TR 101 374-1 V1.2.1 (1998-10)

Technical Report

Satellite Earth Stations and Systems (SES);
Broadband satellite multimedia;
Part 1: Survey on standardization objectives

Reference

DTR/SES-00038-1 (cq090ios.PDF)

Keywords

broadband, satellite, earth station, multimedia

ETSI

Postal address

F-06921 Sophia Antipolis Cedex - FRANCE

Office address

650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16
Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Internet

secretariat@etsi.fr
http://www.etsi.org

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

The present document is part 1 of a multi-part TR covering Broadband satellite multimedia, as identified below:

Part 1: "Survey on standardization objectives".

Part 2: "Scenario for standardization".

1 Scope

The present document surveys the current scenario and the status of proposals from both existing and future satellite operators, for provision of broadband multimedia services via satellite (broadband satellite multimedia).

The information presented is available as a basis for further discussions within ETSI and the European Commission regarding the requirement for the development of standards applicable to equipment and systems to be used to provide such services.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] Final Acts WRC-97 (ITU Radiocommunications Bureau).

[2] ERC/DEC/(97)03: "ERC Decision of 30 June 1997 on the Harmonised Use of Spectrum for Satellite Personal Communication Services (S-PCS) operating within the bands 1610-1626.5 MHz, 2483.5-2500 MHz, 1980-2010 MHz and 2170-2200 MHz".

[3] ERC/DEC/(97)05: "ERC Decision of 30 June 1997 on free circulation, use and licensing of Mobile Earth Stations of Satellite Personal Communications Services (S-PCS) operating within the bands 1610-1626.5 MHz, 2483.5-2500 MHz, 1980-2010 MHz and 2170-2200 MHz within the CEPT".

[4] ETSI GMM Report: Global Multimedia Mobility.

[5] EN 301 359: "Satellite Earth Stations and Systems (SES); Satellite Interactive Terminals (SIT) using satellites in geostationary orbit operating in the 11 GHz to 12 GHz (space-to-earth) and 29 GHz to 30 GHz (earth-to-space) frequency bands".

[6] EN 301 358: "Satellite Earth Stations and Systems (SES); Satellite User Terminals (SUT) using satellites in geostationary orbit operating in the 19,7 GHz to 20,2 GHz (space-to-earth) and 29,5 GHz to 30 GHz (earth-to-space) frequency bands".

[7] EN 300 421: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for 11/12 GHz satellite services".

[8] STF126 Questionnaire: Broadband Satellite multimedia (www.etsi.org/ses/news/BroadSat.htm)

[9] Memorandum of Understanding to Facilitate Arrangements for Global Mobile Personal Communications by Satellite, Including Regional Systems (GMPCS-MoU).

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACTS (EU)	Advanced Communications Technologies and Services
ACTS (NASA)	Advanced Communications Technology Satellite Program
AM	Amplitude Modulation
ARTES	Advanced Research in Telecommunications Systems
ATM	Asynchronous Transfer Mode
ADSL	Asymmetric Digital Subscriber Line
API	Application Programming Interface
ATDM	Asynchronous TDM
BRAN	Broadband Radio Access Network
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BSM	Broadband Satellite Multimedia
CATV	Cable Television
CCITT	Comité Consultatif International des Postes et Télécommunications
CDMA	Code Division Multiple Access
CD-ROM	Compact Disc Read-Only Memory
CEPT	European Conference of Postal and Telecommunications administrations
CERP	European Committee for Postal Regulation
CMF	Control and Monitoring Functions
CMOS	Charge-coupled Metal Oxide Silicon
CONUS	Continental US
CPE	Customer Premizes Equipment
DAMA	Demand Assigned Multiple Access
DAVIC	Digital Audio Visual Council
DBS	Direct Broadcast(ing) by Satellite
dBW	deciBels relative to 1 Watt
DECT	Digital Enhanced Cordless Telecommunications
DTVB	Direct TV Broadcasting
DSL	Digital Subscriber Line
DSM-CC	Digital Storage Media - Command and Control
DSP	Digital Signal Processing
DVB	Digital Video Broadcasting
DVB MHP	Digital Video Broadcasting - Multimedia Home Platform
DVB NIP	Digital Video Broadcasting - Network Independent Protocols
DVB RC	Digital Video Broadcasting - Return Channel
DVB RCC	Digital Video Broadcasting - Return Channel Cable
DVB RT	Digital Video Broadcasting - Return Channel Telecommunications (Telephone or ISDN)
DVB-S	Digital Video Broadcasting - Satellite
DVB-SI	Digital Video Broadcasting - Service Information
Eb/No	Energy per bit to Noise density
ECTRA	European Committee for Telecommunications Regulatory Affairs
ECU	European Currency Unit
EDTV	Enhanced Definition Television
EHF	Extra High Frequency
EIRP	Equivalent Isotropically Radiated Power
E.L.	East Latitude
EMC	Electro-Magnetic Compatibility
EN	European Standard (harmonized)
ERC	European Radiocommunications Committee (subgroup of CEPT)
ERO	European Radiocommunications Office (of ERC)
ESA	European Space Agency
ESTEC	European Space Research and Technology Centre (of the ESA)
ETO	European Telecommunications Office (of ECTRA)
ETS	European Telecommunications Standard
ETSI	European Telecommunications Standards Institute
EU	European Union

FAA	Federal Aviation Administration (US)
FEC	Forward Error Correction
FCC	Federal Communications Commission (US)
FDMA	Frequency Division Multiple Access
FM	Frequency Modulation
F/TDMA	Frequency division TDMA
FS	Fixed Service
FSS	Fixed Satellite Service
GEO	Geostationary Earth Orbit
GII	Global Information Infrastructure
GMM	Global Multimedia Mobility
GMPCS	Global Mobile Personal Communications by Satellite
GSM	Global System for Mobile communication
GSO	Geo-Stationary Orbit
G/T	Gain - Temperature Ratio
HDTV	High Definition Television
HEO	Highly Elliptical Orbit
HFC	Hybrid Fibre Coaxial
HPA	High Power Amplifier
ICO	Intermediate Circular Orbit
IEEE	Institute of Electrical and Electronic Engineers (US)
IETF	Internet Engineering Task Force
IF	Intermediate Frequency
IMT 2000	International Mobile Telecommunications 2000
IN	Intelligent Network
IP	Internet Protocol
IPR	Intellectual Property Rights
ISDN	Integrated Services Digital Network
ISL	Inter Satellite Link
ISP	Internet Service Provider
ITU	International Telecommunications Union
ITU-R	Radiocommunication bureau of ITU
K	Degrees Kelvin (temperature)
kbps	Kilobits per second
LAN	Local Area Network
LEO	Low Earth Orbit
LHCP	Left Hand Circular Polarization
LMDS	Local Multipoint Distribution Service
LNB	Low Noise Block
Mbps	Megabits per second
MBS	Mobile Broadband System
MEO	Medium Earth Orbit
MF-TDMA	Multi Frequency TDMA
MHP	Multimedia Home Platform
MIFR	Master International Frequency Register (ITU-R)
MoU	Memorandum of Understanding
MPEG	Motion Picture Experts Group
MPOA	Multi-Protocol Over ATM
MPLS	Multi-Protocol Label Switching
MSS	Mobile Satellite Service
MTSO	Mobile Telephone Switching Office
N/A	Not Available
NASA	North American Space Agency
NASDA	National Space Development Agency (Japan)
NGSO	Non-geostationary Orbit
NNI	Network to Network Interface
OA&M	Operation, Administration and Maintenance
OBP	On Board Processor
OQPSK	Offset QPSK
PA	Power Amplifier

PC	Personal Computer
PCMCIA	Personal Computer Memory Card International Association
PCS	Personal Communications Service
POTS	Plain Old Telephone Service
PPP	Point-to-Point Protocol
PSK	Phase Shift Keying
PSTN	Public Switched Telephone Network
PTT	Posts, Telegraph and Telephone (a licensed common carrier of telecommunications traffic)
PVC	Permanent Virtual Circuit
QPSK	Quadrature Phase Shift Keying
RAN	Radio Access Network
RF	Radio Frequency
RHCP	Right Hand Circular Polarization
RR	Radio Regulation
SDH	Synchronous Digital Hierarchy
SDTV	Standard Definition Television
SIM	Subscriber Identification Module
SMATV	Satellite Master Antenna Television system
SCPC	Single Channel Per Carrier
SOHO	Small Office Home Office
SMIT	Satellite Master Interactive Terminal
S-PCS	Satellite Personal Communications Service
SSPA	Solid State Power Amplifier
S-UMTS	Satellite component of UMTS
TBD	To Be Defined
TBR	Technical Basis for Regulation
TCM	Trellis Coded Modulation
TCP/IP	Transmission Control Protocol over Internet Protocol
TC-SES	Technical Committee - Satellite Earth Stations and Systems (within ETSI)
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access
TIA	Telecommunications Industry Association (US)
TNM	Telecommunication Network Management
TT&C	Telemetry, Tracking & Control
TV	Television
TWTA	Travelling Wave Tube Amplifier
UNI	User Network Interface
UMTS	Universal Mobile Telecommunications System
UPU	Universal Postal Union
URL	Universal Resource Locator (Internet)
US	United States (of America)
USB	Universal Serial Bus
USD	US Dollars
USAT	Ultra Small Aperture Terminal (satellite)
VDSL	Very High-speed Digital Subscriber Loop
VSAT	Very Small Aperture Terminal (satellite)
WAG	Wireless Access Group
WARC	World Administrative Radio Convention (superseded by WRC)
W-ATM	Wireless ATM
WLAN	Wireless LAN
WRC	World Radiocommunications Conference
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
VHS	Video Home System
WAN	Wide Area Network
WISDOM	Wideband Satellite Demonstrator of Multimedia Services
W.L.	West Latitude

4 Introduction

The present document has been produced to reflect the growing interest in the development and deployment of Broadband Satellite Multimedia Systems. It is a first-phase report focusing on gathering and presenting information; believed to be valid at the time it was collected. A second phase study, expected to take place in the early part of 1999, will concentrate on a scenario for standardization.

An outline is given of present and future systems which provide broadband multimedia services via satellite. Those systems which are already in operation include: ASTRA-NET; EUTELSAT Multimedia Platform; HISPASAT.

The Final Acts WRC-97 [1] confirmed previous frequency allocations and allocated new frequencies for such systems at the Ku and Ka-band. The FCC in the United States has awarded several licenses to construct, launch and operate, to qualifying system proponents at the Ka-band. These systems under development are expected to be deployed around years 2001/2003.

Within Europe, the Commission of the European Union has highlighted speedy harmonization of technical standards for advanced broadband multimedia satellite terminals and receivers as significant for the prospects of the European industry, operators and users in this area.

In order to promote the appropriate technical standardization, a survey of the views of potential players has been conducted; this world-wide request for information has resulted in direct responses from eleven proponents for Broadband Satellite Multimedia Systems: Astrolink, Eutelsat, ICO, Matra Marconi Space, Motorola, SES-ASTRA, SkyBridge, Teledesic, CyberStar, Hispasat, Intelsat, Inmarsat. This information is presented in clause 8 of the present document.

In addition, a great deal of information on scenarios, other systems, and research and experimental programmes has been gathered from publicly available sources and is presented as appropriate throughout the present document.

The dynamism of the current scenario for Broadband Satellite Multimedia systems and associated technologies is an aspect to consider when producing standards.

A common theme from system proponents is that a liberal licensing scheme is seen as a necessary precondition for the commercial success of the envisioned systems, see clause 10. A potential roadmap to this licensing scheme has been established in the framework of S-PCS, where the ERC has produced Decisions, see clause 11. Such Decisions are also needed for Broadband Satellite Multimeda terminals, especially in regard to excemption from individual licenses.

5 Broadband multimedia

5.1 What is broadband multimedia communications?

5.1.1 Multimedia

Multimedia is the combined presentation of several sources of data, most notably text, audio and pictures (moving or still).

The definition does not imply any transfer requirements from a distant location, and as such also covers the retrieval of such data from a local storage medium on a computer.

5.1.2 Multimedia communications

Multimedia communication is defined as joint transfer and presentation of multimedia data, sound (audio) and picture (moving or still).

