the viewers.

That this success factor proves also to be valid in the digital era, is best shown in France. Here our customer Canal+/Canal Satellite numerique' has achieved more than 68,000 subscriptions in little less than two months since its commercial launch.

The eight ASTRA-satellites at a single orbital position will also offer a unique self-contained standby capacity system which backs up the active transponders and therefore guarantees program providers optimal operational security for the continuation of their analogue packages as well as for the development of new digital offers on ASTRA.

The majority of the 56 digital transponders is already assigned or is currently under advanced negotiations with prestigious European and International program providers.

Throughout 1995, SES announced contracts with customers who are leaders in their respective markets in pay TV, radio and television broadcasting: Kirch and Bertelsmann from Germany, France's Canal Plus, Luxembourg based CLT Multimedia, the International Nethold Group and Viacom. The German Public Broadcasters are also on board and others, such as BSkyB and Turner will certainly be among the front runners.

As some of these pay TV operators are participating in this forum, I will not comment on the range of applications which will be offered in the short-term as part of the, roughly speaking, 500 digitally compressed services to be delivered on the ASTRA platform at 19.2° East.

Over the next 3 to 6 months with the commercial launch of further linguistic bouquets in the German, Benelux and Nordic markets, we shall be able to provide a large variety of mass-marketed programs which will increasingly enable consumers to suit their own individual requirements. The viewer becomes his/her own program director.

The services which will become available through digital compression will differentiate themselves from analogue TV and radio services by offering time convenience, exclusiveness of events and tailor-made/ personalized program content.

As we enter the age of digital transmissions for the consumer markets, success for a business appealing to the masses must be achieved by offering a broader and more individual choice. In a word, a paradox, individual service or custom-built information as mass production. The only possibility for the quick and cost effective distribution of such high a number of programs is the transmission "out of space" via satellite.

The digital ASTRA capacity already committed under the form of firm long term transponder leases will target all of the most attractive Western European markets. In addition, newly emerging markets such as those in Central and Eastern Europe require different approaches to be developed over the next two to three years.

In order to maintain leadership in Europe, SES must continue to win the strongest private and public broadcasters with the most attractive programming as customers for and in each linguistic market. SES will expand capacity at a second orbital position for the ASTRA Satellite System at 28.2° East. The opening of a second orbital position will meet current requests and mitigates the pressure on customers to seek capacity from the competition due to unavailability of ASTRA satellites. The necessary coordination process by the Luxembourg Authorities is proceeding with the ITU in Geneva.

ASTRA will continue to provide high quality transmission services to new markets as well as to existing and new customers in existing markets. SES, for sure, will not control the gateway to the digital markets.

In concert with its customers, SES will develop a coherent market alignment using linguistic market separation by orbital positions. We will promote the smallest possible, fixed, single feed dish in most markets and for most customers.

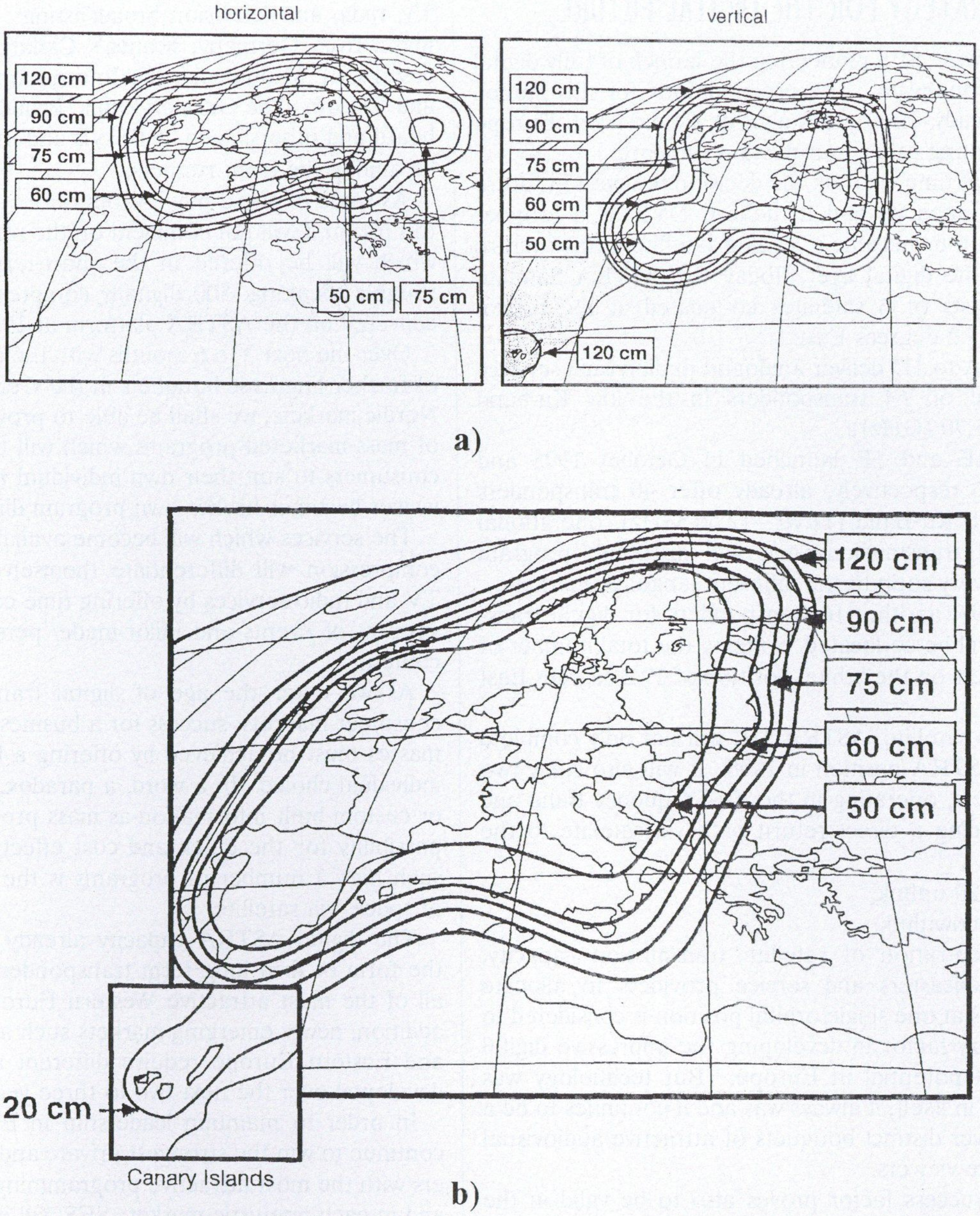


Fig. 8. ASTRA 1E/1F (a) and 1G/1H (b) Footprint

Furthermore our marketing policies will also ensure a smooth transition from analogue to digital in markets where we have a very strong basis of DTH homes as well as in markets, where digital will only be launched in some 15 – 18 months from now.

As the Figures below indicate, the ASTRA dish for digital reception will be only 50 cm small in the majority of the markets in our footprint.

As increased spectrum is a valuable asset for SES expansion, the company, with the support of the Luxembourg government, has therefore requested the coordination of 8 new orbital positions in the Ku-band as well as for Ka-band frequencies on 21 orbital slots.

This will also create capacity for new services.

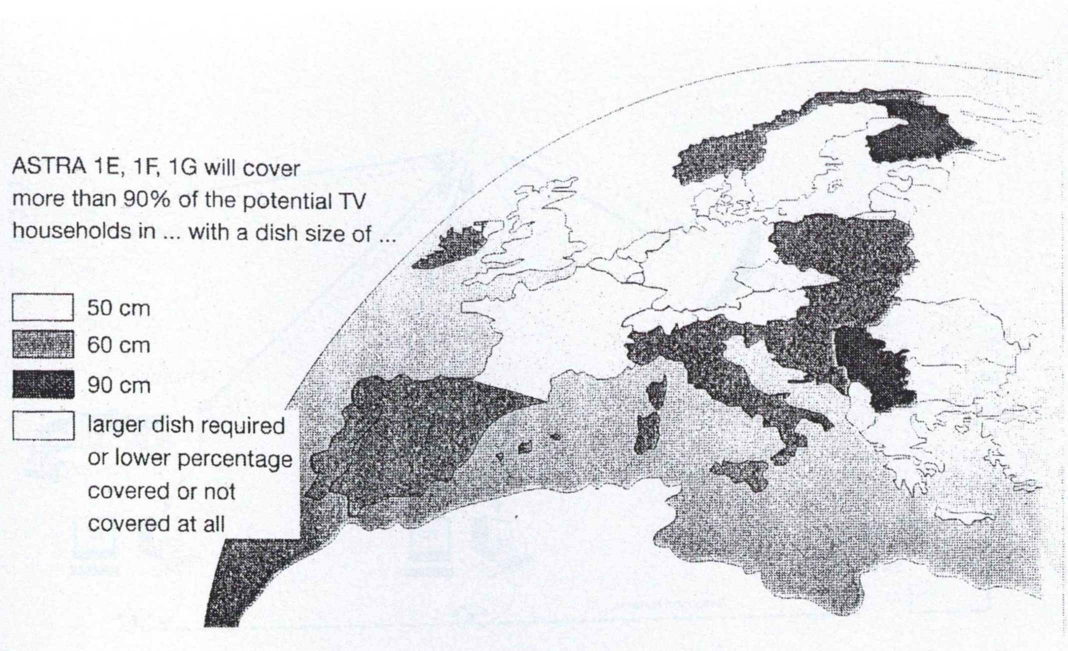
Through the launch of digital, geostationary medium power satellites will indeed offer an immense business opportunity for services in the field of enterprise information distribution.

Whilst most cable networks are currently not optimised to receive the quantity of digital transmissions to be on offer, ASTRA-satellite distribution allows to transmit large information packages from central points to many receiving locations throughout the system's footprint.

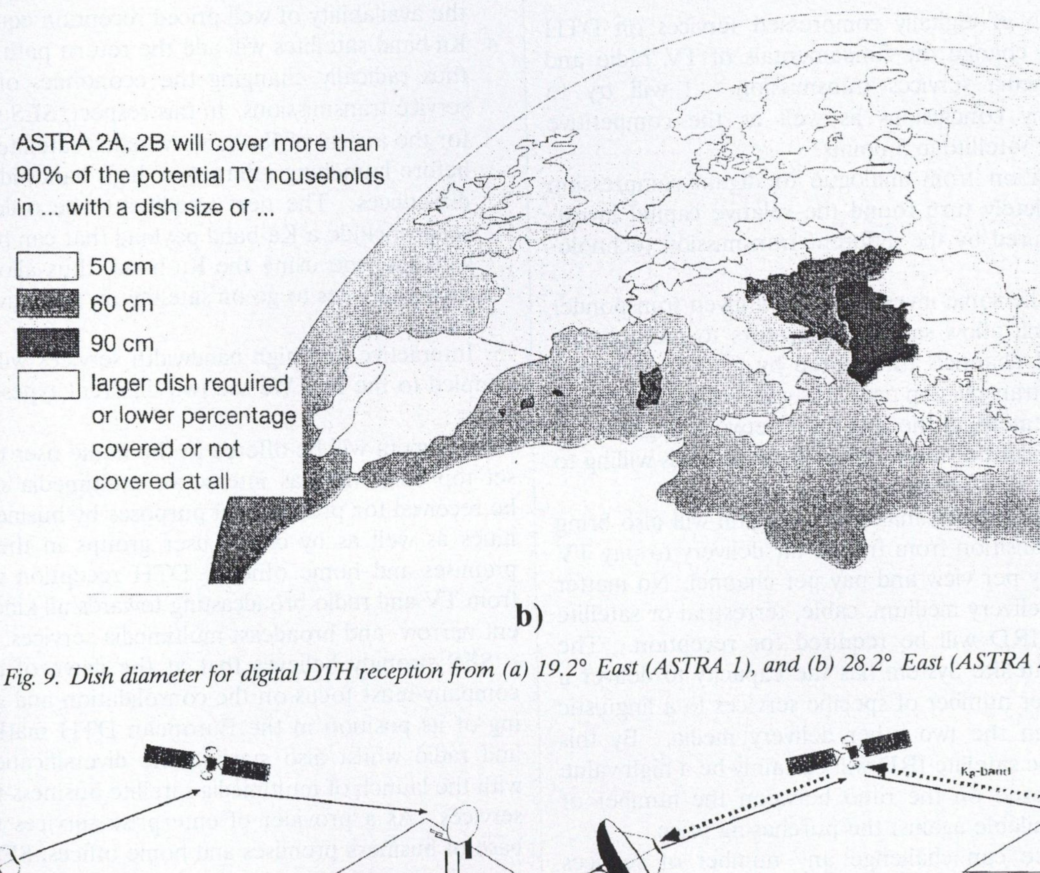
Today, ASTRA television and radio transmission consists of the one-way bandwidth transponder lease for video and audio services.

Building on the existing as well as on the designed satellite system, ASTRA shall lead new technologies in the multi-media markets.

SES is currently proceeding with the development of a concept for a full service package providing for multimedia transmission (video, audio, data) of mostly non-real time high bandwidth applications based on a "store and forward" system for point to multi-point communications. The distribution of information to subscribers of professional information and data bases is part of such an information distribution system.



a)



b)

Fig. 9. Dish diameter for digital DTH reception from (a) 19.2° East (ASTRA 1), and (b) 28.2° East (ASTRA 2)

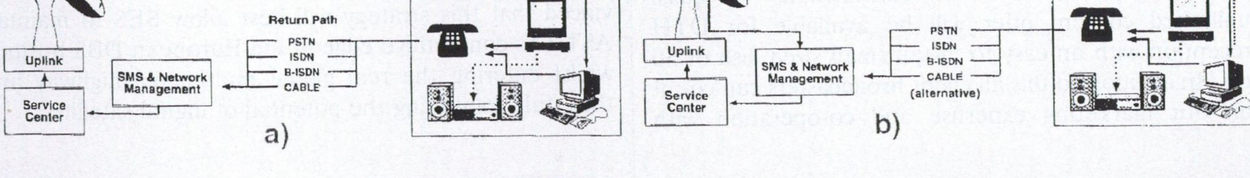


Fig. 10. Satellite Delivered Services with Return Path (a) today, (b) tomorrow

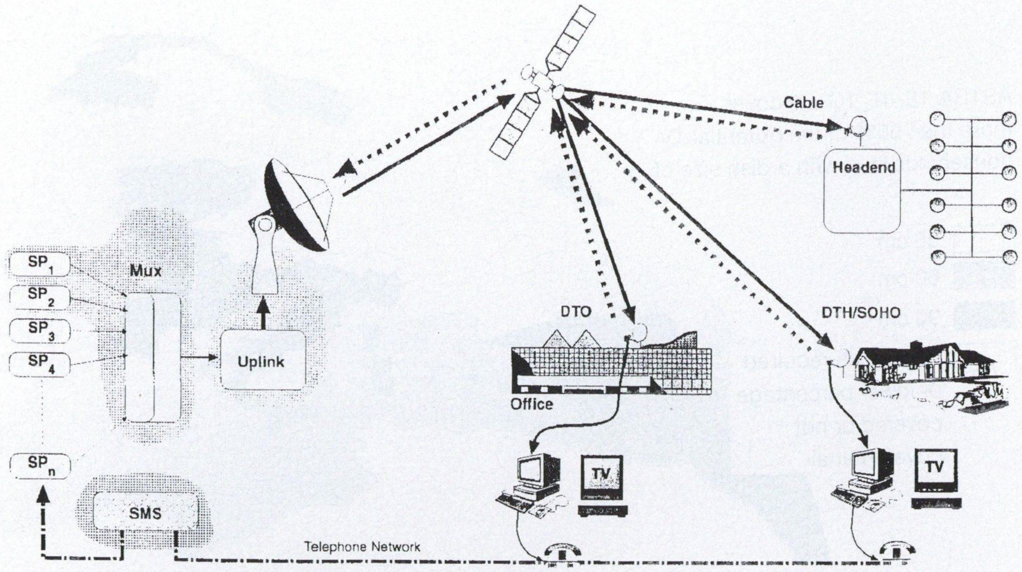


Fig. 11. SES/ASTRA Multimedia Service Platform

4. CONCLUSIONS

The launch of digitally compressed services on DTH networks will change the fundamentals of TV, radio and other multimedia services transmission. I will try to summarize my conclusions as well as the competitive advantages of satellite in 5 points.