The definition does not incorporate any real-time requirements. However, real time requirements may be important for the Quality of Service (QoS) of some services.

Multimedia services are particularly interesting in connection with Internet applications.

5.1.3 Broadband multimedia communication

By broadband multimedia, it is meant that the rate of transfer allows "high speed" transfer of multimedia applications and services.

The word "broadband" tends to be used in at least two different ways, depending on which community one comes from. In the computer communications world it usually implies a high bit rate, and as such a broadband system could be implemented in a narrower spectrum with a higher order modulation. Thus, the band is seen from the users perspective, and the bandwidth can be interpreted e.g. as a measure of how quickly data can be transferred through a channel.

Alternatively, and more generally from the users point of view, how quickly can a service be offered over a channel? In this case the combination of source coding and modulation comes into play for audio and video.

The transmission community, on the other hand, interprets bandwidth more physically as a share of the spectrum the (satellite) system operates within. The spectrum is always a limited resource, and is considered of significant importance to use the spectrum efficiently, i.e. that a system should use as little bandwidth as possible to support the services it is designed for. Compression techniques come into play, but definitely also the coding and modulation schemes.

Further, the term broad band tends to be subjective. ISDN at 64 kbps in telephone lines is generally not considered to be broadband. In general it does not provide any significant enhancements for voice transmission for the end user either. All he normally gets is plain old telephone quality voice. And nobody would call a computer network with 64 kbps for broadband. Even thin Ethernet has 10 Mbps capacity. However, in a mobile and satellite environment, 64 kbps is sometimes termed both "high speed" and "broad band".

Mobile users are generally, and as for the time being, satisfied with having the same services available as fixed users but at a lower rate or poorer quality. However, the mobile users will generally require similar quality as fixed users have, only some years later.

For fixed, multimedia satellite users, however, there should be available the same quality as for wired users. This will imply at least VHS-like quality on moving images, requiring around 2 Mbps with MPEG-2 coding.

One may therefore make the following interpretations:

- multimedia services makes no requirement for a minimum bit rate;
- for fixed terminals, broadband multimedia services are likely to require around 2 Mbps or more;
- for mobile terminals, broadband services are likely to require around 64 kbps or more with MPEG-4;
- for nomadic terminals, the requirement is as for fixed terminals.

The definitions of the different types of terminals is not always clear, but the following provides an example of what is meant above:

- Fixed terminals are permanently installed, and are not intended to be moved. Parameters, such as log-on frequencies and down-link frequencies and other parameters (like their exact position on earth) can be "hard-coded" during installation, and does not need to be changed by a user. The antenna is permanently installed, possible by a professional.
- Nomadic terminals are movable terminal, but only when they are not in use. They will therefore not be subjects to fading as mobile terminals are. But since they can log-on to a system from another place on earth next time, the system and terminal needs to be designed accordingly. This may require home location registers and visitor location registers, but no hand-over procedures are far as terminal movement is concerned. Antenna installation (or self-installation) may here be an issue.
- Mobile terminals will or can move during operation (as in GSM). This results in completely different (and unpredictable) fading/blocking characteristics, and may not allow as accurate antenna pointing as fixed or nomadic installations.

There are several different types of mobility: A user may be mobile (or at least nomadic) even if the terminal is not. A good example of this is though SIM-card technology. A user may take his or her personal profile an log on to different (fixed) terminals. Different mobile multimedia schemes are outlined in the ETSI GMM Report [4].

5.2 Multimedia mobility and nomadic use

5.2.1 Global Multimedia Mobility (GMM)

In October 1996, ETSI published the report "Global Multimedia Mobility, A Standardization Framework for Multimedia Mobility in the Information Society". The report recognizes the, then new, allocations by WRC 1995 of Ka-band spectrum to non-geostationary satellite networks, as well as existing allocations for geostationary satellites, as permitting the development of new systems offering multimedia services. It states "The major attraction of such systems is that they could provide a global, high quality set of services in a mobile environment".

The report defines a generalized standardization framework for GMM by identifying four "domains" for standardization:

- the terminal equipment domain;
- the access network domain;
- the core transport network domain;
- the application services domain (including content provision).

Any ETSI standardization developed for Broadband Satellite Multimedia will fit within this domain structure.

A GMM Companion Document is currently in preparation in ETSI. Like the original GMM report, the proposed companion document is intended to provide the ETSI view on a broad range of aspects of critical importance for the future telecommunications business (e.g. fixed-mobile convergence, virtual home environment).

5.2.2 UMTS and S-UMTS

The ITU's work on the IMT 2000 (previously Future Public Land Mobile Telecommunication System (FPLMTS) is aimed at the establishment of advanced global mobile communication services within the frequency bands identified by the World Administrative Radio Convention (WARC 92) at 1 885 to 2 025 MHz and 2 110 to 2 200 MHz.

ETSI is defining UMTS as the European third generation system within the IMT 2000 family framework. UMTS standards and ITU Recommendations for FPLMTS will be available before the turn of the century, the system will be introduced around the year 2000, with some services or features possibly implemented earlier in GSM.

- Mobility will dominate personal communications in year 2000.
- Broadband services will dominate computer communications.
- UMTS will have a satellite component.

UMTS aims to provide a comprehensive set of services, features and tools which enable services to have the "same look and feel" wherever they are used. UMTS will support multimedia services. All calls will have the potential of becoming multimedia calls and there will be no requirement to signal in advance any requirement for any number of media components.

5.3 Satellites in multimedia communications

5.3.1 The target markets

There is an increasing need for high speed communication. Boosted by a convergence between information and entertainment, both business and home users are looking for faster connections to the global information infrastructure.

The target markets for broadband services varies for different systems. Most seem to focus on Internet access as the service for the market, and also the home user, since it is estimated that there lies the mass market. But also corporate use, as video-conferencing and wireless (and global) LAN expansion are often mentioned applications.

The markets also vary in geographic location, and whether it is urban, suburban or rural areas. Several systems highlight the ability to provide global coverage with the same service for an African farmer as a businessman in New York, but there is no reason to suspect that the former sort of market will provide any strong financial benefit for any global data-transport provider. The exception may be for travelling (nomadic) users, like TV-crews and news gathering applications, as a cheaper alternative to the super VSAT systems of today. But, basically, it comes down to urban and suburban markets.

In urban areas the strong competitor is ADSL, later optical fibers and terrestrial UMTS. Since users will be concentrated geographically, the cost per user of establishing a broadband service, along with the expected traffic these users will generate, may favour the use of wired solutions in urban areas. However, the HALO and SkyStation projects focus on just these urban areas as prime market targets (but then again these are not satellite systems). GEO satellites in general may focus their downlink capacity to regions where the market is. This focus can also be adaptive, taking into account a changing market or corrections to initial predictions. LEO systems, on the other hand will more or less need to be able to offer the same services world-wide. It has been estimated, the cheaper home terminal will generate a market of tens of million units. The corporate units (terminals) will be far fewer, but may generate more traffic.

There are different scenarios for the market for broadband satellite communications. None are certain as of today. Probably the wiser approach is to be flexible, but it seems that if terminals can be made as cheap as 500 to 1000 USD, then the home market will be the mass market, and their requirements will dominate the system design. For home users, the cost of the terminals is just one side of the coin. The other is the price of carrying the data, which need to be as low as terrestrial connections can offer or at least in the same range.

In addition to the mass markets, there will definitely be niche markets; at least for terminals, like terminals for nomadic use. Possibly also the GEO and NGSO systems will aim for different markets, services or applications.

The Internet is now a spearhead and driving force, with all its associated forms on on-line communications, while modern television is a second factor. There is a trend towards a merge between computers and television, and a large demand for PCs to do what TVs can do; display moving images with high quality while keeping the interactive aspect of computers and Internet.

Business users want to make remote and branch operations a more immediate part of the corporate structure, with virtual meetings, instantaneous updating of everyone at the company, and seamless information sharing.

TV-like content may well be delivered by GEO satellites, as the delay is not usually critical, while video-conferencing and similar applications will use NGSO connections.

According to research completed by Andersen Consulting, it is predicted that by 2002, the total world-wide broadband market for transport services will be worth $65 billion, and 12 percent or $8 billion will go to satellite-based communications. By 2005, the amount spent on satellite communications will reach $16 billion and the total world-wide broadband market for transport services will be worth $98 billion.

5.3.2 Technological issues

There are many technological issues involved in the development of future broadband satellite multimedia systems. These cover areas from TCP/IP and Internet over satellite, ATM over satellite, cheap terminal technology, advanced space and antenna technology, spot-beams, network and networking issues, operator issues, service provider issues, billing mechanisms, network and satellite management and much more.

Standardization can benefit technology development, as it can focus research and technology development, and define consistent target for different communities. Therefore, broadly speaking, many of the areas that are currently in focus for R&D, may also be interesting to standardize.

The European ACTS programme has ongoing research in several fields, including an Interactive Digital Multimedia Services Domain. This includes work on, for example, MPEG, defining a range of state of the art image and sound coding and multiplexing techniques. This standard has been accepted by bodies like the Digital Video Broadcasting project (DVB), ETSI as the basis for new television broadcasting services and by Digital Audio-Visual Council (DAVIC) as the basis for multimedia services via Telecom, CATV and satellite networks.

The NASA ACTS project of the US is focusing on:

- ATM, IP, and Other Protocols over Satellites, including Interoperability with Terrestrial Networks;
- evaluating Satellite Inclined Orbit Operations;
- new Ka-band Technology and Hardware Verification.

Some of the technological issues involved in broadband multimedia satellite communications can also be seen from what issues and topics a forthcoming IEEE Journal on Selected Areas in Communications lists as topics in this field:

- satellite system concepts and architectures;
- Ka-band and EHF band technologies;
- On-Board Processing (OBP) and Inter-Satellite Link (ISL) routing;
- performance analyses and interference issues;
- channel modelling and fading countermeasures;
- multiple access techniques;
- on-board antennas and beamforming techniques;
- portable terminals, multimedia and Ka band Direct TV Broadcasting (DTVB) terminals;
- V/USAT front-end, IF and baseband sections (design and technology to cost);
- interworking and integration with terrestrial networks;
- technologies for LEO systems;
- satellite multimedia services: technical and economic issues;
- standardization issues.

5.3.3 Applications and services

5.3.3.1 Applications

Broadband satellite communications can and will be used for numerous applications. A first, coarse division, may be into:

- broadband Access to the Global Information Infrastrucure (typ. Internet access);
- closed, global or regional, broadband communication systems. (typ. LAN expansion).

There seem to be no particular dominant application for broadband satellite communication systems, but the Internet is definitely now a driving factor. The Internet enables access to a number of services and applications.

However, satellite system are able to offer some benefits over other broadband systems, as:

- rapid global deployment;
- universal access to services;
- coverage of sparsely populated areas;
- maritime usage;
- infrastructure for developing Countries;
- global equality of cost of deployment;
- flexibility and adaptivity to changing markets, even on 24-hour basis;
- single point of contact for global organizations;
- temporary increase in capacity for special events;
- back-up infrastructure in any part of the world in case of emergencies;
- independent of local and regional censorship. Useful for Embassies and suchlike;

- secure communications;
- suitable for broadcast and multicast services;
- ability to support movable / nomadic terminals globally;
- ability to support mobile terminals globally;
- ability to offer lowest cost for some services.

Also of interest are issues focused upon on at the (EU) ACTS Mobile Communication Summit 98:

- Technology/System Trials for UMTS/MBS/WLAN/BRAN;
- Mobile/Wireless Services and Applications;
- Mobile Multimedia;
- Network Management, TMN, IN;
- Digital Cellular Technology and Planning;
- Service Access Procedures and QoS;
- Multi-Functional and Multi-Mode Terminals;
- Broadband Wireless Local Loop;
- Mobile Satellite Systems;
- UMTS/MBS/WLAN/BRAN System Design;
- Multiple Access Techniques;
- Receiver and Transmitter Technology;
- Radio over Fiber;
- Wireless ATM;
- Advanced Antenna Systems;
- Spectrum standards aspects;
- the role of industrial wireless fora.

5.3.3.2 Services

These services constitute a blend for private and business users. Some typical services for broadband satellite are:

- Internet Access and Web browsing;
- electronic file transfer;
- email and other electronic message services;
- SW Distribution services;
- direct-to-home video and Video on Demand;
- audio on demand. World-wide radio and music distribution;
- books on demand. Local publishing and printing;
- switched broadcast services and interactive TV;
- TV Broadcasting;

- video-conferencing;
- electronic transaction processing (banking etc.);
- electronic commerce;
- tele-medicine;
- distance learning, remote education and corporate training;
- satellite news gathering;
- wireless LAN and remote location LAN extension;
- library services and information data bases;
- flexible back-haul service;
- hot stand-by (restoration) for a terrestrial infrastructure;
- link-up for terrestrial systems.

5.3.3.3 Satellites as LAN inter-connection

When satellites are used for LAN inter-connection, a typical requirement is the ability to offer symmetrical transmission capabilities. A company that wants to extent their LAN to another location, will be able to use satellites between e.g. a location in Europe and the far east. Satellites will then typically be an alternative (or supplement) to terrestrial LAN interconnection, such as Ethernet.

5.3.3.4 Satellites as broadband user access

When satellites are used for broadband user access, as for multimedia Internet applications, typical transmission rate requirements are asymmetric. More data is sent to the user than from the user. In these cases, an uplink with lower capacity, maybe in the order of tens to hundreds of kbps can be acceptable. Downlink rates, on the other hand, must be able to carry video, at a few Mbps, or moving images with HDTV quality, at a few tens of Mbps.

5.3.3.5 Satellites for broadband service providers

When considering the service providers, anything from one to hundreds of gateways may be required. Each gateway generally has from one to a few uplink carriers, and from one (broadband) to potentially thousands of (TDMA) downlinks. If the asymmetric users with individual traffic dominate the traffic pattern, then the gateways will in general uplink more traffic than they downlink.

5.4 Multimedia communication interfaces

There is no, single, multimedia communication interface for non-satellite systems.

Elaborating on different high-capacity interfaces is beyond the scope of the present document. However, it is noted that work has been initiated in several fora that addresses the application in the satellite environment of standardized broadband interfaces that have largely been developed thus far for application in terrestrial networks, the objective being to ensure that protocols that are in use in terrestrial systems can smoothly inter-operate with a satellite equipment. Among these efforts is the work to develop ATM protocols for satellite systems.

Further study is needed to determine the appropriate way forward for ETSI in this area (phase 2).

6 Broadband satellite communications

6.1 Satellites for broadband communication

There are a number of issues relating to the use of satellites for broadband communications. These include the transponder frequencies, licensing, coverage, orbits, number of satellites, network architecture, latency, competitive technologies and enabling and complementary technologies.

These sections in this subclause will touch upon some of these, hopefully enabling the reader to as good as possible compare the aspects of the different systems described in the clauses 8 and 9.

6.2 Current satellite internet and multimedia services

ETSI is not aware of any current Internet over satellite service provider or system that offers users an integrated satellites solution; the systems rely on broadband delivery over satellite, and a receive-only antenna at the customer premizes.

The return link, which then is not usually broadband, is often via terrestrial modems to some central hub, or gateway, which transmits to the satellite.

6.3 System aspects

Broadband satellite multimedia systems are not homogenous. They vary with respects to numerous issues. Most notably are perhaps:

- Frequency bands they operate in. Ku / Ka, and later so-called V and Q (40/50 GHz). Also some at lower frequencies.
- Orbits. GEO and LEO. Later also MEO and HEO. Thereby also latency.
- Coverage: Global and regional. Land mass or oceans as well. Polar regions.
- Bit-rates offered. From a few tens or hundreds of kbps to Gbps.
- Availability, and thus power requirements and antenna sizes.
- Markets that are targeted. Business / consumer trade-off.
- Protocols supported / used. Typically DVB or ATM.

Looking at the number of degrees of freedom, it will be important to identify commonalties between the systems with respect to standardization.

6.3.1 Satellite orbits alternatives

6.3.1.1 Low Earth Orbit (LEO)

LEOs are either circular (or elliptical) orbits less than 2 000 km above the surface of the earth. In communications satellites, LEO satellites are generally found some 700 to 1 400 km above the Earth's surface. Orbit periods vary between 90 to 120 minutes, while the maximum time during which a satellite is above the horizon for an observer on the earth is 20 minutes. The footprint radius of a LEO communications satellite is generally 3 000 to 4 000 km. A global communications system using this type of orbit requires many satellites in different inclined, orbits. When a satellite serving a particular user moves below the local horizon, it needs to be able to hand over the service to another satellite in the constellation. Due to the relatively large movement of a satellite in LEO with respect to an observer on the earth, satellite systems using this type of orbit need to be able to cope with large Doppler shifts.

6.3.1.2 Medium Earth Orbits (MEO) / Intermediate Circular Orbits (ICO)

MEOs are circular orbits at an altitude of around 10 000 km, with an orbit period of around 6 hours. The time during which a MEO satellite is in view for an observer on the earth is in the order of a few hours. A global communications system using this type of orbit, requires a modest number of satellites (around 10 to 20) in 2 to 3 orbital planes to achieve global coverage. Compared to a LEO system, hand-over is less frequent, and propagation delay and free space loss are greater.

6.3.1.3 Highly Elliptical Orbits (HEO)

HEOs typically have a perigee at about 500 km above the surface of the earth and an apogee as high as 50 000 km. The orbits are inclined at 63,4 degrees in order to provide communications services to locations at high northern latitudes. The particular inclination value is selected in order to avoid rotation of the apses, i.e. the intersection of a line from earth centre to apogee and the earth surface will always occur at a latitude of 63,4 degrees North. Orbit period varies from eight to 24 hours. Free space loss and propagation delay is comparable to that of GEO satellites, but HEO systems need to be able to cope with large Doppler shifts.

6.3.1.4 Geosynchronous orbit

A geosynchronous orbit is any type of orbit which produces a repeating ground track.

6.3.1.5 Geostationary Orbit (GEO)

A geostationary orbit is a circular orbit in the equatorial plane with an orbital period equal to that of the Earth. A GEO satellite appears fixed from an observer on Earth. This is achieved with an orbital height of 35 786 km (or an orbital radius of 6,6107 Equatorial Earth Radii). A GEO orbit has small non-zero values for inclination and eccentricity, causing the satellite to trace out a small figure of eight in the sky. The round-trip delay is approximately 250 milliseconds.

6.3.1.6 Polar orbit

A polar orbit covers both poles, and is inclined at about 90 degrees to the equatorial plane. The orbit is fixed in space, and the Earth rotates underneath, therefore a single satellite can in principle provide coverage to the entire globe (but not at the same time). There would be long periods when such a satellite is out of view of a particular ground station, but it may still be acceptable for a store-and-forward type of communication system (messaging).

6.3.1.7 Sun-synchronous orbit

A satellite in a Sun-synchronous or Helio-synchronous orbit sun-synchronous orbit crosses the equator and each latitude at the same time each day. The angle between the orbital plane and Sun remains constant, resulting in consistent light conditions. The orbit is therefore advantageous for an Earth Observation satellite.

6.3.1.8 Groundtrack

The satellite track in orbit, traced on the surface of the Earth is termed the satellite groundtrack.

Satellite footprint or coverage circle.

There are propositions for multimedia satellites in GEO, MEO and LEO orbits, and at the frequency bands S, Ku, Ka and V.

6.3.2 Frequency bands

The frequency bands are subdivided into different regions, depending on their frequency. The grouping may vary, and there is no exact definition. This subclause aims to illustrate that by a few examples.

One commonly seen sub-division of frequency characterization as:

Table 1: Common designation of communications bands

ultra-low (ULF)	3 to 30 Hz
extremely low (ELF)	30 to 300 Hz
voice frequencies (VF)	300 Hz to 3 kHz
very low (VLF)	3 to 30 kHz
low (LF)	30 to 300 kHz
medium (MF)	300 kHz to 3 MHz
high (HF)	3 to 30 MHz
very high (VHF)	30 to 300 MHz
ultra high (UHF)	300 MHz to 3 GHz
super high (SHF)	3 to 30 GHz
extremely high (EHF)	30 to 300 GHz

The following is an approximate division of the bands and the segments used for satellite communication.

Table 2: Common designation of satellite communications bands

Segment	Name	Band	Bandwidth Used
UHF		200 to 400 MHz	160 kHz
	L	1,5 to 1,6 GHz	47 MHz
	S	1,6/4 GHz	
SHF	C	6/4 GHz	800 MHz
	X	8/7 GHz	500 MHz
	Ku	14/12 GHz	500 MHz
	Ka	30/20 GHz	2 500 MHz
EHF	Q	44/20 GHz	3 500 MHz
	V	64/59 GHz	5 000 MHz

Table 3: More detailed band designations

HF-band	1,8 to 30 MHz
VHF-band	50 to 146 MHz
P-band	0,230 to 1 GHz
UHF-band	430 to 1 300 MHz
L-band	1,530 to 2,700 GHz
S-band	2,700 to 3,500 GHz
C-band Downlink:	3,700 to 4,200 GHz
C-band Uplink	5,925 to 6,425 GHz
X-band Downlink:	7,250 to 7,745 GHz
X-band Uplink:	7,900 to 8,395 GHz
Ku-band Downlink: (region 1)	FSS: 10,700 to 11,700 GHz DBS: 11,700 to 12,500 GHz Telecom: 12,500 to 12,750 GHz
Ku-band Uplink:	FSS & Telecom: 13,75 to 14,5 GHz DBS: 17,300 to 18,100 GHz
Ka-band (one interpretation)	17,7 to 31 GHz
V-band	36 to 51,4 GHz

Table 4: Frequency and Wavelength of the IEEE Radar Band designations

Band	Designation Nominal Frequency	Unit
HF	3 to 30	MHz
VHF	30 to 300	MHz
UHF	300 to 1 000	MHz
L	1 to 2	GHz
S	2 to 4	GHz
C	4 to 8	GHz
X	8 to 12	GHz
Ku	12 to 18	GHz
K	18 to 27	GHz
Ka	27 to 40	GHz
V	40 to 75	GHz
W	75 to 110	GHz
millimetre (mm)	110 to 300	GHz
micrometre (μm)	300 to 3 000	GHz

6.3.2.1 L/S/C band

These bands have long been used for satellite communications, and their propagation characteristics are well known. There are little problems with rain fading, and the technology is well developed. A drawback may be that antenna sizes need to be relatively large. Inmarsat communications, as an example, have used the L-band for global satellite communications to the terminals up to now, and the C band for gateway-satellite communications.

6.3.2.2 Ku band

The Ku-band has for some time been used for broadcast purposes. There can be problems with rain fading in very wet regions, but generally the issue is not critical. The technology is well developed and commercialized through the millions of consumer direct-to-home TV-systems around the world.

The Ku-band supports several Internet over satellite connections today, and it is expected that the broadband satellite multimedia systems prior to around year 2000 will use the Ku-band for content delivery to the customer. The Ka-band may be used for return links.

ASTRA, Eutelsat and SkyBridge are systems that will use the Ku-band.

6.3.2.3 Ka band

As the Ka band has come to be synonymous with multimedia satellite systems, it is discussed to a slightly larger degree than the other bands here.

The Ka-band is often meant to span the range from 18 to 31 GHz, albeit the exact definition of the frequency range covered by the Ka-band is seen to include frequencies up to 40 GHz in some contexts. For satellite communication purposes, the Ka-band in any case implies uplinks around 30 GHz and downlinks around 20 GHz. Please refer to the section on ITU for exact allocations.

The Ka-band is of interest because there is more bandwidth available at these higher frequencies than at the Ku-band, and lower band. It is therefore possible to accommodate more users, and presumably deliver high bit-rate transmission links at a lower cost (per bit/s) for the end users than at lower frequencies and in addition, smaller antennas can be used.

The principal problem, or challenge, with the Ka-band, is its susceptibility to rain; resulting in heavy fading, sometimes in the range of 20 dB. This results in requirements for spare power, both in the terminals and satellite, and power control algorithms in the systems, and terminals are required to operate with as little power as possible so as not to interfere more than necessary with other users. Some systems also include rain-adaptive coding on the downlink, whereas adaptive modulation has not (yet) been observed designed into planned systems.