1. The transition from analogue to digital compression will completely turn round the relative capital investment required by the different transmission technologies:
   Whereas the same investment for a given transponder capacity will allow satellite operators to multiply the number of channels transmitted by 6 to 8, cable and terrestrial transmission networks will require a high and risky investment, as the cost for a network upgrade will be independent of the number of households willing to pay for the new services.
2. The transition from analogue to digital will also bring about a transition from free-to-air delivery to pay TV such as pay per view and pay per channel. No matter what the delivery medium, cable, terrestrial or satellite DTH, an IRD will be required for reception. The ASTRA Satellite System has the capacity to deliver a much higher number of specific services to a linguistic market than the two other delivery media. By this measure the satellite IRD will certainly be a high value product, based on the ratio between the number of services available against the purchasing price.
3. The satellite can challenge any number of services offered by other means of transmission. A quasi unlimited content offer will be available for DTH reception with an easy to install small sized dish of 50 cm. In addition to this all client broadcasters can count on our marketing expertise and co-operation with equipment manufacturers, trade and retail to achieve the availability of well priced reception equipment.
4. Ka-band satellites will add the return path on satellite, thus radically changing the economics of broadband service transmissions. In this respect, SES will not wait for the arrival of Ka-band switched satellite technology before launching interactive, high bandwidth multimediaservices. The next satellites to be ordered will already include a Ka-band payload that can be combined with the one using the Ku-band, thus allowing multimedia services to go on satellite on a relatively low risk basis.
5. Interactive and high bandwidth services will be closely coupled to the PC. We see two different types of applications:

Infotainment will be offered to the home user through the set top box, whereas interactive multimedia services will be received for professional purposes by business communities as well as by closed user groups in their business premises and home offices. DTH reception will expand from TV and radio broadcasting towards all kinds of different narrow- and broadcast multimedia services.

SES strongly believes that at the dawn of digital, our company must focus on the consolidation and strengthening of its position in the European DTH market for TV and radio whilst also starting the diversification process with the launch of multimedia satellite business-to-business services. As a provider of enterprise services to a broad base of business premises and home offices, SES becomes part of a large international service network. We are convinced that this strategy will best allow SES to maintain ASTRA's competitive edge in the European DBS business whilst entering the real global multimedia highway and, thus, fully exploiting the potential of digital satellite.

BANKNET'S VSAT COMMUNICATION SERVICES

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VSAT (Very Small Aperture Terminal) satellite communication technology in the last two decades had proved many advantages comparing with terrestrial technologies.

1. INTRODUCTION

In June, 1993 BankNet had installed and commissioned its VSAT data communication networks and services. BankNet's satellite technology is based on the ISBN (Integrated Satellite Business Networks) product of Hughes Network Systems (HNS, US), the world leader and pioneer in satellite communications. The ISBN networks are designed to data, voice and video communications.

The ISBN satellite data communication network consists of 3 major components:

- central earth station (hub),
- VSAT terminals at the customers' IT equipment (PES: Personal Earth Station),
- data networking and management.

These components or a part of these which are dedicated to the customers' network is a corporate private *business network.* ISBN can support many private business networks. For the IT and telecom manager of a company the important question is that how the data ports at the central front-end and remotes can be interconnected. In that sense a business network includes:

- the *back haul connection* between the customer's IT centre (host) and the hub,
- the *satellite communication link capacity and management* between the remote branches and the hub,
- the remote branch *data ports connected to a VSAT terminal,*
- the *data flow control,* including *protocol support, package handling and switching, bridging and routing* both at the hub site and/or at remotes.

2. THE CENTRAL EARTH STATION (HUB)

The hub is the controlling and switching centre of the data exchange between the data points of the remote and/or of the host computer to the ISBN network via satellite link. The hub facilitates the satellite channel capacity and allocates it in a shared way to the connected VSAT terminals, PESs.

2.1. Shared hub services

This technology offers a huge hub capacity to the VSAT terminals, but this capacity is shared among many users in a time division multiplexed way, hence the basic costs can be spread over more customers than if a fraction of this capacity would be dedicated to the terminals. These costs are related to the satellite channel, to the hub-related investments, to the network management, and, to the networking services.

The time division method is based on that fact that user's data terminals are not continuously sending and receiving data to and from the host computer, so meantime other terminals can use the same capacity.

The architecture of the network ensures that many corporate networks (business networks, or private networks) can be installed and serviced. These networks are fully isolated from each other. The number of the VSAT terminals in customers network is not limited.

The hub can be connected to the customer's IT centre via satellite or directly with any other means (microwave, fibre, etc.) by the back-haul link. The capacity of the backhaul is defined by the data traffic, it can be 64 kbit/s or a multiple of that.

2.2. Satellite capacity

BankNet's hub offers you at the present configuration 512 kbit/s *outroute,* i.e. from the hub to the remote link capacity (can be extended easily with 256 kbit/s, 512 kbit/s, or even with 2 Mbit/s steps). The link from the remote station to the hub, the so-called *inroute* link has 128 kbit/s capacity. To one outroute we can allocate as many as 31 inroutes, or, expressed by other words, 3.968 kbit/s capacity in total. One inroute can represent 64, 128 or 256 kbit/s.

At present, BankNet has one 512 kbit/s outroute and 7 inroutes, each with 128 kbit/s, so we can offer 1.408 Mbit/s. However, BankNet created framework for up to 40 Mbit/s capacity with demand driven expansions.

The number of the terminals which can be connected to these networks is 64,000.

2.3. Hub antenna

The most spectacular piece of every satellite communication system is the huge central antenna of the hub. This is also true for BankNet's central earth station. It is a 6.1 meter antenna, with automatic de-icing and moisture-cleaning system, and tracking mechanism.

The central antenna aims the Eutelsat II-F4 satellite, positioned geo-stationary at 7° East. This satellite was launched in September, 1992, substituting an older one, without any loss of a bit on BankNet's running VSAT networks. This satellite covers the whole of Europe from Iceland to West Siberia, and from Scandinavia to North Africa. This coverage is called as "foot-print" of the satellite.

Hence BankNet provides Pan-European telecommunication services. Our networks are up and running from Moscow or from the Mountains Urals till the UK.

The Radio Frequency R/F head power is 125 W, the actual emitted power is much less and automatically adjusted to the environmental conditions – like rain fade, etc.

2.4. Reliability

The reliability of the ISBN networks is based on a highly redundant architecture of the hub. Each of the modules has a hot back up parallel running with the primary module and without any interruption the secondary is ready to continue the operation. So neither a failure, nor the regular preventive maintenance, nor capacity expansion can disturb the communication services.

BankNet's VSAT communication is based on one of the most reliable technology. The availability is always above 99.5 %, the bit-error rate is 10^{-13}.

The above features characterize the extremely high quality of the telecommunication carrier level services. Data communication networks, however, are defined not only by the quality of the carrier but, sometimes more importantly, the data handling services.

2.5. Data networking and management

X.25 package switching networks can be connected to the ISBN networks at the remotes, as well as at the hub site. In some applications the X.25 PAD service (X.3, X.28, X.29) saves resources of the customers.

There are many other communication protocols supported, like SDLC, Burrough's Poll, BSC 3270, TINET, Bit and Byte transparent, Broadcast, and others. LAN interconnections are supported by the LAN*Advantage* (both Ethernet and Token Ring).

The networks, using these WAN or LAN protocols utilize the available capacity much better, due to the optimal link level proprietary protocol and the protoco spoofing technique applied. As the satellite transmissions is highly reliable, only the user's bytes are transmitted and the communication overhead is drastically reduce both in the number of transmitted bytes and in the response time, generating local acknowledgements and handshakes. Due to the protocol spoofing, the response times are even better in this ISBN time shared networks than in a dedicated point-to-point satellite connection.

At the hub site a package switch is installed in order to offer full or partially meshed topology for the customers who wants it.

Using the LAN*Advantage* option, the hub plays the role of an advanced, state of the art, highly intelligent *router* (with all functions like dynamic routing, learning, ageing, broadcasting, filtering, etc.). For back haul connections a LAN (Ethernet or Token Ring) bridge should be used to connect the host.

LAN*Advantage* is protocol transparent above the link protocol, in accordance with the IEEE 802 MAC, Media Access Control architecture. Above the MAC level the protocols are transparent, so every protocol (TCP/IP, DECnet, Apple Talk, ARP, XNS) can be used, even simultaneously many of them on the same LAN and WAN. As an option, in a multiprotocol environment some of the protocols can be filtered, too, hence the customer can filter them, and in this way the customer can keep that information in the local network, which is not intended to use in the wide area network.

3. VSAT TERMINALS: PES PERSONAL EARTH STATIONS

The PES terminals are installed at the branches of the customers' networks. A PES consists of

- 1.2 or 1.8 meter antenna,
- Radio Frequency R/F transmitter/receiver, the so-called transcever with 1 W or 2 W power,
- the indoor unit.

The antenna system is pointed to the same satellite as the hub antenna. It receives the signals of the outroute frequency to whom it belongs, down converts it to an intermediate frequency, sends it to the indoor unit, where it is converted to bit stream.

In the present configuration this is a 512 kbit/s continuous bit stream.

3.1. Data flow

The digital unit watches in the stream the data port addresses allocated to that remote station. If one of the data ports at the remote is addressed in the bit stream, it decodes and de-scrambles the information package received, and transmits this user information to the data port addressed.

In the opposite direction, the remote sends user data to the hub utilising the frequency, allocated to the inroute. The data is converted first to the intermediate frequency, and the R/F up-converts it to 14 GHz. The hub receives it and decodes the packages, and according to the addresses, it sends either to another remote PES via the satellite or to the customer's IT centre on the *backhaul* connection.

3.2. Data ports

Data ports are conform with all international standards. The maximal number of the data ports can be 8 or 32, which depends on the application and the selected configuration. The PES 6000 can accommodate up to 8 data ports, the PES 8000 up to 32 data ports. The difference is that PES 8000 can have 4 MPCs, Multi Port Card, whilst the PES 6000 can have 1. Each MPC offers up to 8 data ports.

If the LAN*Advantage* is used, the TPC version is installed and that offers 1 LAN port for Ethernet or Token Ring, and 2 additional serial data ports are also can be installed. The LAN ports are the bridges in this architecture, whilst the hub is the router.

The data port interface can be RS-232, RS-422, V.35, IEEE 802.X, etc. The protocols are the same as at the hub.

These data ports are fully independent of each other. The data port transmission speed can be 9,600 bit/s, 19,200 bit/s, or in the case of synchronous transmission, up to 64 kbit/s. Of course LAN*Advantage* LAN ports are set to the usual LAN capacity of 10 Mbit/s for Ethernet, or 4/16 Mbit/s for Token Ring.

4. THE SATELLITE LINKS: THE OUTROUTE AND THE INROUTE

4.1. Outroute

The outroute is the outgoing stream of users' data and network control information from the hub to the remotes. As such, the customers's networks share this stream.

Sharing the outroute is relatively simple, due to the central architecture of the satellite communications: all data on the outroute is passing a unique point, the hub. The hub sends the data packages to be transmitted as they arrived immediately.

The outroute is divided — in the time scale — into superframes, and a superframe consists of 8 frames. The superframe represents a 360 msec time-slot, or, equivalently 23.040 Bytes, expressed in data length. A frame is 45 msec, or 2.880 Byte in data length. The superframe has as header, with superframe number and other information. The superframe header represents a synchronization signal to the remotes. The remotes use this signal as a time-reference signal till the next superframe.

The outroute can carry network management, "housekeeping" information from the hub, like new specification of remote from the hub network management, commands and instructions, "health and care" report requests and questions, wake-up signals.

The outroute is a continuous stream, in order to keep control over the network. It always sends data in the superframes, even there is no data to be transmitted; by inserting dummy packages into the empty slots.

4.2. Inroute

The structure of the inroute is similar to that of the outroute. So a superframe is 360 msec, it is composed from frames of 45 msec in the time scale, but — due to the smaller capacity — the length expressed in Bytes is smaller: a superframe is 5.720 Byte, and a frame is 720 Byte in length.

There is no superframe header in the inroute. The frames are divided into 8 Byte slots, and a user package occupies an integer number of slots, staring with 8 Byte boundary.

The remotes transmit the data in burst mode, and only if they have data to send, so they leave the capacity available to the other remotes, according to the time sharing principle.

The number of PESs sharing the same frequency, i.e. the same inroute capacity, depends on the application. It is obvious that sharing a resource like inroute should be driven by very strictly synchronized methods. This control is kept in the hands of the hub, and the hub applies four basic methods to distribute this resource on demand and utilises it in the most economic way on one side, and warrants the best response time for the customers on the other side.

The cost-effective resource management and the high quality in response time seems contradictory, and in order to resolve the conflict, the *art of network design* and the *operational* type of *network management* are the *principal key elements of BankNet's data communication services*. The tools they have to apply are the inroute access methods.

5. THE INROUTE ACCESS METHOD

There are two basic methods to *access* any shared resource: *the random access and the dedicated access*. The *allocation* of any time shared resource can be *static or dynamic*. The combination of these offers four methods.

5.1. ALOHA

This is a *random access but static resource allocation* method. In every frame there are reserved — i.e. dedicated — slots at the same position. The remote, having a message of that slot length, selects one of these reserved slots and inserts its package, i.e. randomly. If there is no other remote who inserted a message to that room, the hub receives the package and acknowledge it.

If there would be another remote at the same time and its package in the same slot, then the two packages will interfere before they reach the satellite, hence the hub receives nothing. In this case there is no acknowledgement, the ACK, even not a negative one, the NACK. After a time-out, designed in accordance with the network characteristics, the two competing remotes selects randomly again a slot and they repeat the transmission.

Theoretically, it could happen that the remotes, competing in accessing these slots, will never send the actual package, but the careful network design and the operation must eliminate these situation with allocating enough dedicated slot to accommodate the traffic demand and to utilize the resources available. This method is similar to the Ethernet architecture, but with strictly synchronized way by allocating the same area, slot and the same length for each. This method is also referred as "slotted" ALOHA.

5.2. Stream

This is a *dedicated access and static allocation method*. Every remote has a dedicated, exclusive time frame or time frames — and the corresponding slots in Bytes — in which it can insert the data to be sent, either it has or hasn't data. No other remote can utilize these slots. Hence the stream access dedicates these slots to the remote. It is static, because even the remote data port has more data to be transmitted, the hub will not allocate more.

5.3. Transaction reservation

The transaction reservation is a *random access and dynamic allocation method*. The remote has no allocated resource available to send data, but an ALOHA slot is reserved to send — randomly — request to the hub to get the necessary capacity to transmit.

The hub allocates the time slots available at the time being, i.e. dynamically, and the remote data port inserts that part — or the whole — of the data into the allocated slots. If meantime the data port received more data from the terminals then it inserts a "piggy backed" package at the end of the data to request more, and the hub reallocates the available space according to the data waiting for transmission.

5.4. Flexroute

The last configuration in the exhaustive list of the possible combinations of accessing and allocating resources would be the *dedicated access and dynamic allocation method*. However, the *flexroute* offers this and much more. This method offers a dynamic application of each of these.

The necessity of a fully flexible method is obvious. As the ALOHA is typically useful in ATM or POS applications, the stream is suitable for heavy interactive applications, the transaction reservation for file transfers, somehow *each of these above described methods assumes a unique, (pre-)determined application architecture on the network*.

But the networks are not defined uniform applications. Networks are organic objects like the companies using the network services. They develop, change, concentrate and/or distribute themselves, both in data traffic and geographically. They are pulsating, and the network services must follow this.

The VSAT technology can adapt the geographical changes of network architecture with ease, the flexroute can do the same, as far the changes in data traffic characteristics are concerned.

Hence the key is the flexroute access. There are threshold values set to the remotes in the network. That value is the number of the bytes to be transmitted in the data port buffer. If this number is more than specified by the threshold parameter, the remote changes its access method to another specified, but more suitable one. For example, from ALOHA to stream, from stream to transaction reservation, and from transaction reservation to ALOHA or stream, as the current load of the different applications dictates.

6. NETWORK REALIABILITY

Although the hub and the remote reliability is a key issue and previously described in details, the network reliability is more than the reliability of the individual elements.

Two aspects of network reliability is presented here: one is the disaster recovery technology for the hub, the other is the Automatic Dial Back-up feature for the remotes.

6.1. Hub disaster recovery

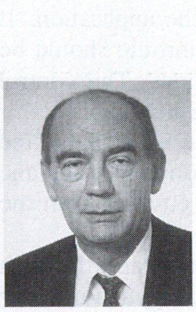
The hub disaster recovery also has two aspects: it is a service provision problem as well as technology problem.

A *service provider* must take into account the following criteria:

- Geographical separation. It is not sensible to have back-up in too close a geographic proximity as natural disasters may well effect both locations.
- National separation. It is better to have the back-up in another country so that both are not effected by the same political or legislative changes.
- Spare capacity. The back-up facility should have enough spare capacity to be able absorb the capacity displace by the disaster.

6.2. The disaster recovery technology

As far as the technology is concerned, the disaster recovery is solved by the following way: every remote has, as parameters the set of outroute frequencies it may belong. The primary is the hub outroute, the secondary is the outroute frequency of the disaster recovery hub. If the primary fails, than the remote receives the secondary and that is the disaster recovery. The new hub down loads the parameters (like the inroute frequencies, etc.) and the network is ready to work.



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VSAT TECHNOLOGY OVERVIEW

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The author of this article gives a short overview of the past and the future of VSAT technology and presents a Central European VSAT success story.

1. GTS HUNGARY

GTS Hungary, a subsidiary of Global TeleSystems Group was established in 1993, under the name SFMT Montana, which was among the first companies to deploy satellite communications in Central Europe, introducing VSAT services in Hungary. Since 1993 the volume of the VSAT business has significantly changed (Table 1.). Currently GTS Hungary is the 7th largest VSAT service provider in Europe.

Table 1. Market Situation – GTS Hungary's VSAT population

	End of 1993	Beginning of 1997
Number of operating VSATs	78	900
Hub station	Polish and German hub stations were used	GTS Hungary owns the largest hub station in the region
Number of clients	1 (Hungarian Lottery)	56 (banks, insurance companies, government agencies, oil companies...)

Besides offering fast and reliable data communications services via VSAT, GTS Hungary has also established a terrestrial network in Budapest and in the suburbs, called GTSRoute. It offers high speed advanced services, like Internet, Frame Relay and leased line services. The share of non satellite services in the company is continously growing (volume of satellite services is also growing). GTS Hungary intends to establish a countrywide terrestrial ATM technology based network to offer the same high quality services for its customers all over Hungary, as GTSRoute today. GTS Hungary expects the terrestrial services to be the major revenue source within 2 years.

Being aware of the various needs of our customers, GTS Hungary has been offering new services to meet all the demands for up-to-date communications: International data connections including 60 countries of the world, Orion satellite based networks (SCPC 'Single Channel Per Carrier' and DAMA 'Demand Assigned Multiple Access' networks), Inmarsat services (GTS Hungary is the 3rd Inmarsat Account Authority in Hungary), Internet capacity sales for ISPs 'Internet Service Provider' and for professional end-users.

2. SHORT HISTORY AND THE FUTURE OF VSAT

The VSAT technology has a nearly ten-year old history. The origin of the technology is the USA, which is still the main area for using VSAT networks. Until a few years ago the VSAT was supposed to disappear in the first decade of the third millennium. Today we believe, that satellite based technologies have an even more prospective future, than anybody has ever thought.

During the past years VSAT gradually changed, to follow the customers' needs: the size of the customer terminal is reducing, the throughput of the VSAT networks is growing very rapidly, new and new protocols are available. In the meantime the cost of VSAT technology has the same tendency as every communications product — decreasing.

Recently the vendors of all the different VSAT trends started to use industry standard architectures to reduce costs and 'time to market' for the new developments. A new way of VSAT development could transform the VSAT to a 'black box' unit — which could be integrated into 3rd party products. We can imagine the future VSAT as a single industry bus standard card (e.g. ISA, EISA, VME) with standard management access method (e.g. SNMP) in a complex equipment, like an ATM (Automatic Teller Machine). The result will be the whole integration of different technologies — routers, LAN/WAN switches, transmission channels — in one single platform.

During the next couple of years we will see some brand new systems as a new branch of VSAT technology — which are similar to the existing systems regarding only one feature: using a satellite for the communication.

2.1. Advantage of the VSAT technology

For a typical corporate network VSAT is the most cost effective solution. The cost of VSAT service can be planned and fixed. There are no sudden changes in service tariffs using VSAT. Over a certain number of remote sites its use is very economical taking into consideration all the additional operational costs (e.g. human resources at the operational department, financial losses because of network outage etc.).

The whole network can be monitored from the customer's data center, continuously checking the service operator and the service quality.

As a VSAT can be installed or re-located in one day — according to the user's demand — it offers full flexibility for the customer.

For example in the USA a terrestrial network spreading over several States, served by many different LTOs (Local Telephone Operator) is very difficult to operate. In case of a network error there are many participants in the service re-establishment. This type of multiple LTO service structure is more and more common for the whole of Europe, including Hungary which is another reason for using VSAT networks.

With the VSAT network the customer has one 'single point of contact' — one phone number — who has full responsibility for the whole network. The network is operated by one company which is responsible for all the remote connections. This also helps VSAT operators to provide a high quality service.

As there are only a few network elements in the VSAT network topology: VSAT terminal (indoor and outdoor unit), the satellite, which has multiple levels of redundancy, the hub station — usually fully redundant — and the hub-host connection, which is usually also redundant — the possibility of a network outage is minimized.

Besides VSAT is an ideal backup solution for every high sensitivity application, because it has a different 'media' from a wire based terrestrial network. Only a different access way to the customer's branch office router can guarantee the real backup capability of the wired last mile connection (Table 3.).

Table 3. VSAT technology compared to other communications alternatives

Technologies	Most suitable application	Advantages	Disadvantages	Capacity	Relative cost
Terrestrial packet switching network	packet switching	easy to connect low cost for occasional use	limited applications	9.6 – 64 (128) kbit/s/connection	$100/connection several cents/segment
Leased lines	data communications	robust	lack of flexibility, high cost, long lead time	64 – 128 kbit/s/line	$250 – 800/site monthly
Digital microwave	point to point communications	low cost for short distance communications	no long hauls only point to point	$n * 2$ Mbit/s	$10 – 50 K/couple
Fiber optics	trunking of voice and video	low cost for trunking application	trunking medium is not appropriate for a single business	1 – 100 Gbit/s	$1 M/link
SCPC/DAMA VSAT	heavy traffic, private networks	flexibility, accessibility availability	expensive suited for limited applications	$n * 64$ kbit/s-1-2 Mbit/s/VSAT	$40 – 100 K/remote site
VSAT	private networks, POS/ATM, reservations, lottery	flexibility, accessibility, availability, low cost/transaction, ideal for large networks	no support of frequent heavy file transfers	64/128 kbit/s Inroute 128/256/512 Outroute	$8 – 15 K/remote site

2.2. Why VSAT technology?

- Easy to install, not dependent on the existing infrastructure
- Advanced network management acces for the customers
- 99.9 % availability
- BER better, than 10^{-10} to the user
- Wide range of services at one SAP 'Service Access Point' (POS, ATM, X.25, FR, Internet – TCP/IP, Voice services)
- Predictable cost
- Excellent price/service value
- Flexibility
- One-stop shopping (no different telecom providers in the connection)

3. DIFFERENT VSAT TECHNOLOGIES

The collective term 'VSAT' means a group of technologies which have one main common feature: the characteristics of the satellite antenna. The 'VSAT' abbreviation simply means Very Small Aperture Terminal and the diameter of the tipical parabolic antenna is between 0,6 — 2.4 meters. This simple definition results in the many, very different VSAT trends. The most characteristic trends are as follows:

- Interactive VSAT (TDM/TDMA)
- One way (broadcast) VSAT
- SCPC point to point VSAT
- DAMA – Mesh VSAT
- Multimedia VSAT
- High speed VSATs (new trends)

3.1. Interactive TDM/TDMA VSAT

Today the interactive star TDM/TDMA 'Time Division Multiplexing/Time Division Multiple Access' VSAT has the highest population among all the VSAT types. This type of VSAT offers a wide range of services for nearly every application.

The main characteristic of interactive star VSATs is the large number of remote sites (thousands of connected remote terminals managed from one hub station) and the very small size VSAT terminals. The hub station is the fundamental investment, the remote sites have relatively low cost.

In Europe the 6.7 – 9 meter hub antenna size and the 1.2 meter VSAT antenna size is common. In the USA the star VSAT terminals usually have submeter (0.9 or 0.95 meter) dishes due to very powerful satellites and use of advanced satellite access methods with cheap and abundant satellite capacity. The hub station has redundancy, in some systems the management computer is fault tolerant (Fig. 1).

The star VSAT was planned for centralized IT systems — like banks, insurance companies, SCADA type applications and the lottery — with one or two host centers (Table 2.).

The interactive star VSATs have many features: X.25, Frame Relay, TCP/IP router, Brouter, Voice, Fax, SLIP, PPP, X.3 PAD, Asynchronous Hayes modem emulation, transparent protocols (bit, byte, frame transparent), SNA. The list of the different protocols is growing from day to day.

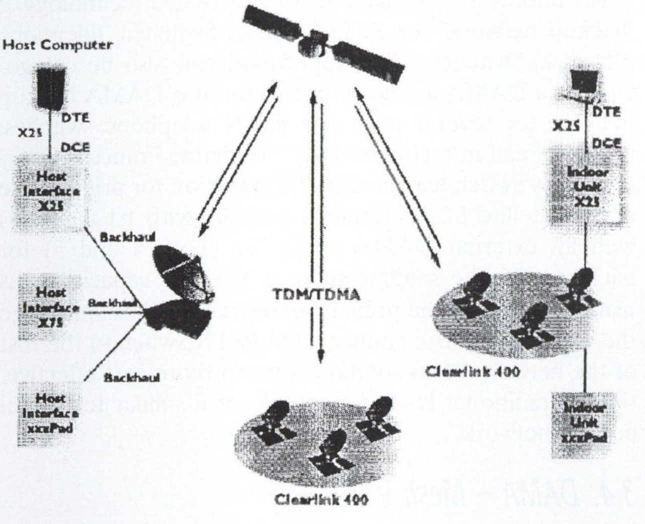


Fig. 1. Typical TDM/TDMA VSAT configuration

From one VSAT terminal a POS with X.3 PAD, an ATM with X.25 PVC or SVC and the branch router's primary or backup communication with X.25 SVC or Frame Relay can be operated without any additional hardware investment. We can use direct LAN (Ethernet/Token Ring) connections to the VSAT to save the router or gateway cost.

Recently the interactive star VSAT has DAMA extension, by which certain high throughput applications — voice, fax, batch data transfer — are handled (Fig. 2). The interactive VSAT is for the management and for the star-type applications. The star and the DAMA indoor unit typically has a common outdoor unit, reducing the cost (the outdoor unit has a significant share in the VSAT price). The common outdoor unit means a lower-cost unit, than a traditional DAMA terminal.

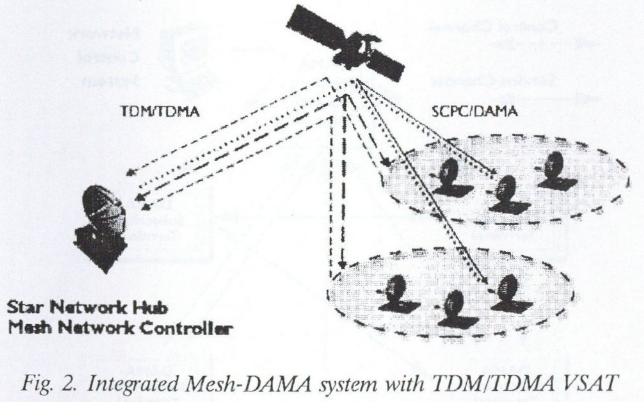


Fig. 2. Integrated Mesh-DAMA system with TDM/TDMA VSAT system

TDM/TDMA VSAT Applications

- Branch office administration
- Retail point of sale applications
- Reservations (hotel, car)
- Financial transactions (e.g. ATM)
- Electronic mail
- Remote data collection and process monitoring, SCADA
- Online, semi-online lottery
- Banking
- Electronic data interchange (EDI)
- Backup connections
- SAP R2, R3

Table 2. Typical TDM/TDMA VSAT application transaction characteristics

Application	Input characters	Output characters	Response time
Insurance	60	300	2-3 s
Retails	50	200	2-3 s
Reservations	100	800	2-4 s
ATMs	40	80	3-4 s
Other financial	100	400	2 s
Electronic mail	varies	varies	5-10 s
Remote data collection	100	25	2-6 s

3.2. One way (broadcast) VSAT

The demand for data broadcast is of the same age as information technology. Broadcast technology is one of the components of some new, advanced technologies, such as 'multimedia VSAT' which is also described in this article. There are three main broadcast types — data, voice and TV.