Satellite communications at the Ka-band will involve the development of new technology that is critical to the success of commercial Ka-band systems. In particular is this is the case for satellites and terminals, as the terminals need to be relatively cheap to be able to compete with other access methods. Ka-band satellite technology has been demonstrated by DFS Kopernicus, N-Star, Italsat, ESA's Olympus project and NASA's ACTS satellite.

6.3.2.4 V band

The V-band is used to classify the band above the Ka-band that will be used for broadband communications purposes. It will basically imply frequencies in the region 40/50 GHz. ETSI has been able to find few details in propagation characteristics, but obviously the rain attenuation problem is even more pronounced than at the Ka-band. As for technology, there are needs for large amounts of R&D work before components can be commercialized. The V-band can support even larger communications bandwidths than the Ka-band, and with smaller antennas.

SkyStation aims to use the V-band, and have had a small portion of the band set aside for stratospheric communication (not satellite). Motorola M-star has filed with the FCC for using the V-band, and this may have lead to more applications for using the band. Currently there are several applications, but not yet any approvals or final allocations. FCC may have been pushed into the V-band applications round following applications from Motorola for its M-Star system. FCC policy states that other players must be given a chance to apply for spectrum on an equal basis before a request can be met. Hughes Communications Inc. and Loral Space & Communications Ltd., have filed for more than one new system, indicating a need to cover all their bases as they try to plan for future services.

The following systems have filed for or are filing for V-band spectrum use:

- Hughes' Expressway, StarLynx and SpaceCast;
- TRW's GESN;
- Lockheed Martin/TRW Milstar (in operation);
- Loral's CyberPath;
- GE Americom's GE*StarPlus;
- Orbital Science's Orblink, extensions to Ellipso;
- PanAmSat's V-Stream;
- Lockheed Martin Q/V-Band System;
- Motorola M-Star;
- Teledesic;
- Spectrum Astro Aster Satellite System.

In addition there is the non-satellite:

- SkyStation system at 47 GHz.

6.3.3 Interference and coexistence

This subclause identifies some of the important issues relating to spectrum sharing among BSM systems and between BSM systems and systems in other radio services. Following are the sharing situations relevant to BSM systems:

- GSO/GSO;
- NGSO/NGSO;
- GSO/NGSO;
- satellite/terrestrial.

It should be noted that the implications of the above-identified BSM sharing situations may vary depending on a number of considerations, several of which are:

- the direction of the satellite transmission (uplink or downlink);

- antenna design and operating considerations (capability, cost, installation and control of consumer marketed devices);
- use of modulation schemes, access techniques, and/or antenna technology to improve system performance and/or sharing capability;
- the type and level of deployment of terrestrial services in certain frequency bands;
- band-specific radio regulations or other regulatory policies affecting the implementation and/or operation of a given BSM satellite system(s) in a certain frequency band(s);
- band-specific radio regulations or other regulatory policies affecting the implementation and/or operation of terrestrial systems in certain shared frequency bands.

As summarized above, there are a number of significant issues to be addressed that impact prospects for sharing between BSM systems and systems in other services, as well as sharing between BSM systems. Due to regulatory uncertainties and a number of other factors, it is difficult to make generalized prioritizations of these issues. It is possible, however, to classify the scope and priority of issues by frequency band.

For example, the technical provisions in the portions of the Ku-Band and Ka-Band targeted for possible use by BSM systems that are subject to provisional power limits adopted at WRC-97, are subject to further review at WRC - 2000. A major component of this further review is the verification of the power limits intended to facilitate sharing between NGSO and GSO BSM systems, as well as other satellite and terrestrial systems. In the 18,8 to 19,3 GHz and 28,6 to 29,1 GHz bands, the applicable international regulatory provisions have been fully established. The issues in these bands are focused largely on prospects for sharing with terrestrial fixed service systems. In the V-Band, there appears to be slightly more flexibility in addressing sharing issues. This is due to the fact that only certain portions of the existing co-primary satellite and terrestrial allocations are in use by the terrestrial services, and because V-Band satellite programs are at a relatively early stage of development, as compared to Ku-Band and Ka-Band programs.

Several CEPT and ITU-R groups are involved in the study of issues relating to sharing between BSM systems and systems in other services, as well as sharing between BSM systems. These include, but are not necessarily limited to: CEPT project teams PT SE-19, PT SE-16, and PT FM-34; ITU-R Working Party 4A, Joint Working Party 4/9S, and Joint Technical Group 4-9-11. In the United States, work relating to BSM sharing issues is underway in a number of proceedings before the Federal Communications Commission. Additionally, the Telecommunications Industry Association has several technical groups that address BSM-related sharing issues. These include TR-34, TR-41, and joint activities between these two groups. Any work conducted in ETSI should take due account of the work being conducted in these fora.

Further consideration should be given to specific approaches to integrating ETSI's BSM work with the work of other technical organizations. It is clear, however, that the work ongoing in CEPT is most relevant to the European environment. This is not meant to discount in any way the importance of the work ongoing in ITU-R or in the United States.

The reader is also referred to ETSI's first two draft standards in a family (Ku/Ka & Ka/Ka): EN 301 359 [5] and EN 301 358 [6] both using satellites in geostationary orbit (GEO).

Satellite Interactive Terminals (SIT) and Satellite User Terminals (SUT) aim at individual or collective use. SUT are used mainly for transmission and reception of data signals. SIT are used for reception of audio-visual signals as well as data and for providing a return channel for interactive services via satellite. Typically the received signal is digitally modulated as defined in EN 300 421 [7].

The two ENs should protect other users of the frequency spectrum, both satellite and terrestrial, from unacceptable interference. The requirements have been selected to ensure an adequate level of compatibility with other radio services.

Both ENs define the minimum specifications of the technical characteristics of SIT/SUT operating as part of a satellite network. The equipment considered comprizes both the outdoor unit, usually composed of the antenna subsystem and associated up-converter, power amplifier and Low Noise Block (LNB) down-converter, and the indoor unit, usually composed of receive and transmit logic as well as the modulator, including cables between these two units.

SIT/SUT common characteristics:

- transmit through geostationary satellites with spacing down to 2° away from any other geostationary satellite operating in the same frequency band and covering the same area;

- linear or circular polarization is used for transmission or reception;
- received signals may be analogue and/or digital;
- transmitted signals are always of digital nature;
- antenna diameter does not exceed 1,8 m, or equivalent corresponding aperture;
- designed for unattended operations.

SIT only characteristics (EN 301 359 [5]):

- SIT reception is in the Fixed Satellite Service (FSS) frequency ranges from 10,70 GHz to 11,70 GHz and from 12,50 GHz to 12,75 GHz as well as the Broadcast Satellite Service (BSS) frequency range from 11,70 GHz to 12,50 GHz;
- SIT transmission is in the frequency band allocated to FSS on a primary basis from 29,5 GHz to 30,0 GHz;

SUT only characteristics (EN 301 358 [6]):

- SUT reception is in the frequency band allocated to the Fixed Satellite Service (FSS) on a primary basis from 19,7 GHz to 20,2 GHz;
- SUT transmission is in the frequency band allocated to FSS on a primary basis from 29,5 GHz to 30,0 GHz.

6.3.4 Bit Error Rates (BER)

In contrast to most current voice communication satellite systems where users are directly connected today, like the Inmarsat system, the new multimedia systems will have to be able to provide services with significantly lower Bit Error Rates (BER). Typically, the target BER lies in the range between 10E-8 and 10E-10, for achieving acceptable quality in ATM systems.

A specific bit error rate will result in a specific cell-loss ration for ATM systems, or in a packet error rate. From a users perspective, that may be the more interesting parameter. However, the two can be related through a formula or table, and from a communications engineers designers point of view the BER is a design criteria.

Some questions that may need to be answered may be:

- how can these low rates be achieved for all conditions?
- if an active power control algorithms is used what limits shall there be?
- how shall applications or APIs react if the targets are not met? Are there ground for standardization here?
- with what probability shall the target BER conditions be met?
- how will the availability affect the use of satellite multimedia systems?

6.3.5 Delay

Delay is also an quality criterion of the system. Satellite systems can provide communication with different delays, reflected in the variety of systems such as store and forward systems, GEO systems, and LEO systems. Adding to the transmission delay from a satellite in a specific orbit, the protocols and coding schemes that are used will also contribute to the overall source-to-receiver delay.

6.3.6 Availability

Satellite systems can have as high availability as terrestrial, cabled systems if properly designed. However, at the Ka-band, current practical limitation in technology coupled with the diverse weather conditions on the Earth, may lead to different availability in different regions. In contrast, the hot and humid tropical regions. While the colder regions can have their periods of heavy rain, the integrated time a system may become unavailable may not be dominant.

To operate globally with an equal availability and quality, both satellite and terminals may need to have quite flexible characteristics relating to power and coding/modulation. A problem with current technology for the Ka-band is that the amplifiers are both expensive, and to some extent not available in high powers (more than a few Watts). At the lower frequencies, like the Ku-band, this is not considered that big problem.

In addition to rain fading, availability is also affected by blocking. For GEO systems and a FSS this is a stationary situation (as long as a tree or building does not appear in front of a terminal after installation). For NGSO systems, however, some of the viewing angles in the horizon are likely to be blocked in some cases. For NGSO systems, satellite visibility and times when satellite diversity can be applied also plays important roles.

The target availability for the planned systems lie in the range from 99,5 % to 99,99 %. With a 99,5 % availability, it implies that it is acceptable that the system is unavailable (with the target BER) more than half an hour a week.

6.3.7 Coverage

Future broadband satellite multimedia systems can be categorized as being either Global or Regional in their coverage domain.

There is a difference in coverage also between GEO and non-GEO systems: While the GEO systems can adapt their beams coverage to market regions, and thus not cover oceans and regions that are not economically worth covering, this is not as easy for LEO and MEO systems. As the satellites will have footprints that cover most of the earth, they will to a larger degree provide "real" global coverage. However, even LEO and MEO systems may chose not to cover some regions, thereby saving satellite power, for instance.

GEO systems will be able to cover approximately 1/3 of the Earth; thus 3 satellites may be sufficient for a global system. The regions that are still not covered at the polar regions; above 70 to 80 degrees, but generally it is accepted close to 100 % of the market potential can be covered.

Non-GEO satellites may have different coverage ability as the orbits inclination vary. Polar orbits can cover the whole Earth, and are thus useful for imagery missions and alike, but a large amount of satellite orbit time is spent over polar regions where little traffic is expected. In practice, therefore, the non-GEO systems will usually provide coverage somewhere between ± 60 to 70 degrees north and south.

6.3.8 Polarization

At the Ka-band, systems will be allowed to use either Linear or Circular polarization, while at the Ku-band, the polarization is typically linear.

Circular polarization has some distinct advantages in particular for LEO satellites requiring tracking antennas. It is also useful for countering Faraday rotation.

6.3.9 Rain attenuation

Signal attenuation due to rain is a characteristic of both microwave and satellite transmissions. The level of attenuation is the product of a number of variables. Rain fading is the interference caused by raindrops on electromagnetic signals travelling through the atmosphere. When rain fading occurs, the transmission is weakened by absorption and scattering of the signal by raindrops. Rain fading is a local phenomena.

To combat rain fading it is common to design the system with a fade-margin, which is the amount of extra power the system can add to the signal strength to compensate for the possibility of rain attenuation. When the reduction in signal strength due to rain does not surpass the rain fade margin, the fade does not have any noticeable effect on transmission. However, as the increased use of power *can* disturb other users, it need to be used carefully and under regulations.

Rain attenuation increases as the signal frequency increases. This is due to the wavelength of each frequency and the size of the raindrop through which the signal has to pass. Transmissions at lower frequencies have a longer wavelength and are less susceptible to rain attenuation. A 6/4 GHz frequency has a wave-length of approximately 7 cm, and a 14/12 GHz frequency has a wavelength of approximately 2 cm. Any raindrop in the path of either signal which approached half the wavelength in diameter, will cause attenuation. Rain also increases the sky temperature.