Data broadcast systems can traditionally be divided into two groups – guaranteed and non-guaranteed broadcast. The main characteristic of the data broadcast systems is the excellent BER (Bit Error Ratio).

One of the main applications of data broadcast is the paging systems. This technology makes it possible to cover the whole territory of the USA (or naturally Hungary) by a single pager network. Another interesting, new data broadcast service is the 'Internet news' distribution for ISPs. This service distributes the same, huge amount of information to the selected users (Fig. 3).

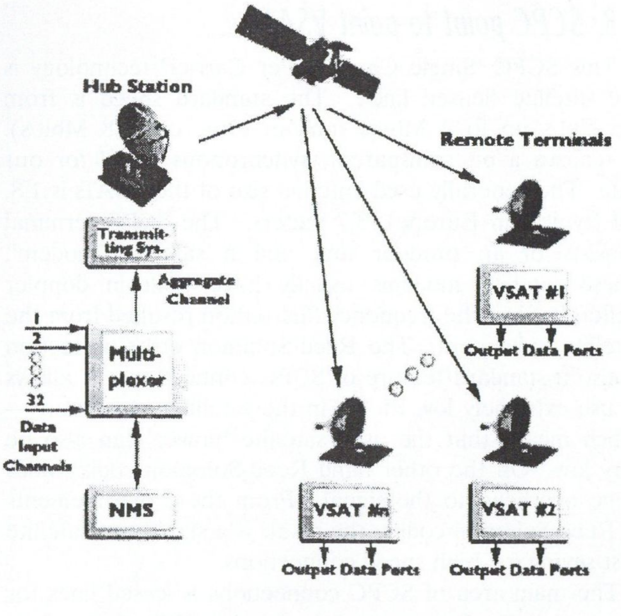


Fig. 3. One way broadcast VSAT application

The guaranteed systems have 'back' channels (traditionally through the X.25 network) where acknowledgments of correct receipt get back to the broadcast hub from each receiver station. If an acknowledgment does not arrive in time, the data segment is re-transmitted until each remote receives it correctly.

When broadcasting voice/TV MPEG-2 compression technology is generally used these days. A relatively low-cost central 'hub' (compression, redundancy and management access) is connected to a standard uplink station. The remote receiver's cost — depending on the performance, data interfaces, etc. — is also low. The main cost element of the system is the satellite space segment. Under a few hundred remotes these systems are not really economical, practice shows, that the actual bottom limit is one hundred remote terminals. Although this limit can hardly be reached in Hungary, one of the cable movie companies has been using this technology since this year to distribute their TV programs. As an interesting contribution, the widely used individual satellite receiver also belongs to this family of VSATs. (See the VSAT definition!)

The one way voice systems (TV channel sub-carrier, SCPC types) such as direct and indirect radio broadcast program source distribution for the regular radio transmitter stations and music/advertisement service distribution for shops are also a very important segment of satellite technologies. The difference between the TV sub-carrier and the digital SCPC type broadcast technologies is the satellite transmission method. The TV sub-carrier distribution systems have a big advantage, the very low unit cost, but can only be uplinked together with a non-compressed TV channel, which means practical difficulty. In Western Europe there are networks with a couple of thousand remote receivers for centralized shop music and advertisement distribution.

In every broadcast system (data, TV, Voice) it is possible to create receiver groups, which can receive the assigned information. One receiver can be dynamically re-assigned from one group to another. The best example for above use is distance learning.

3.3. SCPC point to point VSAT

This SCPC 'Single Channel Per Carrier' technology is the satellite 'leased line'. The standard speed is from 9.6 kbit/s up to 2 Mbit/s (and in some cases 8 Mbit/s). It realizes a bit transparent, synchronous 'pipe' for our data. The generally used antenna size of the VSATs is 1.8, 2.4 (typical in Europe), 3.7 meters. The SCPC terminal consists of an outdoor unit and a satellite 'modem'. These satellite modems usually have built in doppler buffers against the frequency fluctuation resulted from the satellite movement. The Reed-Solomon error correction is also a standard feature of SCPC connections. It allows to use extremely low Eb/No in the satellite connection — which means that the used satellite 'power' can also be very low. On the other hand Reed-Solomon coding adds some overhead to the signal. From these two elements of Reed-Solomon coding the result is a significant satellite cost saving for high speed connections.

The main area of SCPC connections is leased lines for international voice connections, Internet ISP connections (mainly USA — Europe links), hub-host connections for interactive star VSATs and general leased line applications.

Generally speaking, the SCPC leased lines are 10–20 % cheaper, than the same capacity international terrestrial leased lines (this price advantage is primarily valid between Europe and the USA).

An interesting application for the SCPC technology is 'backup network' for PSTN (Public Switched Telephony Network) switches. This application can also be categorized as a DAMA application, because it is DAMA backup network for several small size PSTN telephone switches, widely spread in a country (e.g. Germany, France). Every telephony switch has terrestrial connection for primary use and a satellite SCPC terminal (usually with E1 capacity) with an external DAMA controller (Figs. 4 and 5) for backup. On the satellite there is $n * E1$ capacity (n is usually 1). When the primary terrestrial link has an outage the satellite network connects the PSTN switch to the rest of the network. This solution is much more cost effective, than a traditional DAMA network, or a similar terrestrial backup network.

3.4. DAMA – Mesh VSAT

In a DAMA Mesh network every VSAT terminal can communicate with every other VSAT terminal directly with one satellite hop, which means low delay (approx. 0,5 second) between the remote sites. (Figs. 4 and 5) This low delay is optimal for 'human' voice users.

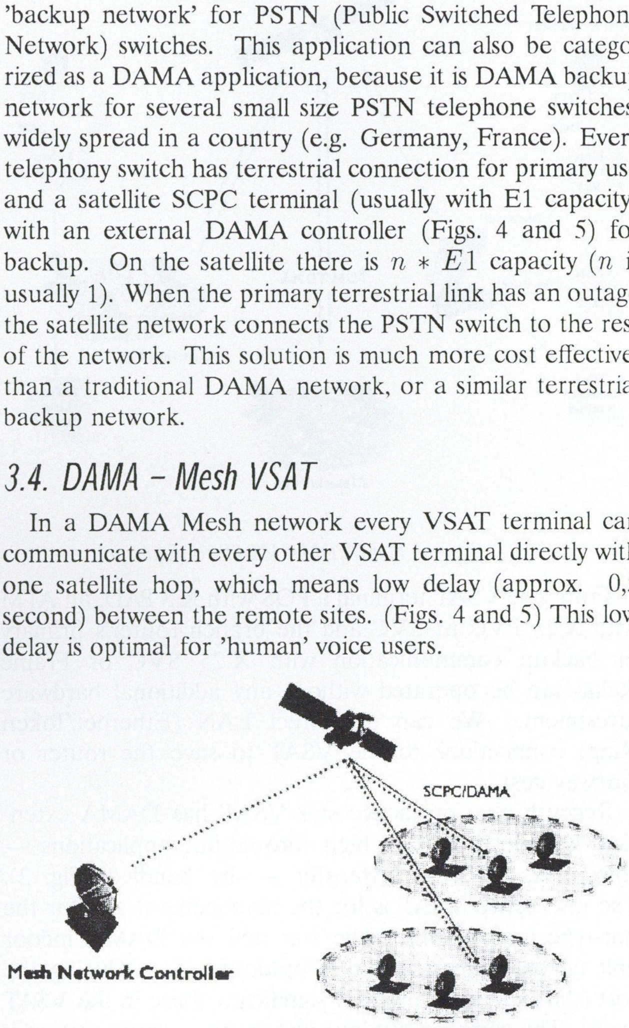


Fig. 4. Mesh-DAMA configuration

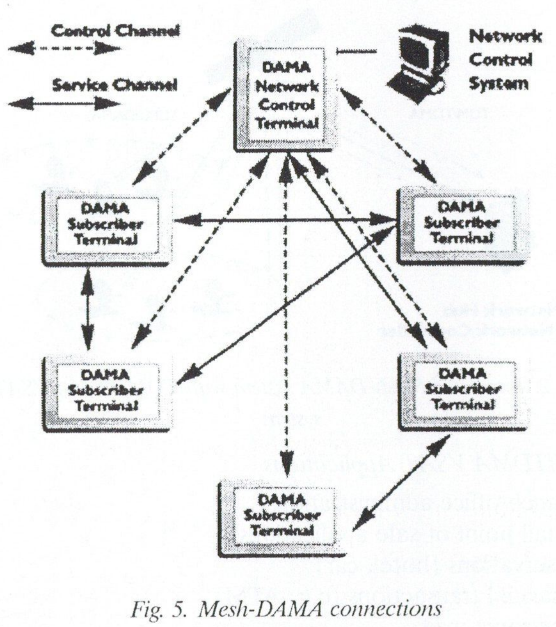


Fig. 5. Mesh-DAMA connections

The DAMA VSAT terminals usually have 1.8–2.4 meter dishes. There are no big hub stations, the network has a management VSAT instead. The unit cost is roughly ten-thirty times higher, than the star VSAT unit cost. In the past the minimal startup satellite capacity was usually at least 1 Mbit/s, today some systems can be started with 512 kbit/s satellite capacity. This reduced startup capacity need helps the operators to start DAMA Mesh networks.

There are many different satellite access techniques: time division, frequency division, their combinations and recently code division systems. The number of sites in one network is usually up to 20–30 although some new systems allow to use a high number of remote stations.

Some new CDMA (Code Division Multiple Access) satellite access based networks can have thousands of VSATs in one network. With this effective satellite access technique a very cost effective per minute rate can be obtained (with the optimal configuration).

The core technology of the traditional DAMA systems is Frame Relay which allows mesh connections for data, voice and fax transmissions.

There is another classification of DAMA systems, regarding the original aim of system optimization: voice or data application. Both of these two trends have data and voice capability, the difference is in the solutions and service levels how these features are implemented.

Regarding DAMA systems the video conference application must be mentioned, which is very successful in the USA.

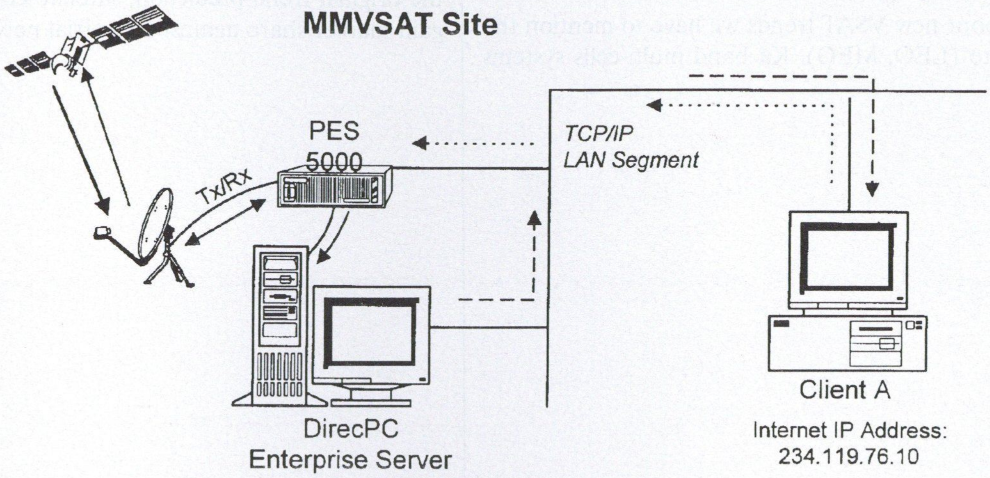


Fig. 6. Multimedia VSAT application

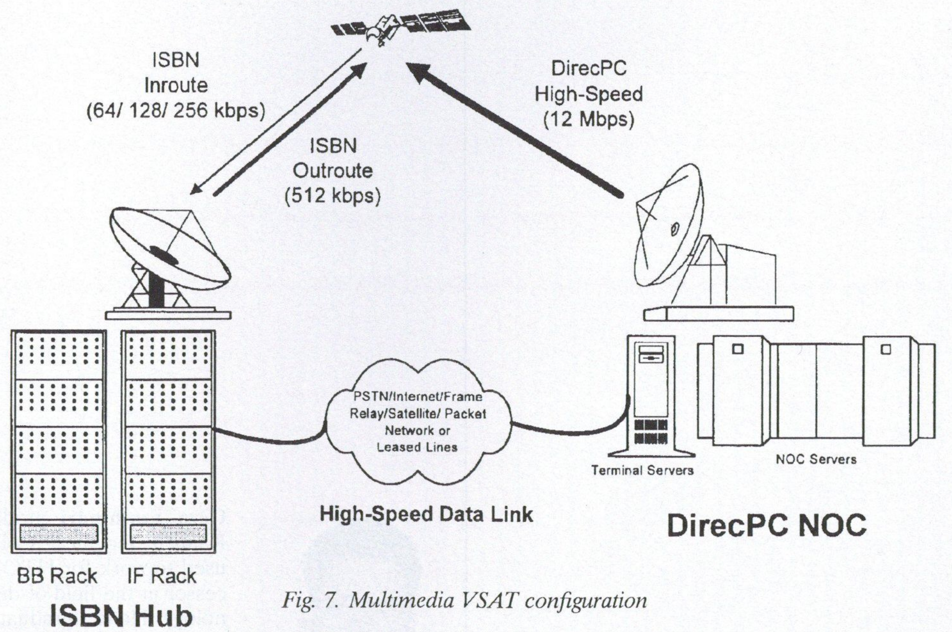


Fig. 7. Multimedia VSAT configuration

DAMA Mesh Applications

- Batch data transfer
- Inter PBX voice connections, international gateway access
- Rural telephony
- High throughput mash data applications
- Low throughput data transfers
- Backup connections between the main telephone switches (e.g. E1 connections)

3.5. Multimedia VSAT

This new VSAT technology trend takes its origin from the data broadcast technology and some traditional 'back' channels (dial-up modem or TDM/TDMA VSAT) (Figs. 6 and 7).

With this technology we can ensure even 400 kbit/s Internet download capacity, which is significantly higher than any conventional terrestrial solution. The capacity of the Internet download stream can be configured from the minimal configuration up to 12 Mbit/s, as the customers' demand justify it. This satellite Internet access can generate fierce competition for the terrestrial Internet solutions. After the USA, this service will come into general use in Europe, too.

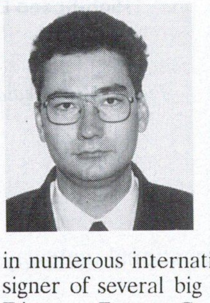
3.6. High speed VSATs

Talking about new VSAT trends we have to mention the lower satellite (LEO, MEO), Ka band multi-cells systems on the first place. These new systems will revolutionize VSAT communication and bring high speed connectivity to every home or office. The new systems' capacity will be hundreds of times more, than the actual systems have.

With a 0.66 meter dish we will be able to uplink a data stream of up to 6 Mbit/s, which opens new dimensions for voice, multimedia and data connections. We will be witnessing the spreading of these new technologies in the next few years.

4. CONCLUSION

As we have seen during this short overview, VSAT will continue to play an important role in communications. VSAT technology transforms to satisfy the new and new customer demands. Most likely we will see, that opposing the original trend prediction, satellite communications will gain market share against terrestrial networks.



Géza Szathmári graduated from Kandó Kálmán Technical College in 1988. He used to work for HTC and its legal predecessor in the field of digital switching technology. He is a graduate 'ADS System Engineer'. In 1991 he joined GTS Hungary's legal predecessor, Montana Telecom. He has wide range of experience of satellite technologies, different microwave, WAN switching technologies. He has taken part in numerous international training programs. He is the main designer of several big WAN networks. Today he is the Technical Director, Deputy General Manager of GTS Hungary.

MATÁV'S EXPERIENCES IN THE FIELD OF BUSINESS SATELLITE COMMUNICATIONS

CS. DOBREFF

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The article deals with satellite services offered by MATÁV for the customers. The different services are defined and described in the article. Moreover, the author presents the sum and component values of the availability measured in the satellite links operated by MATÁV.

1. HISTORY

MATÁV entered the business satellite communication market in the spring of 1992 when it established the SAT-NET Satellite Service Provider Ltd. as its fully owned subsidiary. In order to fully harmonise MATÁV's business communication services SAT-NET Ltd. became integrated with the parent company in the autumn of 1994. At present, the operation tasks of the business satellite communication services are performed by the SAT-NET Operation & Maintenance Centre. The marketing and sales functions of satellite services are performed by the General Directorate's Business Communication Branch.

At the beginning our Company used a foreign service provider's system for providing satellite data transmission services. On the basis of the experience gained in such a way which showed the perspective of providing business satellite communication services, a decision was made for investment of an own satellite system. The NEXTAR IV TDM/TDMA system delivered by the Japanese NEC has officially been in operation since the summer of 1995.

The own digital satellite data transmission central station installed in the Naphegy tér centre of MTI has been serving its customers since 1993.

2. SERVICES

At present MATÁV offers the following satellite and microwave services to its customers:

SAT-STAR packet switched satellite data transmission service

The SATINTERFACE-STAR service is a satellite packet switched data transmission service that is based on MATÁV's TDM/TDMA VSAT system. The elements of the service provider's network are MATÁV's Budapest multipurpose central earth station (HUB), the VSATs installed on the users' sites, the leased capacity on satellite EUTELSAT II-F4, and the leased lines connecting the computer centres of the users with the hub.

The SAT-STAR service provides packet switched type duplex data transmission connection between the user terminals connected to the VSAT stations and the users' computer centres connected to the hub through leased line.

The SAT-STAR service supports the X.25 protocol as basic interface and the X.3/X.28/X.29, ASYNC and IP router protocols optionally.

In addition to the data transmission, also compressed voice transmission is optionally possible.

BROAD-SAT digital information transmission service

The BROAD-SAT service is a unidirectional data transmission service that is suitable for sending data from synchronous and asynchronous data sources to large number of data sinks (users). The elements of the service provider's network are the data transmission central station, the communication lines connecting the data sources with the central station, the receive-only type VSATs installed on the users' sites, and the leased capacity on the satellite EUTELSAT II F4.

The BROAD-SAT service provides a point-to-multipoint simplex data transmission connection between the user data sources connected to the central data transmission station and the user terminals connected to the receive-only type VSAT stations.

SAT-EXPRESS point-to-point satellite digital leased line service

The SAT-EXPRESS service is a point-to-point leased line service established using satellite tools which provides protocol independent, bit-transparent connection directly between the data interfaces of VSATs installed on the users' sites.

The elements of the service provider's network are the VSATs installed on the users' sites, the leased capacity on the appropriate satellite and optionally and according to need the monitoring system operating on the service provider's site. Monitoring of VSATs takes place using dial-up modems through normal telephone lines.

MultiMicro point-to-multipoint terrestrial microwave digital data transmission service

In the area of Budapest, a point-to-multipoint microwave network interconnects the customers' computer centres with MATÁV's multipurpose satellite telecommunications centre (HUB). Moreover, by means of this terrestrial microwave system, MATÁV can provide also independent, bit-transparent transmission routes for instance for the purpose of back-up links.

Operation of foreign service providers' systems within the framework of international agreements — (Outsourcing)

The service includes the installation, operation, and maintenance of foreign service providers' satellite devices.

On the basis of particular special agreements the service may also include arrangement for licensing and administration at the authorities as part of the service.

3. SERVICE QUALITY

The quality of a service consists of numerous components. Here we list some of the most important components:

- customer-friendly attitude in the Customer Service Department,
- management of complaints,
- availability of the equipment and transmission routes,
- accuracy and timely sending out of bills.

Here, considering the SAT-STAR service, we first of all discuss the availability that is in the closest connection with the operation and can the best be quantified.

3.1. Definition of availability

Under the availability of service the availability of connection from the VSAT port to the user end interface of Hub-Host connection is meant.

The availability figure says in what percent of the operation period the connection is functioning according to the specified quality parameters.

The availability of connection is determined by the availability of the particular components.

3.2. Network components

Under network components the pieces of equipment by means of which the connection is established and the communication channels are meant. The network components of the SAT-STAR reference connection are the following:

- VSAT,
- VSAT-Hub satellite link,
- Hub-VSAT satellite link,
- satellite,
- Hub, and
- Hub-Host connection.

3.3. Availability of the equipment

The MTBF and MTTR values serve for calculation of availability of equipment.

MTBF is the Mean Time Between Failures of the given equipment.

MTTR is the Mean Time To Repair that is the average period counted from occurrence until elimination of the faults.

The MTBF values characterise the reliability of the particular equipment while the MTTR value additionally characterises the service convenience, reservation, and last but not least the service provider's response time.

The "Availability" (A) is the most widely used, "integrated" indicator of reliability which can be derived from the MTBF and MTTR values. The relationship between the Annual Average Down Time (AADT) and Availability for a given network component is determined by the following expression:

$$AADT = (1 - A) \times 24 \times 365$$

The table below contains the reliability and availability data for the main components of SAT-STAR reference connection:

Network components	MTBF [hours]	MTTR [hours]	AADT [hours]	Availability
VSAT	30,000	6	1.75	99.980 %
Satellite			0.58	99.993 %
HUB			2.63	99.970 %

3.4. Availability of the transmission routes

Satellite – earth station sections

The system was designed in such a way that the bit error rate of 10^{-7} be fulfilled with an availability of 99.98 % on the *hub-satellite* section and with 99.7 % on the VSAT-satellite section. This means that the bit error rate that is considerably better than 10^{-7} in clear weather and falls below the specified threshold value only during extremely heavy downpour in 0.02 and 0.3 % of the year, respectively.

Another special characteristic feature of the satellite connections is that twice a year – during the spring and autumn equinoxes – the Sun "crosses" the antenna beam of the earth station directed to the satellite. This phenomenon occurs on 3-4 consecutive days for maximum 3-5 minute periods. On the first and the last days the error rate is deteriorated while on the middle day the connection can even be broken. The phenomenon is unavoidable but its occurrence can precisely be calculated in advance. MATÁV notifies the users about this event by a week in advance. These down times are not taken into consideration when the availability is calculated.

Hub-Host connection

From the viewpoint of reliability of the service the Hub-Host connection is specially important. The failure of the Hub-Host connection may result in the outage of the whole user network. In order to keep the reliability at a high level, a back-up Hub-Host connection should also be used. The reliability characteristics of Hub-Host connection with and without stand-by are the following:

Connection	AADT [hours]	Availability
Digital leased line	42	99.5228
Redundant connection (Microwave plus digital leased lines)	0.27	99.9969

Availability of the connection

The availability of the connection is the product of the availability of the particular components:

Availability of connection (in case of Hub-Host redundant connection)	[%]	99.62
Expected annual down time	[hours]	33.3

The availability is the statistical indicator of the reliability and quality of the service. Because of its statistical nature, it can only be measured in case of network of an appropriate size and during a properly long period.

4. OPERATION EXPERIENCE

4.1. Typical reasons of interruption of connections

The most frequent interruptions occurring in the SAT-STAR system are detailed in the following table:

Nature of the outage	Direct reasons of the outage	Frequency related to the total outages	Average down time including the synchronization of the system (minutes)
VSAT supply voltage drop out	• quality of the national electricity network • unintentional cut off the power supply by the user • unintentional cut off the current by the user	50 %	7
Interruption of the satellite transmission route	• rain, snow • bird	40 %	1

The VSAT power supply failures cannot easily be distinguished from other interruptions. Through follow-up processing of data of the central network management system, the SAT-NET Operations Centre is capable to distinguish between in the records. This is important because we do not take into consideration the outages coming from the supply voltage outage when the availability is calculated since we cannot exert influence on it.

4.2. Measured down time data

The SAT-STAR service has the following typical outage characteristics (June 1996):

No. of stations in operation	Total No. of outages	Total duration of outages that do not need repair (hours)	Total duration of outages that need repair (hours)	No. of outages that need repair	Total outage duration (hours)	Outage duration per station (hours)
300	350	31	16	4	47	0.15

Our customers are satisfied because compared the results to the required values of availability specified above, it can be seen that we overfulfilled the quality figures assumed by us.

4.3. Repair and fault clearance

For operation and fault clearance of its business satellite telecommunications services, MATÁV maintains a 24 hours a day Help Desk service. If admittance to the customer is possible, the fault clearance is performed on all days of the week (including also the week end) even at night.

The fault clearance and repair are performed by our professionals within the possible shortest period. The following Table provides information on the time needed by the operations which contribute to the MTTR value. From the following table it can be seen that the assumed fault clearance period of 6 hours is much more than enough.

Operation	Period
Travelling (within the country)	max. 3.5 hours (depends on the distance)
Replacement of outdoor unit	20 minutes (measuring is included)
Replacement of indoor unit	10 minutes (tests are included)
Software downloading	10 minutes

5. ACHIEVEMENTS

In harmony with the original idea, the service based on own devices results in simple, quick, safe, and cost saving service, as it is shown above.

The high quality operation ensures the quality level expected by our customers. Moreover, on the basis of concrete experience, we can state that we have overfulfilled our obligations.

Thus the satisfaction of our customers continues to grow which is reflected also by the number of stations installed.

First half of 1996	Number of stations
Domestic VSAT	350
International VSAT links	80

Csaba Dobreff graduated from Technical University of Budapest in 1989 and received his Ph.D. degree in 1993. He started his career at the Research Institute of Telecommunication. In 1991 he joined MATÁV. In 1992 he was with SAT-NET Ltd established by MATÁV for its VSAT based satellite communications services. His professional interest included satellite linkbudget calculation and videoconferencing. After SAT-NET had been integrated into MATÁV in 1994 he worked as system engineer of satellite group at Long Distance Directorate of MATÁV. Since 1996 he has been working as product manager of MATÁV's business satellite communication services.

ANALYSIS AND DESIGN OF VSAT NETWORKS THROUGH SIMULATION

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Traditionally, most of presentations on this conference concentrate on the hardware side of satellite communications. Topics covered the architecture of VSAT systems, the operations of a satellite, link budget calculations etc. But VSAT equipment contains software as well that makes the iron work: the communication protocols. The selection of communication protocols and their right configuration is a key factor in the network's performance.

1. INTRODUCTION

Hungaro DigiTel, as a satellite communication service provider, knows the importance of network design. It is typically not an easy task to foresee how customer applications will behave on long-delay satellite links, how much bandwidth they need for optimal performance and how the internal communication protocols need to be configured. Simulation is a method that can help answer these questions. Simulation provides exact results at low cost: it is still usable where analytical methods fail because of the inherent complexity of real-life problems, and is more cost-effective than the "let's build it and we'll see" type solutions.

At Hungaro DigiTel, we have constructed simulation models of an imaginary, however typical VSAT system. The components allow us build up models of VSAT networks. Simulation runs of the model produces various statistics which can be used to evaluate the network's performance, track down bottlenecks and poor parameter settings.

2. THE SIMULATION TOOL

Hungaro DigiTel uses OPNET Modeler of MIL 3, Inc. as a simulation tool. OPNET (Fig. 1), being a leading software package for detailed simulation of communication networks, is used by a number of high-tech companies and organizations like BOEING, DEC, MOTOROLA, ERICSSON, NASA.

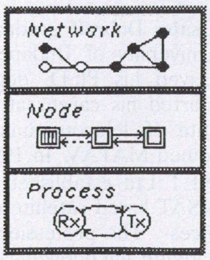


Fig. 1. OPNET model editors

OPNET is based on a series of hierarchically related editors that directly parallel the structure of actual networks. The *network editor* (Fig. 2) graphically captures the physical topology of a communications network. Networks consist of node and link objects, which are graphically assembled and attributes can be assigned to them. To create node objects, users select node types from a library of ready-made and user-defined models. Each node has a specific set of attributes that are used to configure it. Network models can be constructed in a dimensioned workspace, with an optional cartographic background.

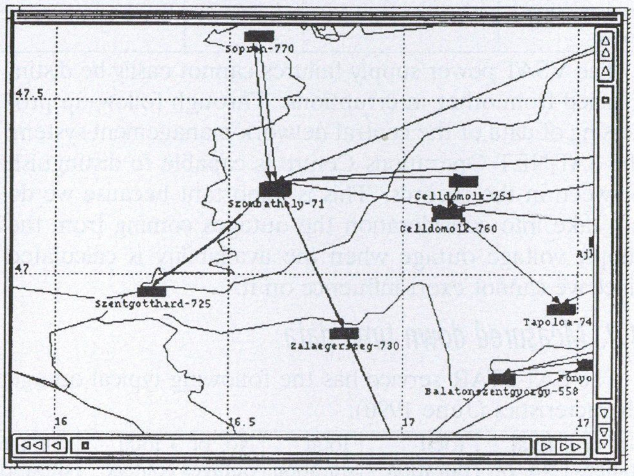


Fig. 2. Network model of a sample X.25 network

The *node editor* (Fig. 3) graphically captures node architectures, which are diagrams of data flow between modules representing hardware and software subsystems. Module types include processors, queues, traffic generators, receivers and transmitters. Processors are general modules that provide complete flexibility in protocol and algorithm specification.