The duration a transmission will be affected by rain attenuation and how deep the attenuation will be is determined by the amount of rainfall. The signal strength can generally be affected for two to three minutes during an average rainfall, and up to 15 minutes for extremely heavy rain periods.

Various regions in a satellite coverage area can experience different weather patterns. Also, the antennas in each region are generally pointed at different elevation angles, resulting in differences in the length a signal must pass through rainy conditions.

L/S and C-band transmissions are virtually immune to adverse weather conditions. For 6/4 GHz signals to be affected would require rain storms approaching hurricane conditions.

At the Ku-band, the strength of the satellite signal may be temporarily reduced under severe rain conditions. To compensate for these potential effects, earth stations located in heavy rain areas are designed with more transmit power.

Rain attenuation is considered a fundamental problem with Ka-band communications. Communication links at the Ka-band frequencies can be degraded by rain. To combat the rain fading there is a requirement for much spare power. Much of the NASA ACTS program has been devoted to experiments around rain fading and propagation. The exact amount of spare power required depends upon the target availability, and on the position and climate on earth. A margin of 10 to 15 dB at 30 GHz may be required, but typically the proposed systems plan to use 8 to 10 dB. The requirement for spare power puts tougher requirements on the power amplifiers in the satellite and terminals.

For the Gateways, spare power is a lesser problem, but reception of very attenuated signal may be impossible with practical limitations. Over-sizing the antenna is a theoretical solution, but in practice one cannot hope to make Ka-band antennas as large as antennas for lower frequencies. This is due to the strict requirements for plain surfaces on these antennas. Further, antenna wetting may also be a problem So can ice and snow. A solution is to establish a remote site with a separate antenna (Antenna Diversity), and use an alternative antenna when conditions are too bad for the primary one. To avoid obstacles it is also required that the satellites are at a high elevation angle above the horizon. For LEO constellations this influences the number of satellites and orbit altitude, and for GEO systems, as well as some LEO systems depending upon orbit inclination, it influences how far north/south one can communicate.

In places such as Southeast Asia or the Caribbean, torrential downpours can lower the level of the incoming Ku-band satellite signal by 20 dB or more; this may severely degrade the quality of the signals or even interrupt reception entirely. The duration of rain outages, however, is usually very short and typically occurs in the afternoons or early evenings rather than during the prime time evening viewing hours. For most Ku-band satellite TV viewers, these service interruptions will only amount to the loss of a few hours of viewing time over the course of any year.

From the NASA ACTS experiment, the following conclusion is drawn: A fixed clear sky margin should be in the range of 4 to 5 dB, and more like 15 dB in the up link for moderate and heavy rain zones. To obtain a higher system margin it is desirable to combine the uplink power control technique with the technique that implements the source information rate and FEC code rate. Most of the proposed Ka-band systems will implement 5 to 10 dB typically, and target a user availability for terminals in the order of 99,5 %. As mentioned before, this corresponds to approximately 30 minutes outage each week, but actual availability will depend strongly upon geographical location and local rain characteristic. The major reason for not having higher margins is due to the desire for low-cost power amplifiers.

6.3.10 Protocols and transmission formats

Most systems claim to be able to support all major protocols and interfaces (like TCP/IP, UNI, User Network Interface, and NNI, Network to Network Interface), but this can be supported by different underlying satellite transmission (air interface) formats.

The broadband satellite multimedia systems coming in the near future often are seen to belong to what can be divided into two different classes:

- DVB systems, adding inter-activity and generally asymmetric data services to a broadcasting system. These generally also take advantage of existing Ku-band DBS systems, and an to some degree an existing consumer customer base.

- ATM systems, typically found fully at the Ka-band.

6.4 The components involved

This subclause briefly describes some of the major individual components involved in broadband satellites systems. An interesting observation may be that the term terminal and gateway are not as clearly defined any longer as they have been. Very high rate terminals can have the same capacity as a gateway, and one may choose to separate them in instance by the way they are interfaced to the network. The components also play different roles when satellites are switching satellites or bent-pipe satellites. In the latter case, the gateways will typically incorporate some switching mechanism. All systems may therefore not include all types of components.

Recognizing the differences and similarities, and the difficulty in defining them precisely, this subclause still uses the terms as headings.

6.4.1 Network components

Network components include components that are used for things like:

- log-on;
- subscriber verification; and
- similar tasks.

Functions like satellite control and TT&C form part of the operational satellite network, but are not part of the telecommunications functions.

All systems need this function, although it may be partly distributed among different types of HW equipment. This type of equipment and functionality can be very system-dependent, at there seem to be little room for or purpose in aiming for any standardization here.

6.4.2 Satellites

6.4.2.1 Satellite stabilization

Most satellites are either spin stabilized or body stabilized.

- A spin-stabilized satellite has a cylindrical shape. The satellite is divided into halves, allowing one half to spin while the other half remains pointing at earth. The spinning portion contains the solar panels that absorb energy from the sun, while the lower half contains the communications payload. They are in general less expensive and faster to produce than larger, dual-payload satellites and are also easier to control from the ground.
- A three-axis or body-stabilized satellite does not spin but instead appears to be continuously pointed at the same spot on earth. Typically larger than the spin-stabilized satellite, the body-stabilized satellite is box-like in appearance upon launch. When the satellite reaches its final orbital location in space, the spacecraft's solar panels are unfurled to a "wing span" of more 20 to 30 m. The solar panels are designed to support greater power, thereby permitting dual payloads and more transmission power to the ground.

6.4.2.2 As switches or bent pipes?

To eliminate the need for an additional round trip delay, several of the proposed broadband systems aim to use switching in the sky, inter-satellite links and routing between satellites.

For the Iridium system, this had the consequences that the system in principle could operate in a closed mode with only terminals and no gateways. In principle, only one gateway was required to get connections in and out of the systems.

In practice an operation without gateways would be of little use, in particular in broadband communications systems, as most of the content an Internet user would download would have to come from terrestrially connected servers. However, switching in the satellite reduces the round trip delay, which may be important in some applications, particularly for GEO satellites. The SkyBridge system has no switching in the satellite, but then again they are at low earth orbit, and delay is small in any case. Teledesic, and Celestri, plus others, are in contrast planned with switching in the space segment, in spite of the LEO characteristics. There is no doubt that intelligent satellites simplify the ground segment, but at the cost of more complex satellites which is in general a higher risk. The satellites are more difficult to repair (if not impossible in some cases) and maintain than a terrestrial infrastructure.

6.4.2.3 Onboard processing

A new feature for many of the forthcoming satellite systems is that they have on-board signal processing, OBP, in contrast to the bent-pipe approach of current systems. The first system to implement this technology in a commercial context will be the Iridium system, scheduled to be operational later this year. On-boards DSP processing will detect and regenerate the uplinks signals, and allowing smaller antennas. Several systems also have inter-satellite links and on-board switching, so that few gateways are needed.

The onboard processor can be responsible for resource control, channelization, demodulation, and decoding/encoding. Onboard decoding allows the satellite to have greater capacity and the system to allow for smaller user terminals. OBP is also useful for adaptive antenna beam-forming.

6.4.2.4 Antennas

New antenna technology in the satellites is a pre-requisite for broadband communication, as it allows the use of spot-beams, and thereby increasing the system capacity significantly. Digital signal processing and beam forming, as well as phased array antennas have contributed to this capability.

Spot beams can be created by different technologies, and they can be shaped permanently or be re-configurable.

Scanning spot-beams can be used to cover low density regions.

6.4.2.5 Inter-Satellite Links (ISL)

Inter-satellite links, connecting satellites in space, are used in switched satellite systems, and combined with switching in the satellite it can offer the system the ability to bypass the terrestrial segment switching and routing.

ISLs can be either optical or at radio frequency.

6.4.2.6 Launch

Rocket launch capacity is limited, and there a few sites world-wide that have the capability to launch satellites into orbit. For GEO systems, this may not be a major problem, but for the LEO systems with a large number of satellites the deployment time required to launch all the satellites is a challenge. LEO systems require all or at least many satellites in orbit to operate as a system, and it can therefore take more than a year before the first satellite is launched until the system begins to create revenues.

6.4.3 Gateways

If one considers a large number of consumer terminals, where the users download broadband multimedia, the content has to come from some gateway or high capacity terminal. To achieve a sufficiently high capacity for a large number of users, the broadband systems may need to have a high number of such gateways (or high capacity terminals). Current satellite systems, primary for voice, need not have more than a few gateways world-wide to operate, as the amount of up- and downlink spectrum is not generally a limitation.

For broadband systems the bandwidth per gateway/terminal is limited (to 500 MHz or 1 GHz, depending on system). Within this bandwidth, only a limited number of individual multimedia channels can be supported, therefore many such gateways may be required. Since these will serve several users, their availability will also generally be required to be higher than that of an individual (single user) terminal. Antenna diversity may therefore be applied.

Since the difference between terminals and gateways tend to diminish, standardization may be equally important and gateways may be considered as multi-user terminals.

Broadband satellite systems may therefore choose to use several hundred gateways, as is the case foe SkyBridge.

6.4.4 Terminals

Responses to the Questionnaire indicate that different BSM system proponents have devized different system architectures. Some of these designs entail the use of "gateway" earth stations to pool traffic or act as PSTN interconnect points. Other design architectures do not classify earth stations in this fashion. The issue of satellite terminal classification has also been addressed in numerous regulatory fora, with the results often creating ambiguous or conflicting working definitions that can result in confusion.

Developments in operational and regulatory classifications for BSM earth stations have clear implications for ETSI standardization efforts.

6.4.4.1 Low-cost SSPA

For the terminal, that aim to obtain the low pricing, the outdoor unit with the high power amplifier is a most challenging unit for Ka-band systems. Solid State Power Amplifier, SSPA, are required to obtain a reasonable cost, and these struggle to obtain 2 W power today. To obtain more, several have to be combined, and this is not trivial as the number of units to combine increase. A cost-effective alternative in the 2 to 15 W region can be tubes (or vacuum electronic devices).

- The EIRP of a terminal may need to be standardized and regulated.
- Recommendations for the SAR of a terminal already exist. These may need updating with the Ku/Ka band systems.

6.4.4.2 Antenna and antenna pointing

The antenna subclause also contributes significantly to the terminal price. But more importantly, when the terminals also shall transmit data then antenna pointing becomes a critical issue. A wrongly pointed antenna may first not transmit or receive enough useful power towards the satellite, but more importantly, it may transmit towards a wrong satellite and distort for other users.

- Antenna characteristics will need to be standardized and regulated.

6.4.4.3 Mobility and nomadic use

Broadband satellite multimedia will typically be used as a fixed satellite service. Currently the Ka band is also only licensed for fixed services. Because of problems associated with antenna pointing, it is not imagined that broadband terminals receiving several Mbps will have the ability to become mobile for some time yet. However, as compression techniques may evolve, the services in question may become available with lower requirements for transmission capacity, and as such may eventually meet technically viable solutions.

Nomadic terminals, on the other hand, are fully possible. These depend mostly on a practical way to get the antenna pointing correct, as one can not rely on a professional installation whenever the terminal is moved. With phased array antennas, which today are expensive, but in the 5 to 10 year term may become reasonable, nomadic terminals for a mass-market may be a reality.

Nomadic terminals may raise an issue with respect to inter-system roaming.

Cruise ships and marine terminals for very stable and slowly moving objects may be considered as a twofold problem. The technical issue is definitely simpler than for land mobile applications, but then again there is the licensing issues that allows the current Ka-band use only for fixed services.

- Marine terminals will raise a question relating to beam hand-over.

6.5 Communication issues

6.5.1 Access multiplexing

The most common access format for the broadband satellites systems are to use some form of frequency division TDMA on the uplink, and a TDM structure on the downlink. There has also been responses to ETSI that CDMA will be used.

Orthogonal Frequency Division Multiple Access (OFDMA) has also been suggested as an access scheme for the return channel of future interactive.

- TDMA schemes raise questions relating to synchronization, and up and down power ramping that maybe of interest with respect to synchronization.

6.5.2 Modulation and coding

6.5.2.1 Modulation

At the Ku-band, modulation for DVB systems are normally of the type QPSK (Quadrature Phase Shift Keying). However, at the L ,S and C band, Inmarsat systems, for instance, uses Offset-QPSK for mobile systems. O-QPSK allows the amplifier to be driven more into saturation.