The *process editor* (Fig. 4) uses a state-transition-diagram approach to support specification of any type of protocol, resource, application, algorithm or queuing policy. States and transitions graphically define the progression of a process in response to events. Within each state, general logic can be specified using the full flexibility of the C language and a library of approximately 300 communication- and simulation-specific OPNET functions.

OPNET simulations are standalone programs which generate user-selected performance and behavioural data of the model during their execution. Simulation results can be plotted as time series graphs, scatter plots, histograms, and probability functions. Standard statistics and confidence intervals are easily generated and mathematical operators can be applied to the connected data.

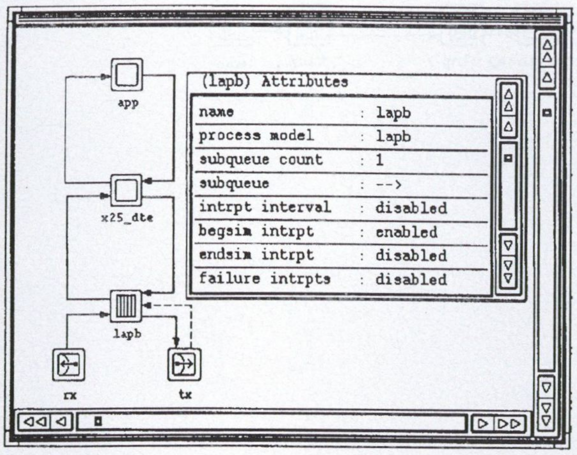


Fig. 3. Node model of a terminal using X.25

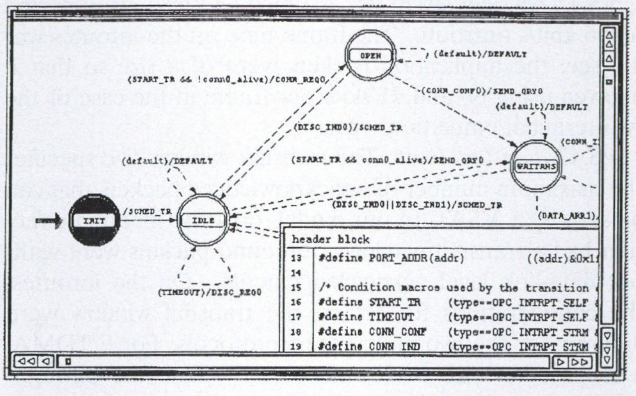


Fig. 4. Process model of a terminal application

The tools described above enable the user to prepare a high-fidelity simulation of any communications network. OPNET comes with models of most widely used protocols: TCP/IP, X.25/LAPB, Ethernet, Token Ring, FDDI, ATM etc., but it is possible to develop new protocol models or modify the existing ones. Application behaviour can also be specified in detail and the statistics of interest can be freely specified. These features make OPNET an ideal environment for analysing communication networks and make it an invaluable help in network design.

3. THE MODEL OF AN IMAGINARY VSAT SYSTEM

We designed our model of a VSAT network around the internal protocol architecture. As the first step, we had to decide which protocols our imaginary VSAT system should have.

Today's VSAT systems have internal protocol structures that were designed with the OSI reference model in mind. The protocol architectures typically correspond to the OSI model, i.e. they have protocols to do the tasks specified by the OSI reference model's physical layer, data-link layer, network layer and transport layer. This doesn't mean necessarily that OSI standard protocols are used as components but the OSI layers and their functionality can be recognized. In our imaginary VSAT system's protocol architecture, we have chosen OSI protocols wherever they were applicable in VSAT systems.

The following levels of VSAT protocols were modelled: physical layer, data-link layer, network layer and transport layer.

Physical Layer: as our focus was not on the hardware, we used a simple model for the physical layer. The characteristics of the physical satellite link and notions like antenna gain, signal/noise ratio, modulation, FEC coding technique etc. were not explicitly modelled. Instead, they appear in the model through four quantities: delay (sec), bit rate (bit/sec), bit error rate (error/bit) and error correction capability (error/bit). In modelling packet collisions we assumed that any overlap between two packets will make both packets unusable.

Data-Link Layer, MAC Sublayer: we have incorporated a number of multi-access protocols that we felt were the most widely used ones in VSAT systems, including "pure" Aloha, slotted Aloha, fixed assigned TDMA and a variation of demand controlled TDMA.

Data-Link Layer, LLC Sublayer: We have modelled a LAPB-like protocol, modified for VSAT requirements. The modification includes the implementation of selective acknowledge/retransmission scheme (that is needed because of the large delay of the satellite links) and the modification of the addressing scheme (to enable addressing of a large number of VSATs). We used mod-128 packet numbering.

Network Layer: We have used the OSI-standard CLNP protocol (Connectionless Network Protocol) for routing purposes within the satellite network.

Transport Layer: A transport layer must be present since a typical VSAT network provides reliable end-to-end connection between sites. Also, the transport-layer protocol provides the multiplexing capabilities. The OSI standard contains five transport protocol classes, depending on the characteristics of the underlying protocols: TP0..TP4. We have modelled TP4 (Transport Protocol class 4) because the lower levels do not provide reliable service.

Application Layer: Above the transport layer, nodes of a VSAT network must have a layer that is used to bridge the gap between user protocols and the VSAT network's transport layer protocol. Since this is not something that is specified in the OSI model and — if correctly implemented — also not something that would much affect performance, we have invented a simple protocol here. In the actual implementation of the VSAT protocols, we have used some protocols from OPNET's sample models, but in the case of the lower layers and the application layer, we had to write our protocol models. We have equipped the protocol models with the capability of generating statistics.

Using the protocol models as building blocks, we have built a set of OPNET node-level models of VSAT and hub nodes, with different quantities and types of user ports (Fig. 5).

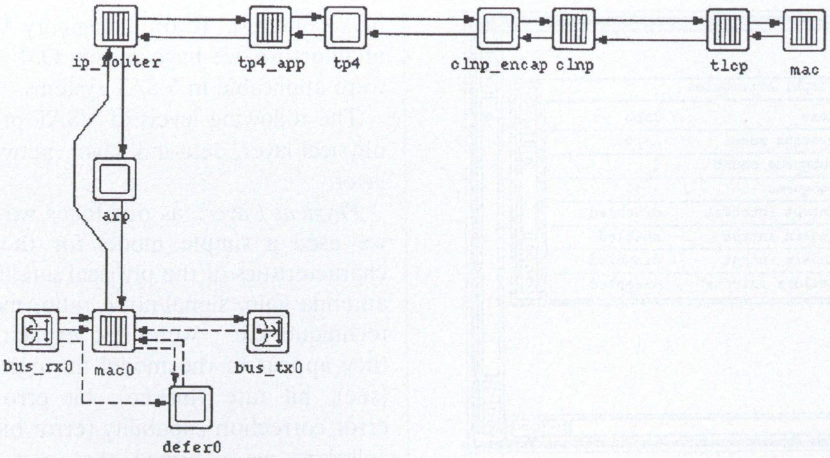


Fig. 5. Node model of a VSAT with an Ethernet port

4. A SIMULATION CASE STUDY: THE MODEL

We have used the protocol models to evaluate a sample application on a one-hop VSAT network. The network consisted of a host computer and several terminals using the services of the host. The terminals were placed to sites (5 to 35 terminals per site) with local Ethernet networks. Each site had a VSAT, connected directly to the Ethernet. The host computer was connected to the hub via a high-speed terrestrial link. The terminals accessed the host with terminal emulation, using TCP/IP. We examined two kinds of block-mode terminal emulations: the first one allowed the user to edit a database field locally and the contents of the field was sent when the user moved to another field (*field-based block terminal*). The second one allowed the user to edit the whole form displayed on the screen locally, and it sent the whole contents of the form when the user signalled that he had finished editing it (*form-based block terminal*).

The subject of the study was to find out how the performances of the two types of terminal emulation compare to one another. We also wanted to know which multi-access protocol would be the optimal choice for the inroutes. A rule of thumb says that for interactive applications slotted Aloha (or Aloha) is the most appropriate protocol. However, in this particular case, VSATs may have required fixed assigned slots (F/TDMA), since there were quite many terminals per site and the aggregate traffic of a site could be quite high and steady. Also, we wanted to find out whether terminals at a small site behave differently than those at a large site.

The most important statistics generated by our OPNET simulation program were: *VSAT physical layer:* channel utilization, packet collision ratio, actual bit rate/packet rate etc; *VSAT data-link layer:* retransmission count, average number of unacknowledged packets, number of packets waiting for transmission etc; *VSAT transmission layer:* end-to-end delay, retransmission count etc; *terminal/host TCP:* end-to-end delay, round-trip time, retransmission count etc; *terminal application:* response time.

A number of parameters were to be configured in the network. To keep the number of simulation runs below a sensible limit, it was necessary to fix the value of most parameters.

VSAT physical layer: We assumed 64 kbit/s inroutes and a 256 kbit/s outroute. The frame time on the inroutes was 1.0 sec; the application packets were of a size so that it allowed using 66 and 71 slots per frame in the case of the two terminal emulation types.

VSAT data-link layer: The transmit window size specifies the maximum number of unacknowledged packets that can be sent by a VSAT. In our model, only the inbound direction had a transmit window: outbound packets went without data-link level acknowledgements. On the inroutes, the considerations for setting the transmit window were different for the two multi-access protocols. For F/TDMA, a low window size could unnecessarily limit the throughput, so a sufficiently high value should be chosen (we used 16). In the case of slotted Aloha, a transmit window greater than one could be specified, that is, a VSAT could send several frames at a time, which contend for the slots individually as if all were sent from different VSATs. A too high value for this transmit window could cause constant collisions so the sound setting is between 1 and 3. As the traffic generated by one site is relatively high, we used transmit window=3 for all slotted Aloha simulation runs.

VSAT transport layer (TP4): The protocol's send window should be sufficiently high so that it doesn't limit the throughput; at the same time, a too high value also has unpleasant side effects: bigger buffer size is needed in the VSATs and packets may spend too much time in the VSAT, waiting for transmission. We set the TP4 window to 30.

Terminal transport layer (TCP): The window size should be sufficiently high so that a low TCP window doesn't prevent the terminal from giving data to the VSAT when it still has free bandwidth. A potential problem is that TCP expects the window size to be given in bytes, while TP4 counts in packets (PDUs).

5. THE SIMULATION RESULTS

We performed four series of simulation runs for the two multi-access protocols and the two types of terminal emulation, each series with an increasing inroute load. The main statistics we looked at were the response times of the application at a small (Békés, 6 terminals), a medium-sized (Cegléd, 12 terminals) and a big (Nyíregyháza, 35 terminals) site.

5.1. Fixed assigned slots

We used a simple rule to generate the slot configurarion: we gave the VSAT one slot for each 2, 3, etc. terminals that connected to it. Within the frame, we tried to evenly distribute the slots reserved to a VSAT. We performed two series of simulation runs for the two types of terminal emulation, the number of terminals per slot being 2, 3 and 5 within each series.

Looking at the statistics produced by the simulation, we observed that results for the two types of terminal emulation did not differ significantly. The field-based block terminal gave lower response time values, but the difference was always small (below 20 %). This seems sensible since the field-based terminal worked with more frequent, smaller messages, but the total amount of user bytes transmitted was roughly the same. The fact that the difference was so small suggests that we prefer form-based block terminal to field-based one since it is more efficient to use: the user of the terminal has to wait fewer times. In the further discussion, we only deal with the form-based terminal emulation.

The response time graphs for the 3 terminals/slot case are shown in Figs. 6–8. It is surprising how much the graphs differ for sites of different size. Even without looking at the averages, it is visible that the small site (Fig. 6) produced higher response times than the others and the values scatter more. This is due to the fact that small sites had few slots so bursty packet arrivals at the VSAT often caused temporary congestions when packets had to wait. For the medium and large sites (Figs. 7 and 8), the graphs are similar to one another.

The exact average response times are: 2.25 sec (6-terminal site), 1.71 sec (12-terminal site), 1.75 sec (35-terminal site). These are relatively high figures and even higher when we take into account that inroute utilization was low (in the 25 . . . 30 % range). However, outroute load was high (65 . . . 75 %) which suggests that congestions might have occurred on it. End-to-end delay statistics show that the outbound direction contributed to the total response time with about 1 sec.

When assigning the slots using the 2 terminals/slot rule, the simulation produced slightly better response times. The decrease was about only 0.3 secs at each site. This is understandable since the delay coming from the outbound direction did not change.

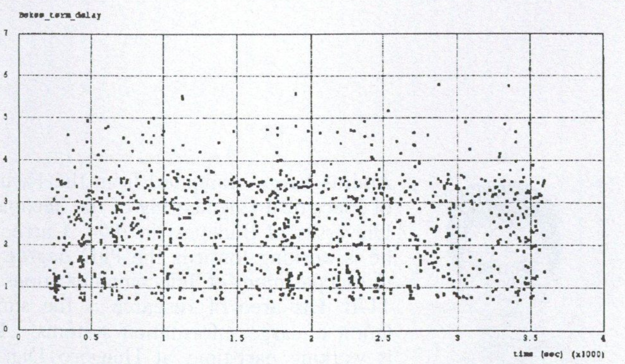


Fig. 6. Response time at a small site (6 terminals), 3 terminals/slot F/TDMA

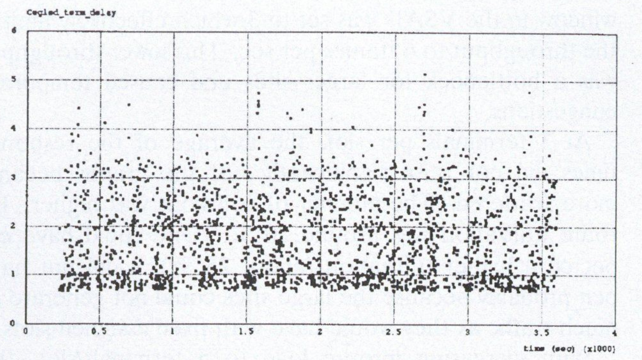


Fig. 7. Response time at a medium-sized site (12 terminals), 3 terminals/slot F/TDMA

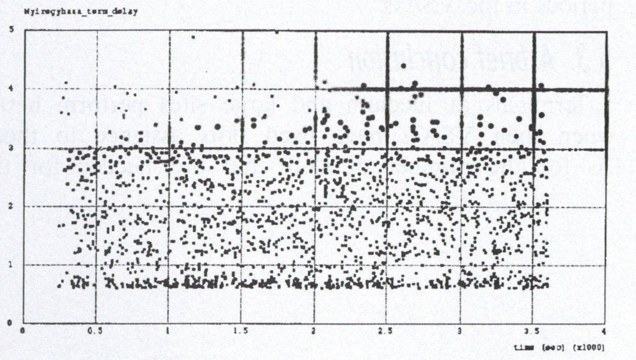


Fig. 8. Response time at a big site (35 terminals), 3 terminals/slot F/TDMA

At 5 terminals/slot, very high response times (above 5 secs) became frequent, and the outbound direction had a bigger share in the average response time. This, along with the fact that outroute load was above 80 %, indicates that the outroute was not capable of handling the increased traffic.