Modulation for the new systems at Ka-band is generally chosen as QPSK, which also is the same as for ACTS, which also indicates that one is not prepared to drive the SSPA into saturation mode to increase the power efficiency even if the terminal power amplifier at the Ka-band is a cost driving element for the terminal price at the moment. The modulation can also influence the spectrum sidelobes when an amplifier is driven into saturation. Some systems plan to use TCM with 8 PSK for gateways.

Higher order modulation, like 16QAM, could be an option, given it was made adaptive, to increase the capacity. 16QAM will be used for some satellite (64 kbps) services in the Inmarsat system.

An Canadian experiment called BASE, (Broadband ATM over Satellite) mentioned 16QAM modulation as one topic for experiments. However, the final reports had no mentioning of such trials. Also, Asia SkyLink mentions 16QAM used at Ka-band system.

In L-band and S-band systems, modulation has often been chosen so as to mimimize side-lobes of the spectrum when an amplifier was driven into saturated mode. For the Ka-band systems, such use of amplifiers is not typical, as power availability is not limited as for battery operated systems. Further, modulation schemes like offset-QPSK tend to require more processing for synchronization when the same performance is desired, than QPSK. This is an important factor when demodulation is to be performed in the satellite.

Finally, as the ACTS satellite used QPSK and 8-PSK modulation, this is now considered proven technology for the Ka-band, and does as such provide some comfort for the systems design engineers.

The major motivation for utilizing the Ka-band is to provide high bandwidth services. Therefore, adaptive modulation can be imagined so that the spectrum is used as efficiently as possible. The use of adaptive modulation, adapted to the fading is possible, at least from the conceptual point of view. As the terminals need to have a spare power reserve, they could apply this power for sending more bits per symbol when not required for combating rain-fading. It could also be combined with the use of BPSK, so more power per bit was used when required. Naturally, the transmission rates would be influenced, but for Internet type of applications, this may not be of negative concern.

Potential use of adaptive modulation could benefit from an ETSI standard, because manufactures making terminals and satellites for different systems could then make ASICs that handled the selected types appropriately. More cost-efficient designs are important, as the terminal price is of concern for all systems.

6.5.2.2 Coding for low BER

To obtain a sufficiently low BER, in the region of 10^{-8} to 10^{-10}, powerful coding will often be required. Typically, a convolutional forward error correcting code, FEC, is used with a Viterbi decoded, combined with a Reed-Salomon code and an interleaver. There is an increasing interest for Turbo codes, but no broadband systems have so far defined the use of such codes, as they are considered to processing demanding for the broadband use. However, they could provide more coding gain, thereby allowing a reduction of the antenna size of satellite power amplifier.

As the decoding rate of the terminals often is seen to be required to handle a high rate TDM downlink, implementation will most probably need to be done through the use of ASICs. As for the modulation, a standard for coding may provide the market with cheaper terminal and satellite technology.

6.5.3 Terminal power amplifiers

The transmitted power density for the terminals will need to be regulated, so as the different systems do not interfere.

As the terminal power amplifiers are a cost-driving factor at the Ka-band, getting a set of standard requirements may inspire the funding houses to get the prices down as they may see one larger market.

6.5.4 The effect of delay in communications

Satellite path delay is approximately 270 milliseconds for GEO systems. Adding system delay caused by processing and buffering adds the total well above 300 ms. In voice communications, the most noticeable effect of path delay has been echo, and challenges have related to echo cancellers.

Where data transfer for computers is concerned, delays are generally more tolerable than errors. The requirement for low error rates for computer-data, therefore results in requirements for high power transponders to obtain a sufficient low carrier to noise ration at the receiver. File transfer and data distribution is not very sensitive to a few hundred ms delay. However, current versions of TCP/IP, for instance, can have a limited upper-bound capacity when a given delay through the channel. These issues will be resolved, and the Internet over satellites can be as for terrestrial connections.

Voice and video distribution services can on the other hand manage surprizingly high error rates (in the order of a few percent) when properly designed. As real-time systems, however, the humans interfacing with the voice and video technology, will generally accept only limited amounts of delay. Currently, many people are disturbed by the long delays in a satellite connection, in particular if it is present both ways on a duplex channel. With a bent pipe satellite and more than one users connected via satellites in different parts of the globe, a total of four satellite "hops" is possible in a practical situation. This will in most cases be unacceptable for duplex audio and video. One hop, on the other hand, is usually acceptable for most people, and indeed, the geostationary NASA ACTS satellite has been used for voice connections, and NASA reports that users did not complain about the delay, but all may not agree on that.

In interactive satellite networks, propagation or path delay has presented unique problems for voice communications and earlier generations of data protocols, but problems have been overcome by the use of equipment and protocols specifically suited to the requirements of satellite transmission.

Client/server applications often rely on "transaction-oriented" application-layer protocols that consist of large numbers of low bandwidth requests and responses. Delay influences the set-up of such connections. Main issues regarding latency in Internet protocols relate to:

- The default buffer-size in many TCP/IP protocol implementations acts as a bottleneck on communications over high-latency links.
- TCP includes congestion control mechanisms which mean that Internet connections (such as viewing web pages and sending e-mail) start out at low speed and then advance up to higher speed if no congestion is encountered. The problem is that each cycle of speed increase requires a full round-trip communication between sender and receiver, and dozens of such round-trips can be necessary to reach the full potential of a link. With a sufficiently long delay, as encountered in some GEO systems, the communication can end before the connection can ever reach the full bandwidth of the link.

The above issues are one set of arguments for LEO and MEO systems.

6.5.5 Modes of operation

The different terminals modes of operation broadband satellite system can have may vary. The below list is an indication of what can be found:

- New: The terminal is unused, uninstalled and unconfigured. Not recognized by a network.
- Off: The terminal is switched off, but installed.
- Idle / cold standby: The terminal has logged on to the system, but is not receiving or transmitting.
- Ready / hot standby: The terminal is in synchronism, and ready to transmit. (May include a minimum stand-by rate).

- Active: The terminal is transmitting and/or receiving.
- Resynchronizing: The terminal has lost its synchronization, and is in the process of regaining it.
- Synchronizing: The terminal is in the process of synchronizing to the system.

As some systems envision a minimum bit rate to keep the terminals in synchronism when it is in use, a large number of users may actually consume a significant capacity, and contribute negatively to system noise for other users. This may be true even it the user is not sending any information. Typical, minimum rates are in the order of 16 kbps. This situation may for instance occur when users are surfing on the Internet and reading web-content. During that period they do not send anything but would like the system to respond immediately (without any log-on procedure) when they click to download another page.

It may be of benefit to give this matter some consideration in ETSI.

6.5.6 Synchronization

The method and concept used for synchronization can influence both the data rates and the overall noise of the systems. As mentioned above, using a minimum stand-by rate to keep the system in synchronism can contribute to increasing noise levels an unnecessary radio emission.

Open loop, closed loop or feedback loop synchronization can influence the maximum bit rates for the return transmission for the terminals. It can also influence the design and the available third-party ASICs. For inter-system roaming, conceptually similar synchronization methods may be of importance.

Inter-system roaming can be of interest for nomadic terminals, or for a users ability to choose different service providers with is single terminal. ETSI may want to look into to the technical requirements and ability for inter-system roaming.

6.6 Competing broadband access technologies

6.6.1 Broadband copper access - xDSL

The advent of the ADSL (Asymmetric Digital Subscriber Line) technology has opened the possibility for using the existing copper twisted pair access network for broadband access to the premizes. Copper twisted pair lines connects more than 90 % of residences in developed countries and more than 700 million locations globally. ADSL delivers an asymmetric capacity of up to 9 Mbit/s downstream and 640 kbit/s upstream, thus expanding the capacity of the existing copper telephone lines by a factor of up to 300 compared to voice grade modems and 50 compared to ISDN. Even though the full capacity can not be offered to every customer, ADSL enables the incumbent telephone companies to play a dominant role in the megabit access markets since no other access infrastructure will cover so much of the market for many years.

Another xDSL technique, called Very high-Speed Digital Subscriber Line (VDSL), is expected around year 2000. It is a continuation of ADSL but for shorter lines. VDSL can increase the maximum downstream capacity to 52 Mbit/s. VDSL will be employed in combination with Fiber-to-the-curb or Fiber-to-the cabinet, covering the last drop to the premizes.

Both ADSL and VDSL are perfectly suited for typical Internet traffic, where users download significantly more data than they transmit. VDSL can even support High Definition Television (HDTV) transmission over copper, requiring in the order of 20 Mbps, and even ADSL can support several VHS-quality video transmissions using MPEG-2 (or MPEG-4).

Manufactures of VDSL chip sets, in particular, may be able to provide chips where the ration of the upstream bandwidth can be traded for downstream bandwidth. A general, potential drawback, however, is that within one cable, with a number of twisted pair wires, all connections must use the same tx/rx bandwidth ratio. This is due to echo cancellation problems and the enormous dynamic range required to cancel near end echo for higher frequencies.

Both ADSL and VDSL use multi-tone transmission, although there are two competing technologies for ADSL. Echo-cancellation is an option for ADSL, but is not used for VDSL, as the frequency band is divided into non-overlapping regions. Except for the higher speed processing required for VDSL, it is actually simpler from a transmission point of view, as the transmission characteristics vary much less for different lines over short distances.

For ADSL, it is often envisioned that an end-user (home user) will have an ATM.25 interface, and a small multiplexer at his premizes. Thus an ADSL modem will be able to support several services, and will probably not be used as a traditional modem of today.

ADSL, as opposed to ISDN, allows coexistence with plain old analog telephony service (POTS), since the lower 25 kHz of the band is not used. VDSL even allows coexistence with ISDN, as it allows the 80 kHz or 120 kHz that ISDN requires to be unused. ADSL modems are available today from a number of different manufacturers, and commercial introductions is in general awaiting a market strategy and pricing policies. ADSL is by many seen as a "killer" for CATV-modems.

ADSL is likely to be a major competitor to satellite access into the GII, and a users expectations for the satellite systems is in many cases likely to be similar as for ADSL.

6.6.2 Cable TV modems

In the field of CATV networks, a number of operators are currently deploying Hybrid Fiber Coax (HFC) networks, aiming to provide their customers with both traditional services and broadband access. HFC is by some also considered as a viable architecture for the introduction of advanced services such as interactive services.

However, the lack of financial strength and telecommunication background limits the power of cable TV operators to provide efficient services to a large community. Further, CATV modems sometimes require that users share the capacity, so that with a large number of users on a CATV-loop, the realistic bitrate per user is limited. An issue often mentioned related to CATV modems is that service providers are not as economically strong as telecom service providers, and do not have the necessary economic power to rapidly employ a large, new infrastructure for many users. The price charged today for this type of modems and use is high, as of today.

There are all in all a number of other obstacles with CATV modems and systems, and many believe that their life in the market is limited when ADSL is fully introduced in the not too distant future.

6.6.3 Optical fiber

Optical fiber has long played an essential role, and much wishful thinking has pointed out that "soon will bandwidth no longer be a problem" and "we will soon all have fiber to our homes". This is not true. It will take decades, if not centuries, before every home can be connected through an optical fiber, and meanwhile there is a need for other alternatives.

Fiber to the home is therefore a long-term future scenario, while fiber to the curb is more reasonable for large portions of the population. From there on, xDSL techniques can support broadband services for many fixed users.

For large business users, optical fibers is still the best alternative to satellite communications, and certainly it is quite common for new buildings to be cabled with optical communications cables.

6.6.4 Terrestrial radio access

Broadband terrestrial radio access is another means of rapidly connecting users on a point to point (or point to multi-point) basis. 155 Mbps radio access networks are available today. However, such systems do not provide the (global) coverage that a satellite system can provide.

6.7 Complementary technologies

6.7.1 The Internet

The ability to provide Internet services has become the most important issue of future interactive broadband satellite systems.

The Internet itself can contain such a vast amount of applications and services that most users need can be covered. Development of new protocols and Internet technologies will be able to increase the number of services further. Some of these include the introduction of push technologies and multicasting.

Reliable IP Multicast protocols are also an emerging standards area, and new protocols have been developed to support real-time multimedia delivery and Quality-of-Service (QoS) specifiers for multicast and unicast network services. These include the:

- Real-time Transport Protocol (RTP);
- Control protocol (RTCP) that works in conjunction with RTP;
- Resource Reservation Protocol (RSVP);
- Real-Time Streaming Protocol (RTSP).

6.7.2 ATM, QoS

There is a large interest in ATM over satellite.

ATM stands for Asynchronous Transfer Mode, and ATM is a network technology based on transferring data in cells or packets of a fixed size. The cell used with ATM is relatively small (only 53 bytes) compared to similar units used with older technologies. Implementations of ATM support data transfer rates of from 25 Mbps to 2,5 Gbps.

ATM creates a virtual channel between two points whenever data transfer begins, as opposed to TCP/IP, in which messages are divided into packets and each packet can take a different route from source to destination.

The physical layer supports various transmission media with rates from kilobits per second to gigabits per second. However, due to the so called "cell-tax" (frame overhead), ATM is not often used on connections where the rate is low and capacity is a major limit (like telephone line modems).

ATM supports a choice of various transfer capabilities, or ATC, (ITU definitions in I.371)or service catagories (ATM Forum definitions in TM 4.0):

- Constant Bit Rate (CBR) is defined by a commited Peak Cell Rate (PCR) for the duration of the connection.
- Variable Bit Rate (VBR) , where the connection is defined by a Sustainable Cell Rate and the Maximum Burst Size. Real time (RT) considerations adds a constraint on the cell transfer delay and the cell delay variation, while non-Real Time (nRT) does not.
- Unspecified Bit Rate (UBR) is a “best effort” scheme. There is no commitment on errors, delays or throughput.
- Available Bit Rate (ABR) is a network protocol, which is ratebased, allowing the overall bandwidth of the network to be optimized. A flow control mechanism is provided (through resource management cells), enabling modification during a connection of a guaranteed Minimum Cell Rate (MCR).
- Guaranteed Frame Rate (GFR) is a frame based ATC, suitable for IP traffic, and also for Frame Relay / ATM inter-networking. It is defined by a source traffic descriptor including Peak Cell Rate (PCR), Minumum Cell Rate (MCR), Maximum Frame Size (MFS), Maximum Burst Size (MBS).

The ATM adaptation layers are called:

- AAL 1: For CBR services.
- AAL 2: For VBR type of services; VBR may be difficult to implement with satellites. VBR is particularly well suited for video coding.
- AAL 3/4: For connectionless services/data protocols; This is used for applications, such as file transfer, that can tolerate delays.
- AAL 5: for high-speed data protocol.

ATM supports QoS, which can guarantee a user a set of service parameters. QoS is short for Quality of Service. One of the biggest advantages of ATM over competing technologies such as Frame Relay and Fast Ethernet, is that it does support different QoS levels.

6.7.3 Personal computers

The evolution of personal computers and computer SW merges the computing world and the broadcast (TV) world. Already computers can be used as TVs, and TV-sets are possible to use for Internet browsing. This development will continue, and the improvements in the ability of the equipment to support different services (and with better quality) may sometimes change the consumer behaviour.

It is impossible to detail the expected changes in the personal computer system in the near future in the present document, but we can merely state that the development will have a great influence also on the need for and requirements for broadband satellites communication systems.

6.7.4 DVB and MPEG-2

Digital television and Digital Video Broadcasting is one of the other complementary technologies that provide a need for (personal) broadband satellite communication systems. In 1997, DVB delivered its Data Broadcasting specification to ETSI. Already Data Broadcast Networks (DBNs) making use of DVB return channels and DVB-S satellite delivery are up and running in Europe. DVB DBN operators include ASTRA, Hispasat and Eutelsat. Services include Internet.

MPEG packets are fixed-length containers with 188 bytes of data (longer than ATM cells). MPEG includes Program Specific Information (PSI) so that the MPEG-2 decoder can capture and decode this packet structure. This data, transmitted with the pictures and sound, automatically configures the decoder and provides the synchronization information necessary for the decoder to produce a complete video signal at its output.

The DVB approach provides great flexibility in terms of transmitted digital information, owing to its data "container" concept. DVB simply delivers to the receiver "containers" with compressed image, sound or data. No restrictions exist as to the kind of information which can be stored in these containers. The DVB Service Information acts like a header to the MPEG-container, ensuring that the receiver knows what it needs to decode.

The DVB-S system is designed to cope with the full range of satellite transponder bandwidths. DVB-S is a single-carrier system.

A Reed-Solomon Forward Error-Correction (FEC) overhead is used as an outer code., followed by interleaving. After this, a further error-correction system is added, using a punctured convolutional code as inner code. The amount of inner code can be adjusted to suit different circumstances (power, dish size, bit rate available). Data is modulated with QPSK.

The 39 Mbit/s (or other bit rates allowed by parameter sets for a given satellite transponder) can be used to carry any combination of MPEG-2 video, audio and data. Service providers are free to deliver anything from multiple-channel SDTV, 16:9 Widescreen EDTV or single-channel HDTV, to Multimedia Data.

Broadcast Network services and Internet over the air. As the DVB project has progressed, interactive TV has been identified as one of the key areas ideally suited to an entirely digital transmission system. Many DVB members have developed comprehensive plans for the introduction of interactive TV and 1997 has seen a number of large-scale trials in Europe.

- The various DVB Return Channel specifications have been published by ETSI. These include DVB-RCC (Cable) and DVB-RCT (Telephone or ISDN). These are complemented by the DVB-NIP (Network Independent Protocols), based on the MPEG-2 DSM-CC (Digital Storage Media –Command and Control) again published by ETSI.

- DVB has produced specifications for interactive return channels based on Public Switched Telephone Networks (PSTN), Integrated Services Digital Networks (ISDN), hybrid SMATV and satellite, DECT, LMDS and Cable Networks (CATV), including Hybrid Fibre Coaxial (HFC) Networks. The work is now concentrating on finding suitable technical solutions for Satellite Systems and Local Multipoint Microwave Systems (LDMS).

- The new revised DECT Return Channel specification contains a vital "Data Service Profile for Point-to-Point Protocol (PPP)", which ties in with the DVB's Network Independent Protocols.

- The new LMDS return channel specification is based on the DVB-RCC specification, currently in the final stage of approval in ETSI.

- Technical specifications for the API and the Multimedia Home Platform will be produced in Summer 1998 by the DVB Technical Module.

Reference: http://www.dvb.org.

6.7.5 Audio/Video compression techniques

Source coding algorithms like MPEG contribute significantly to the ability for satellites to transfer multimedia. The speed at which multimedia services like voice, audio and video can be provided is not independent of the coding that is used. Efficient compression like MPEG-2 can thus provide broadband services at a higher quality given the same transmission channel.

For a users, it is irrelevant when downloading a video clip whether the speed or quality of which he can get video transferred with is improved by enabling a higher bit-rate or by better compression techniques. A significant amount of the multimedia content will be from audio and video sources, and raw, uncoded video requires very high rates (in the order of hundreds of Mbps) to be transferred with a good quality unless it is coded. Efficient coding, like MPEG-2, can provide high definition television with a few tens of Mbps. Advances in source coding technology can reduce these rates further.

Another issues that may be further exploited in the future is the fact the, when properly designed, audio and video coders can tolerate quite high error rates; in the order of a few percent. This may lead to a higher throughput, as there is always a trade-off between the bit rate and the bit error rate. To exploit this fact in a combined system that transmits both data from analog sources like audio and video, as well as computer data, requires future work.

6.8 Enabling technologies

Enabling technologies are technologies that make possible broadband satellite communications. Such technologies relate to:

- the ability to create small spot beams;
- the ability to manufacture and launch satellites cheaper;
- active switching satellites, inter-satellite links;
- Ka-band technologies in general, and in particular for consumer applications;
- high rate digital signal processing for space applications / on-board processing;
- phased array antennas;
- network architecture;
- low voltage and low consumption space qualified technology for digital equipment;
- space qualified software development and implementation;
- the presence of standards.

7 Existing broadband access satellite systems

There are may current suppliers of Internet services over satellite.

The offered bitrates range from 45 Mbps (Telenor) and down to 64 kbps.

Hughes has for some time offered the DirecPC service. With DirecPC, the upstream connection is made via a land-line telephone modem to an ISP or regional uplink facility. Only the downstream path is via satellite to the users satellite dish. The service provides 400 Kbps of connectivity downstream, whereas upstream speed are conceptually limited by current modem technology and network issues (like the availability of IDSN or xDSL).

PanAmSat also offers Internet services where ISPs offer a high-speed Internet service to subscribers using the PanAmSat satellite system, with speeds from 64 Kbps to 2,048 Mbps, simplex or duplex, and options for balanced or asymmetrical traffic.

Ka-Star Communications, a US company, has proposed a backbone networking service for North America using ATM technology to support broadband data speeds from 1,5 Mbps and up. This will be offered to ISPs, DBS providers and private network operators.

Eutelsat also offer services like DirecPC.

It is in practice impossible to compile a complete list of Internet-over-satellite suppliers, but just to indicate that there is a large activity within this field, some of them are listed below:

- Telekom Austria
- BankNet
- Bekkoame
- BT Satlink
- Charter Communications
- Concert
- Crawford Satellite Services
- Datel
- DCI
- Digex
- Eutelsat
- Gilat Satellite Comms
- Global One
- Globecast
- GSI System
- Impsat
- Insat
- Israsat
- MCI
- NASA ISN
- Netsat
- NSN
- Orion Network Systems
- Satko (GIBS)
- Taide
- TeleGlobe
- Telekomunikacja Polska
- Telenor
- Telstra
- Transtel
- UNDP
- Wilken/Afsat
- Wisper Bandwidth
- Worldcom

8 Information received on BSM systems

This clause contains information supplied by proponents of broadband satellite systems in response to the questionnaire "Standardization Objectives for Broadband Satellite Multimedia" (www.etsi.org/ses/news/BroadSat.htm).

8.1 Astrolink

Astrolink International Limited is at the stage of proposal evaluation prior to contract award for a geostationary satellite project to provide high data rate communications to a full range of commercial, private sector and government users, with potentially global coverage. Initial service is planned for mid 2002.

The projected budget for initial global infrastructure, consisting of 4 satellites and a ground network of control centres and gateways servicing world-wide deployed user terminals, is $2B+.

Currently, the sole shareholder in Astrolink International Limited, is Lockheed Martin; other investors are soon to be announced.

8.1.1 Target market

- SOHO, small, medium and large businesses.
- Rural telephony.
- Civil and military government users.

No specific dedicated military services are envisioned; military will be treated as any commercial user.

8.1.2 Satellite constellation

The Astrolink satellite system will ultimately consist of a maximum of nine satellites:

- two at 97° West;
- two at 21,5° West;
- two at 2° East;
- two at 130° East;
- one at 175,25° East.

Each satellite will have 44 user beams and 14 gateway beams, on-board switching capability and ISLs.

8.1.3 Frequency bands

Astrolink will use the following frequencies in all areas; there is frequency reuse within a given region:

Terminals:

- Uplink: 29,5 to 30,0 GHz.
- Downlink: 19,7 to 20,2 GHz.

Gateways:

- Uplink: 28,35 to 28,6 and 29,25 to 29,5 GHz.
- Downlink: 18,3 to 18,8 GHz.

8.1.4 Terminals

Three terminal types are proposed:

- Class "A": 16 to 416 Kbps PA Power ~ 2W;
- Class "B": 16 Kbps to 2,08 Mbps PA Power ~ 12W;
- Class "C": 16 Kbps to 10,4Mbps PA Power ~ 15W.

The modulation scheme on the radio interface is QPSK and its variants.

The terminals listen to the satellite downlink to obtain the satellite clock and then synchronize their local clocks and continue time tracking.

Minor Doppler correction is required, and is done by the terminal.

The terminal installation will be performed by professionals,

8.1.5 Mobility

Initial fielding will service fixed users; mobile service is being considered for future block developments.

8.1.6 Gateways and network interfaces

14 beams per satellite are planned with the opportunity to place many Gateways in each beam.

Astrolink gateways will be linked through the Astrolink satellites.