5.2. Slotted Aloha

We also tested the slotted Aloha protocol. In successive simulation runs, we gradually increased the load of the inroutes by placing more sites on them, so that the average terminals/slot ratio moved from 2.0 to 5.0.

As in the case of the fixed slot assignment, there was no characteristic difference between the two types of terminal emulation.

It was expected that small sites would behave much better with slotted Aloha. We also expected that large sites with many terminals would produce high response times, because the data-link level transmit window (set to 3 frames) would limit the VSAT's throughput, causing packets to be queued up in the VSAT. The simulation results have largely justified our expectations.

In the first simulation run (2 terminals/slot), terminals at the small site showed a much better response time than in the case of using F/TDMA (an average 1.3 sec). Most values were under 1 sec which suggests that there were few collisions, as shown also by the collision count statistics. Medium-sized and large sites yielded higher response times (1.8 sec and 2.0 sec), with the values strongly scattered. This is due to the fact that the data-link level transmit window in the VSATs was set to 3 which effectively limited the throughput to 6 frames per sec. This lower throughput was a bottleneck for larger sites and caused temporary congestions.

At 3 terminals per slot, the average of the response times did not raise significantly but the graphs became more scattered. The number of collisions was higher. Inroute utilization was around 20 %. One could have expected a higher utilization (about 25 %), it did not happen probably because the large sites could not generate as much traffic as they would have with fixed assigned slots.

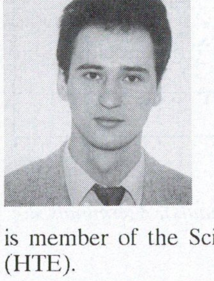
With increasing inroute load to 5 terminals/slot, the response times of even small sites were high. It could be observed that larger sites became instable: response time graphs indicate that there were relatively long congestion periods in the VSATs.

5.3. A brief conclusion

Terminals at medium and large sites perform better when their VSATs have fixed slots assigned to them. As for the number of slots that are needed for the sites, the roughly 3 terminal per slot rule is a good compromise between cost-effectiveness and performance. VSATs at smaller sites should be operated with slotted Aloha protocol.

6. SUMMARY

At Hungaro DigiTel, a major satellite communications service provider in Hungary, we have constructed simulation models of a VSAT system to analyse the performance of satellite networks and their applications. We have used a leading simulation product, OPNET Modeler of MIL3, Inc. The simulation models were organized around the internal protocol architecture of VSAT systems. To see the usability of our models, we carried out a case study, simulating and analysing a sample network with a host computer and several terminals. The case study made it clear that simulation can answer nontrivial questions that arise in the design of VSAT networks and applications, and simulation projects pay off very often in terms of engineering time, cost, and the quality of the resulting network.



András Varga graduated from the Faculty of Electrtical Engineering of the Technical University of Budapest in 1994. Currently he is working towards the PhD degree at the Department of Telecommunications of TUB. His area of research is the simulation of large information systems. He is working part-time at Hungaro DigiTel Ltd. where he is dealing with simulation of VSAT-based communication networks. He is member of the Scientific Association for Telecommunications (HTE).

THE WORLDWIDE PROGRAM AND DATA BROADCASTING SYSTEM OF MERLIN COMMUNICATIONS

A program and data broadcasting system called the Global Distribution System (GDS) has been implemented by Merlin Communications International Limited to cover, by means of five satellites, 75 per cent of the surface of the Earth and to reach 90 per cent of the inhabitants of the globe providing them with information. The primary goal of GDS is to forward sound and fast digital data signals to broadcasting transmitters being located virtually anywhere in the world and operating in the MF, HF and VHF/UHF frequency band. Technically, the GDS makes use of the special equipment developed by Control Resources Corporation and of the satellite channels leased from different operators (refer to the Fig. 1 showing the structure of the system).

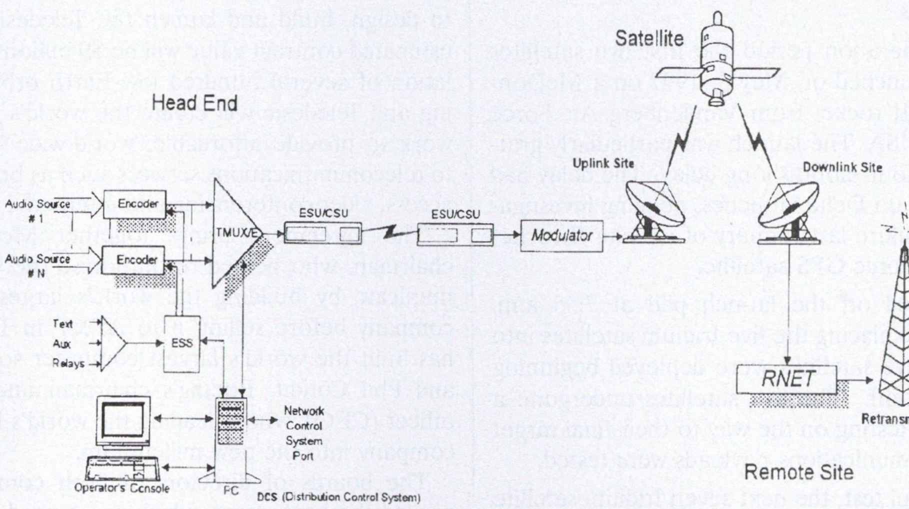


Fig. 1. Typical RNETs Network

The information coming from different sources and the data needed to control the receiving units individually are forwarded on a single satellite channel from the centre to the remote receivers called the RNETs (Radio Network Export Terminal) according to the Multiple Channel Per Carrier method. The system is controlled from the Bush House, the headquarters of Merlin Communications in London. The original sound material is received here in analog form and digitized using that MPEG compression method meeting the needs of the user. The digitized sound channels, the signals of the digital sources, and the data ensuring the control of the remote RNETs are then applied to the Transmit Multiplexer the output of which, the digital multiplex stream, is forwarded to the satellite feeder stations. A Viterbi error connection coding is first carried out there, and then BPSK or QPSK modulation is used to produce the RF signal, which, converted into the C- or the Ku-band, is radiated toward the satellites. To cover the five continents, five satellites are used: Intelsat 706, Intelsat 707, Asiasat 2, Panamsat 3R, and Eutelsat II-F4.

At the users' station, head converters placed in parabolic reflectors of appropriate measure are used to produce the L band RF signal for the RNETs. The RF module of the RNET outputs the demodulated composite baseband signal of max. 2048 kbit/s bitrate which is first submitted to an error correction procedure and then fed to the demultiplexer. An 8 kbit/s system control channel is furnishing the instructions which make the 64 to 384 kbit/s data streams assigned to the different users to appear at the output of the demultiplexer. These streams are directed either to the digital output ports of the RNET or to the built-in MPEG decoder producing a monophonic or stereophonic sound signal the quality of which depends on the sampling frequency (16 to 48 kHz) and the extent of the compression. There is a wide variety of digital user output ports extending from power relays to asynchronous RS-232 interfaces at 9600 bit/s speed.

The 1024 kbit/s data rate stream of the GDS can be received on the territory of Hungary from the Eutelsat II-F4 satellite as a BPSK modulated 2 MHz RF bandwidth signal in the Ku-band. The programs originated in the Bush House are received by fourty RNETs throughout the country. The RNETs are equipped with parabolic rettectors of 140 to 180 cm diameter and they can be assigned individually.

The time being, GDS provides some 140 million people with 42 different news and entertainment programs of the BBC World Service, using a number of broadcasting transmitters and CATV head stations. In Hungary, the Regional Studios of the Magyar Rádió (the Hungarian sound broadcasting organization) and more than 30 business-type sound broadcasting operators are receiving, using the RNETs, the Hungarian-speaking programs produced by the Hungarian Section of the BBC World Service.

Further information on the GDS is available at
Merlin Communications International Ltd
Room 724 NE Wing, PO Box 76, Bush House,
WC2B 4PH, England, Fax: +44 171 379 3205;
or, regarding first of all the RNET system in Hungary, by
ISTVÁN TASZNER; Phone: +36 30 439 492

THE FIRST STEPS OF IRIDIUM

The first global satellite phone system Iridium has made the first steps to start a commercial service availability in late 1998. The Iridium system is a satellite-based, wireless personal communications network that is designed to permit any type of telephone transmission — voice, data, fax or paging — to reach its destination anywhere on Earth. Consisting of 66 interconnected satellite (plus 6 spares) orbiting 780 km above the Earth, the Iridium system will facilitate communication for business professionals, travellers, residents of rural or undeveloped areas, disaster relief teams and others.

After a long preparation period the first five satellites were successfully launched on May 5, 1997 on a McDonnell Douglas Delta II rocket from Vandenberg Air Force Base in California, USA. The launch was particularly gratifying, as it ended a four-months long delay. The delay had resulted from a hold on Delta launches, pending investigation of the launch failure last January of a Delta II rocket carrying a U.S. Air Force GPS satellite.

The Delta II lifted off the launch pad at 7:55 a.m. Pacific Daylight Time placing the five Iridium satellites into transfer orbit. All five satellites were deployed beginning 63 minutes after lift-off. The five satellites undergone a detailed in-orbit bus testing on the way to their final target orbit where the communications payloads were tested.

After the successful test, the next seven Iridium satellite were launched from Baikonur Cosmodrome on June 18 on a Proton rocket manufactured by Krunichev Enterprise. On 9 July a Delta II rocket started again from Vandenberg Air Force Base carrying five additional Iridium system satellites to low-Earth orbit. Now 17 satellite from the 66 are in LEO (Low Earth Orbit) constellation. As the latest test shows, 16 satellite works without any problem, but Iridium LLC was informed by Motorola on 18 July, that it has lost the communication with an Iridium satellite. The Iridium experts declared, that the problem will not impact the scheduled date for commercial service in September 1998.

Iridium LLC has a $3.45 billion fixed-price contract with Motorola Inc. to manufacture, launch and operate the Iridium satellite network, as well as to construct various ground control facilities to manage the orbiting satellite constellation. Iridium LLC is an international consortium of leading telecommunications and industrial companies financing the development of the Iridium system. Owner organizations include: Iridium Africa, Iridium Canada, Iridium China, Iridium India Telecom Limited, Iridium Middle East, Iridium Sud America, Krunichev State Research and Production Space Center, Lockheed Martin, Motorola, Nippon Iridium of Japan, o.tel.o communications of Germany, Pacific Electric Wire (Cable of Taiwan, Bakrie Communications of Indonesia, Raytheon Company, SK Telecom of Korea, Sprint, STET Group of Italy, Thai Satellite Telecommunications of Thailand.

BOEING TO BUILD TELEDESIC'S "INTERNET-IN-THE-SKY"

Teledesic Corporation and The Boeing Company announced that Boeing will become an equity partner in Teledesic and serve as prime contractor for the company's global, broadband "Internet-In-the-Sky".

Boeing will invest up to $100 million for 10 percent of the current ownership of Teledesic, a private company whose primary investors are telecommunications pioneer Craig McCaw and Microsoft Chairman Bill Gates. As the prime contractor, Boeing will lead an international effort to design, build and launch the Teledesic Network. The estimated contract value will be $9 billion. Using a constellation of several hundred low-Earth orbit satellites, Boeing and Teledesic will create the world's first satellite network to provide affordable, world-wide "fiber-like" access to telecommunications services such as broadband Internet access, videoconferencing and interactive multimedia.

The agreement brings together McCaw, Teledesic's chairman, who helped revolutionise the way people communicate by building the world's largest cellular phone company before selling it to AT&T in 1994; Gates, who has built the world's largest computer software company; and Phil Condit, Boeing's chairman and chief executive officer (CEO), who is leading the world's largest aerospace company into the new millennium.

The boards of directors of both companies have approved the agreement, which was signed by Alan Mulally, president of Boeing Defense and Space Group, and David Twyver, Teledesic's chief executive officer.

Teledesic said it selected Boeing as the prime contractor because of its pioneering work in space; its experience in managing large, complex, global alliances; its commitment to aggressive cost and schedule goals; and the companies' shared vision.

The announcement comes on the heels of the Federal Communications Commission's March 14 approval of Teledesic's licence to build and operate the advanced, two-way telecommunications network. Teledesic had stated previously that the FCC licence was a necessary first step before entering into commitments with industrial, service and investment partners.

The Teledesic Network will provide switched, broadband network connections through service partners in host countries world-wide – from the largest urban centers to the most remote villages. The network emulates the most famous distributed network, the Internet, while adding the benefits of high-quality service and location-intensive access. Service is targeted to begin in 2002.

With the Teledesic Network, enterprises will be able to connect branch offices throughout the world to their existing global networks, and workers will be able to telecommute from anywhere.

Teledesic's satellite constellations will orbit about 50 times closer to Earth than traditional geostacionary satellites. The Teledesic Network's low orbit eliminates the long signal delay normally experienced in satellite communications and enables the use of small, low-power terminals and antennas, about the size of direct broadcast satellite (DBS) dishes.

■ FOURTH INMARSAT-3 LAUNCH COMPLETES GLOBAL COVERAGE

The fourth satellite in the Inmarsat-3 series, to be launched June 3, will bring virtual global coverage for Inmarsat's new lightweight portable satellite phone services, and will boost capacity for Inmarsat's other commercial maritime, aeronautical and land-mobile communications systems.

The satellite, the world's most advanced commercial mobile communications spacecraft, will be launched aboard an Ariane 4 rocket from Kourou, French Guiana.

It will use high-powered spot beams and one global beam to serve the Atlantic Ocean West region, an area that encompasses most of the Americas, Greenland and Europe and all Eastern Africa. Inmarsat-3 F1, covering the Indian Ocean region, Inmarsat-3 F2, covering the Atlantic Ocean region and Inmarsat-3 F3, covering the Pacific Ocean region, were all launched successfully last year and have now entered service. Together with F4, they will cover virtually all of the globe's land mass for the new Inmarsat services.

Inmarsat-3 has enabled the introduction of satellite phones smaller than an A4 laptop computer, with advanced features found in cellular systems such as smart cards and, in future, short message service and voice-mail. Inmarsat-phones weigh about 2.2 kg including the battery, and offer voice, 2.4 kbit/s data and fax services.

Inmarsat's third generation also supports:

- a pocket-sized global information system for messaging and for the distribution of financial news and other data;
- new products and services offering lower cost fleet management packages to road transport customers (scheduled for introduction in late 1997);
- a new addition to Inmarsat's range of aeronautical satellite services especially suited to short- and medium-haul commercial and passenger aircraft that provides voice and data communications through smaller, lighter and less expensive avionics equipment and antennas (Aero-I, due to be launched in 1998);
- a navigation capability which has been designed to enhance the accuracy, availability and integrity of GPS and Glonass navigation system.

US-based Lockheed Martin Telecommunications designed the overall spacecraft and conducted its assembly, integration and testing. Matra Marconi Space of the UK manufactured the communications payload, which includes the antennas, repeater and other communications electronics.

Inmarsat's London Satellite Control Centre (SCC) will monitor the launch and manage the post-launch activities. The spacecraft will be launched into a highly elliptical transfer orbit, the lowest point, the perigee, of which is 1000 km and the highest point, the apogee, of which will be the geostationary altitude of 36.000 km. A series of manoeuvres will then be conducted which will place the spacecraft in near geosynchronous orbit and moving towards its testing location at 28 degrees East.

The solar array will be deployed and pointed towards the Sun so that electrical power can be supplied to the satellite from its solar cells. The spacecraft will then be re-oriented so that its communications antennas can "see" the Earth.

After the tests on the satellite's subsystems and its payload are completed, the satellite will be moved to its final on-station location of 54 degrees West to be ready for service on July 26. It will take over from Inmarsat's previous Atlantic Ocean West region satellite, which will become a spare.

The fifth and final satellite in the Inmarsat-3 series will also be launched on an Ariane 4 rocket from Kourou. The satellite will serve as a spare in the Inmarsat constellation and is scheduled for lift-off in December 1997/January 1998.

Inmarsat is an internationally owned co-operative that provides mobile satellite communications world-wide. Established in 1979 to serve the maritime community, Inmarsat has since evolved to become the only provider of global mobile satellite communications for commercial and distress and safety applications at sea, in the air, and on land. Some of the markets served by Inmarsat system are: merchant, shipping, fisheries, airlines and corporate jets, land transport, oil and gas, the news media and business people who travel beyond the reach of conventional communications.

■ HUNGARY BECOMES INMARSAT'S 81ST MEMBER

Hungary has joined Inmarsat, the global mobile satellite organization, becoming its 81st member-country.

Mr. István Hazay, Director General of HUNSAT Hungarian Satellite Communications Association, today signed the Operating Agreement of Inmarsat in London, England. The Agreement makes HUNSAT the Republic of Hungary's signatory organization.

"We are very pleased that Hungary has joined Inmarsat" — said Pál Horváth, regional director for central and eastern Europe.

"Hungary's rapidly developing economy and sophisticated business environment will allow us to work together with a growing number of partners in the region to explore new market opportunities. We foresee a further rapid development of mobile satellite communications within the country" — he added.

Throughout central and eastern Europe and around the world, Inmarsat provides seamless global communications via satellite, reaching areas unserved by terrestrial systems.

In Hungary, Inmarsat has developed a pilot project with national haulage company Hungarocamion, fitting 50 of their fleet with Inmarsat-C data messaging systems. The trucks travel across Europe, Russia and the Middle East and find Inmarsat invaluable for ensuring their daily communications while on the move, improving the company's overall operations.

Inmarsat is working with other local partners in the region to enhance and extend communications services. A new generations of satellites, Inmarsat-3, has enabled the introduction of smaller, lighter, cheaper satellite communications (see our other Inmarsat news). Later this year will see the introduction of satellite phones specially developed for use in remote rural communities, bringing communications to areas which previously had minimal or no links to the rest of the world.

Using high-gain antennas, these Inmarsat-phones will offer voice, 2.4 kbit/s data and fax services with provisions for extensions such as a payphone or PABX. Built to withstand harsh environmental conditions, they will be well-suited for communications to and from sparsely populated zones and scattered settlements, including remote industrial, farming and business communities and resort hotels. The phones are expected to bridge communications gaps in central and eastern Europe, especially in Albania, Romania, Russia and the Ukraine. Diplomatic and peace-keeping missions and oil and mineral exploration units in the region will particulaly benefit.

■ COMPETITION DEADLINES

European Commission officials hae said that Greece must fully liberalize its telecommunications markets by 1 Januar, 2001, instead of 1 January, 2003 — as had previously been demanded by the Greeks. The Commission said Greece was not justified in seeking the maximum five year extension fromn the 1 January, 1998 main telecomms liberalization deadline in order to adapt its market to competition.

"The modernization and digitalization of the network of national operator OTE are clearly insufficient, but this ought to be completed in the main at the end of 2000" — the Commission said. "These improvements are vital for the growth of the sector."

"The profitability of these investments is less than those in other countries which have asked for postponements of liberalization, due to the difficult geography of Greece — its mountains and islands — and the great number of lines used seasonally" — the Commission said, adding that other reasons for the three year delay include the low average income of Greece's inhabitants and the risk that tariff rebalancing could lead to a slowing of market growth.

The Commission has also approved a 1 October, 1997 Greek liberalization of alternative telecomms networks, such as those owned by utilities, instead of the normal 1 July, 1996 date. The 1 January, 2001 liberalization, notably for voice telephony, requires publication of licensing and interconnection conditions by 30 June, 2000.

Greece is the last country to be cleared by the Commission to delay telecomms liberalization out of the five with scope to apply for an extension. The Commission has already cleared full liberalization in Ireland and Portugal by 1 January, 2000, in Spain by 30 November, 1998, and in Luxembourg by 1 July, 1998.

■ ASIA TELECOM 97 BEATS ALL FORECASTS

Asia Telecom 97, the fourth regional telecommunications Exhibition and Forum for the Asia region, which was held from 9–14 June, at the World Trade Centre, Singapore.

This year's event attracted over 40,000 telecommunication professionals, who came to see the latest technology on display from 477 exhibitors from the telecommunications, information technology and audio-visual entertainment fields.

The event attracted industry leaders at the highest level, from ambassadors and government ministers, to the CEOs of the front-ranked market players, as well as some of the most respected industry analysts and commentators. Great interest was expressed throughout the event by external investors who came to see what role they could play in the world's biggest and most rapidly expanding telecommunications market.

The Opening Ceremony, held on Monday 9 June, was hosted by H.E. Mr Goh Chok Tong, Prime Minister, Singapore, Mr Teo Ming Kian, Chairman, Telecommunication Authority of Singapore, Dr Pekka Tarjanne, secretary-general of the International Telecommunication Union (ITU) and Christopher Galvin, CEO, Motorola. Both it and the Press Day, held on Sunday, 8 June, received extensive press coverage around the world, and the Prime Minister of Singapore used the occasion to launch the pilot network for Singapore ONE – Singapore's ambitious project to wire together businesses, schools, public areas and some 800,000 households on the intelligent island by the end of 1998.

The ITU secretary-general, Dr. Pekka Tarjanne, highlighted the importance of finding new ways of co-operating and working together and stressed that the promise of technological innovations, trade agreements and global systems would never be realized if policies and regulations designed for a different era stood in their way. His message was complemented by Chris Galvin of Motorola, who noted that the benefits of global information highways would extend to all parts of the world more quickly than had previously been thought. "One of the ironies of technology is that as software becomes more complex and sophisticated, the product for the end user becomes easier to operate," he said. "This challenges old assumptions about how innovation occurs and how rapidly a culture adopts new technology."

Over a thousand people took part in the Forum programme, which opened with Dr. Pekka Tarjanne, Mr Teo Ming Kian and Mr Frank Blount, the Chairman of Telstra. Mr Bill Gates, CEO of Microsoft, spoke live from Seattle via videoconference. The Forum encompassed the Strategies and Technology Summits, which focused both on new technological developments, and on the greater challenges of communications in the developing world. A TELECOM Development Symposium was also organized, in conjunction with the Forum, which brought 40 telecommunications specialists from 38 countries to Asia TELECOM 97 on a fellowship to discuss the issues relating to interconnection, the rationalization of tariffs, and the need for balanced development programmes.

The next TELECOM event will be TELECOM INTERACTIVE 97 – a new forum and exhibition focusing on interactive and multimedia services and applications. It will be held in Geneva from 8 to 14 September 1997. AFRICA TELECOM 98 will then be held at the National Exhibition Centre in Johannesburg, South Africa, from 4 to 10 May 1998, while the next World TELECOM Exhibition and Forum, TELECOM 99, is being staged in Geneva from 10 to 17 October 1999.

ISTVÁN BARTOLITS

GUARDS

On 24th July 1997 Hungary joined the INMARSAT organization in ceremonial conditions. Main coordinator of the event was the Guards Co. Ltd, which is the Hungarian provider of the INMARSAT services.

Guards Ltd. is Hungarian limited liability company based in Budapest. It's yearly turnover is 3 million US dollars (based on last years' figures). It has 19 employees, all of them highly experienced and qualified. It was founded in 1993. Guards Ltd. mainly deals with mobile telecommunication services and retail. Besides the Budapest head office, it has a national level dealer network with more than 50 outlets and three own retail shops in Eger, Miskolc and Gyöngyös.

A large scale of telecommunication tools are available from the Motorla land mobile radios, through GSM phones, to INMARSAT based mobile satellite terminals. Guards Ltd. furthermore deals with Magellan GPS satellite navigation products as a distributor of Magellan Systems Corp. Guards Ltd. is an authorized distributor of the Hungarian GSM service provider "Pannon GSM". The 10 % of the total Pannon GSM sales are sold at Guards Ltd.

Guards Ltd. has entered the satellite telecommunication market in 1995. It is an INMARSAT Service Provider and Accounting Authority HU04, which enables Guards Ltd. to offer mobile satellite services. It offers the whole range of INMARSAT services, via PTT Telecom Netherlands LES "STATION 12".

Guards Ltd. is a system integrator, therefore is able to offer the products of many manufacturers and can always provide the best solution for your needs from INMARSAT-A and -B terminals, that are good solutions for voice and high speed data and telex communication, through INMARSAT-C, the cost effective low speed data communication service, to the notebook size INMARSAT-Mini-M portable phones.

Special products include for example fleet management, which enables transportation and shipping companies to communicate with and keep track of their fleet. Guards Ltd's fleet management product is highly flexible, so it can be adjusted to your company needs and be translated to your own language.

* * * * * * * * * * *

Guards Ltd. is always there guarding your telecommunication needs.

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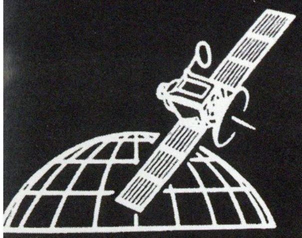

With Key Contributions from:

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5th Budapest International Conference on Up-to-Date Satellite Communications

9th - 12th September 1997

Participants of the former conferences, representing more than ten countries spanning the globe from the USA to Russia, with intellectual support of the ITU, much appreciated the opportunity of contacts for a regional cooperation.

Tutorial Seminar

9th September 1997

Basics of Advanced Satellite Communications
Principles,Technologies, Engineering, Operation
Comparison of Satellite and Terrestrial Systems

Scientific Symposium

10th - 12th September 1997

KEY TOPICS FOR DEBATE
International Geostationary Satellite Communications
Low Earth Orbiting Communications Satellite Systems
Model National Communications Satellite Systems
Regulatory Matters in Satellite Communications
Business Communications and Direct Broadcast Systems

Technical Presentations

10th - 12th September 1997

Companies involved in Satellite Communications (Satellite operators, Satellite equipment manufacturers, VSAT-companies) exhibit their products and services.

PLEASE, BOOK BEFORE THE 15TH JULY 1997!

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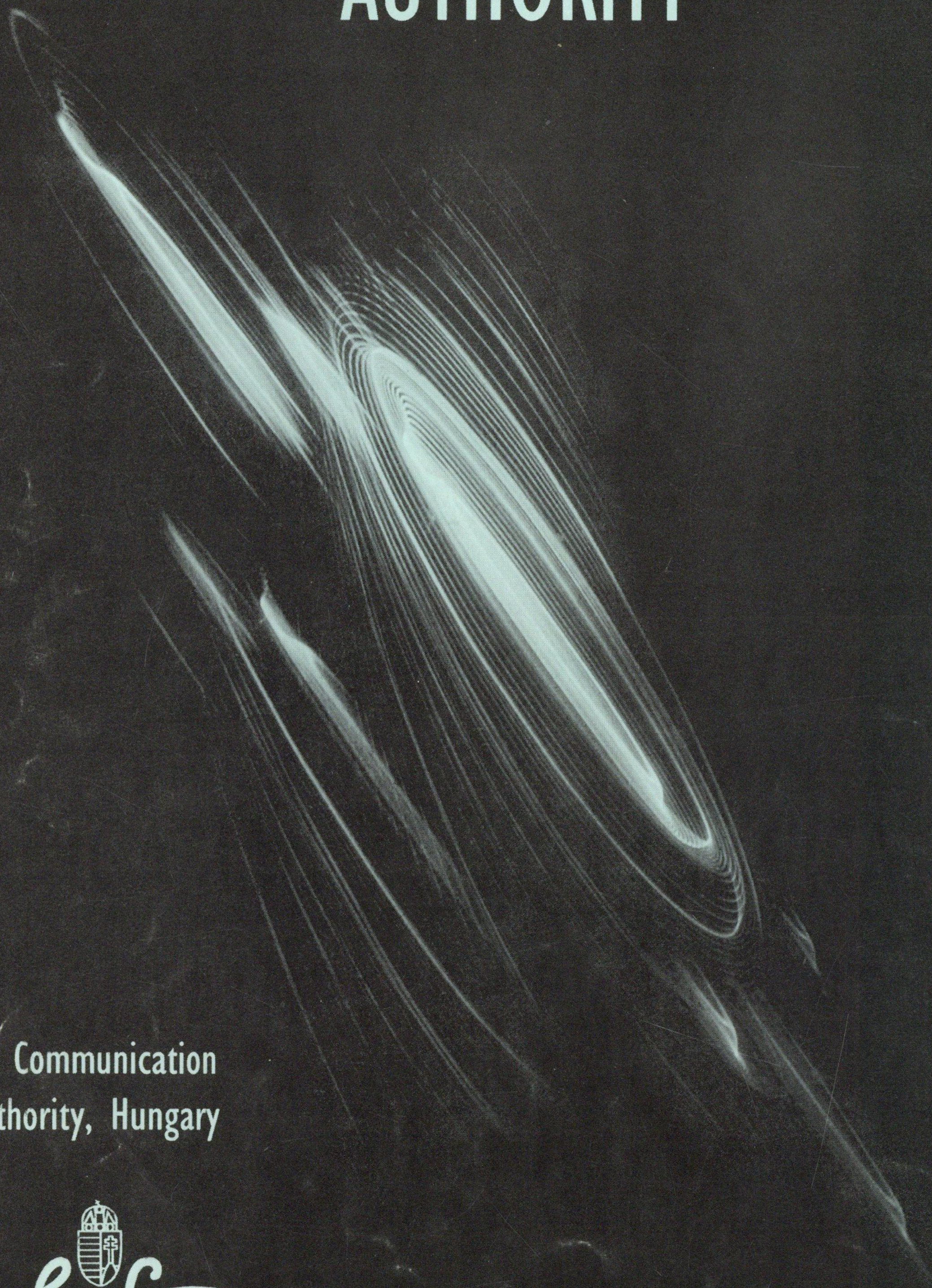

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