Interconnection with other networks will be at local service nodes as required.

The gateways will be operated by local/country service providers and Astrolink International Limited at each satellite's Network Control Centre.

8.1.7 Co-existence with other systems

Astrolink expects that compatibility problems with other systems using the same spectrum will arize.

The PDF limits for NSGO operations in the FSS band are a major concern, and will need to be resolved through regulatory adjudication.

8.1.8 Applications

Astrolink will offer a full range of commercial, private sector and government, high data rate, global communications.

Astrolink will use an ATM transport layer for IP.

Open systems and a common operating environment will be utilized to assure a wide array of compatible commercial applications are usable.

8.1.9 Satellite component of UMTS

Astrolink does not have involvement in S-UMTS.

8.1.10 Licensing

Application has been made to, and been approved by, FCC and ITU.

Landing rights, and host nation agreements are seen as difficult regulatory areas.

8.1.11 Standardization

Astrolink considers landing rights, blanket licensing, and host nation agreements to be the most relevant issues for standardization.

Astrolink thinks an ETSI standard for type approval would most probably be helpful, depending on details of type approval. They would be interested in influencing the development of the standards ETSI will produce for type approval.

8.2 EUTELSAT

EUTELSAT (European Telecommunications Satellite Organization) provide broadband satellite multimedia services through three projects:

- EUTELSAT Multimedia platforms;
- EUTELSAT Digital platforms;
- SKYPLEX.

These facilities are commercially available today and operational using DVB standards. In some cases the return link is by terrestrial telecommunications.

EUTELSAT is a Transport Provider and, through the EUTELSAT Digital platform, an Access Provider.

Service is provided to all of Europe and Mediterranean basin, Africa and parts of Asia.

The major partners are Comnet/Telecom Italia; BT/Easynet; Polycom and Antenna Hungaria.

8.2.1 Target market

Small, medium and large companies, and consumers.

8.2.2 Satellite constellation

There are 12 geostationary Ku-band satellites, with up to 4 beams per satellite.

Mostly, the satellite transponders are transparent. However, SKYPLEX involves on-board switching.

The satellite projected lifetime is 12 years.

8.2.3 Frequency bands

8.2.4 Terminals

The Ku band downlink channel is DVB compliant.

The power amplifiers tend to be of 10W and 20W, and are compliant with ETS 300 159.

No Doppler correction is necessary in the terminal.

Installation problems are minimized by maintaining a high level of system and individual terminal specifications and maintaining a high standard for approval of such systems/terminal to ensure the risk of poor installation is minimized.

The terminal installation is today performed by professionals, but in the future may be by less qualified persons, e.g. any person able to use a PC Internet connection via modem.

Receiver DVB-DATA cards are already at less than 300 ECU and these prices will go down proportionally to that of the DVB set-top boxes.

8.2.5 Mobility

EUTELSAT operates in the fixed satellite service; there are no plans to support non-fixed terminals.

8.2.6 Gateway and network interfaces

A single gateway is required, but more may be used.

Gateways can be chained for redundancy management functions.

Interconnection with other networks will be via standard interfaces.

Gateways are operated by Access and/or Service and/or Content providers.

Using the SKYPLEX network, data gateways can be distributed in any site under the coverage of the satellite, contributing data into a single channel (transponder) which can be received by all users simultaneously.

8.2.7 Co-existence with other systems

EUTELSAT do not expect any problems with interference between their system and other systems.

8.2.8 Applications

The system will carry any IP compatible application, multicast or unicast.

Applications will interface using an Ethernet based gateway.

The current windows size for TCP/IP over satellite limits the data rate to < 2 Mbps per user on a single session.

8.2.9 Satellite component of UMTS

General discussions with current and potential partners are being conducted under non-disclosure agreements. Any future involvement with S-UMTS will depend on the strategic and commercial choices and alliances made within the framework of projects currently under investigation.

8.2.10 Licensing

The satellite system is fully operational, with licenses being obtained from each national regulatory authority as required.

EUTELSAT are participants in the GMPCS MoU, and want to see its principles applied to fixed satellite service as well as mobile, as blanket licensing is difficult to obtain for fixed satellite service.

8.2.11 Standardization

EUTELSAT considers the following to be relevant issues for standardization:

- RF spectrum emissions;
- application interface (see DVB-MHP);
- radio interface;
- IF interfaces and/or antenna interfaces.

EUTELSAT participates in standardization work, mainly within the DVB project.

8.3 ICO

ICO will be a global Access and Transport provider, via its integrated satellite and terrestrial core network.

The end-to-end cost of establishing the ICO business will be $US 4,6 billion, of which $US 3,5 billion will cover the system infrastructure costs.

ICO currently has 57 international strategic investment partners, most of whom are operators of mobile telecommunications networks.

ICO's European investors include DeTeMobil, BT, OTE, Swiss Telecom, Telecom Finland, PTT Netherlands, Telecom Poland, CPRM (Portugal), Navigation Maritime Bulgare, Cyprus Telecom, Telefonica de Espana and Turk Telecom.

ICO will begin offering service in the year 2000.

Additionally, ICO is currently engaged in a project with the European Commission named TEN-ICO-SAT. This is an ECU 1,4 million project to investigate the provision of satellite mobile multimedia via the ICO satellite network. The study includes:

- a market assessment, to both identify suitable products for the European markets and estimate likely demand for them in the timeframe 2002 to 2007;
- a technical assessment, to quantify the developments required to provide multimedia services. The assessment will also estimate the costs involved in developing the infrastructure and user terminals to support the new services;
- a regulatory assessment, to identify any regulatory constraints which may impede the introduction or development of new multimedia satellite services;
- the modelling of the variables of costs, revenues and returns, in order to understand the likely impact of different products;
- a set of business cases to illustrate the findings of the study.

The geographical scope of the study extends to all 43 CEPT countries, and thus encompasses the needs and opportunities of both developed and emerging markets.

8.3.1 Target market

Being assessed (see above).

8.3.2 Satellite constellation

12 satellites in Medium-Earth orbit (MEO).

8.3.3 Frequency bands

No information provided (but 1 980 to 2 010 MHz).

8.3.4 Terminals

No information provided.

8.3.5 Mobility

UMTS is a mobile service.

8.3.6 Gateway and network interfaces

Standardization recommended (see below).

8.3.7 Co-existence with other systems

Through standardization (see below).

8.3.8 Applications

Being assessed (see above).

8.3.9 Satellite component of UMTS

ICO will be providing voice and data services compatible with the satellite component of UMTS/IMT-2000.

8.3.10 Licensing

Being assessed (see above).

8.3.11 Standardization

The standardization of the satellite component of UMTS reflects many parallels with that of Satellite Personal Communications Networks (S-PCN); it has been recognized that system standards for global satellite systems are not appropriate and provide little or no added benefit. Areas which would benefit from standardization, however, would be:

- type approval of user terminals (for adoption as harmonized standards);
- standards for EMC certification;
- certain elements related to the interconnection and interworking of the core network of satellite UMTS with the core network(s) of the fixed and terrestrial mobile UMTS systems. It is envizaged that these would be undertaken in co-operation with the development of standards for the terrestrial networks.

8.4 Motorola

Motorola Incorporated is developing four related wideband satellite systems:

- Celestri Multimedia LEO, a global network on non-geostationary satellites operating in the Ka band: estimated cost: $US 2,3B;
- Celestri GEO, a global network on geostationary satellites operating in the Ka band: estimated cost: $US 6,15B;
- Millennium, a regional system for the Americas on geostationary satellites: estimated cost: $US 12,9B;
- M-Star, a global network on non-geostationary satellites operating in the 40 GHz band: estimated cost: $US 1,55B.

In all cases the cost associated with the development, test, launch and control of the satellite portion of the system is included on a stand alone basis. End-user subscriber terminal equipment is not included in the total projected system costs.

The combined architecture represented by the systems Motorola has under development cover the following areas:

- point-to-point real time symmetric connection services ranging from 64 kbps to 155 Mbps;
- point-to-point, bursty, asymmetric services, in which each direction of communication uses varying amounts of bandwidth as needed, ranging up to 16 Kbps;
- broadcast and multicast services using variable service areas and communication rates;
- interactive and integrated broadcast and real-time response services.

These services are combined and integrated with applications to serve the following market segments:

- residential consumers purchasing multimedia applications (data, video and voice), for work at home, personal productivity, entertainment, education, health care and security purposes;
- small businesses purchasing in the multimedia marketplace;
- large multinational corporations seeking strategic multimedia applications that improve their business processes and customer responsiveness to all corners of the world;
- telecommunications carriers and service providers world wide seeking to extend their reach, control and service quality to areas not presently covered well by their currents service offerings.

At the present time Motorola has an MoU with Matra Marconi Space of Toulouse France for development and supply of satellite bus elements for the Celestri program. Other European development organizations are being actively pursued to support the four programs. Launch services are being pursued from within Europe and Asia as well as in the United States. As with the Iridium program Motorola will probably use multiple launch vehicle types in order to minimize launch risks associated with launch failures with any type of launcher.

8.4.1 Celestri GEO

The Celestri GEO system is a broadband network capable of providing direct access for residential and business users anywhere in the world.

The system will provide virtual real-time, high speed, broadband digital communications in the FSS. It will support residential and business communications that include: telecommuting, education, medical information access, home shopping, information services, access to on-line services and the Internet, person-to-person interactive communications, multimedia video, financial transaction processing, data base transfers, communications between LANs, training and education services, healthcare data transfer and information sharing.

The Celestri Architecture supports dynamic allocation of satellite resources (bandwidth on demand). This feature allows users to pay only for the bandwidth they need, and assures efficient use of the spectrum. From an end-user perspective, requests for bandwidth will be transparent.

The network architecture for the Celestri GEO system is based on an ATM-like packet routing protocol. Users gain access to the network through bi-directional links between user terminals and satellites with packet routing accomplished through a baseband switch in each satellite.

The application for authority to construct, launch and operate was filed with the FCC in July 1997, with intention to commence operation by the year 2002.

8.4.1.1 Target market

The Celestri GEO system will operate as a non-common carrier, providing space segment capacity on a wholesale basis to a small number of service providers. It will not provide services directly to the public.

Residential:

> It is anticipated that by the year 2002 there will be more than 200 million people connected to the Internet, with 150 million subscriptions to on-line services.

Business:

> In addition to services for residential based SOHO and telecommuting, the business market will be targeted with specific services.

8.4.1.2 Satellite constellation

The Celestri GEO system is comprized of five geostationary orbit satellites. These will operate in conjunction with other geostationary and non-geostationary satellites to bring the full array of broadband services to consumers and businesses world wide.

The orbital slots requested are at:

139° W.L: to cover Western United States, Western Canada and Central America.

7.5° W.L: to cover Brazil, Europe, Middle East and Africa.

42° E.L: to cover Europe, Africa, Middle East, Central Russia, India and Western China.

97° E.L: to cover Central Russia, India, China, Japan, Australia and the Pacific Rim.

160° E.L: to cover Eastern China, Australia, Pacific Rim and Japan.

Motorola proposes to use 750 MHz of spectrum in each direction in the Ka band for service links and 2 000 MHz in the 60 GHz band for intersatellite links.

Each satellite has 32 antenna beams, 25 of which use dual orthogonal circular polarization to provide re-use patterns that effectively double the bandwidth. There will be 57 transponders per satellite, each capable of a peak data rate on uplink or downlink of 92 Mbps. By this arrangement, system capacity is multiplied by 9,5 over the coverage area for each satellite.

Network connectivity is provided by two full duplex inter-satellite links per satellite using dual orthogonal circular polarization, providing a data rate up to 1 244 Gbps.

Each satellite supports a throughput rate of over 7,5 Gbps, including service links and inter-satellite links, the equivalent of 260,000 bi-directional 16 kbps channels.

The effective total system bandwidth is 35 625 MHz, providing over 1,25 million equivalent 16 kbps channels.

The projected satellite operational lifetime is 10 years.

8.4.1.3 Frequency bands

The Ka band frequencies are used:

- Downlink: 18,8 to 19,3 GHz.

- Uplink: 28,6 to 29,1 GHz.

8.4.1.4 Terminals

Subscriber terminals will operate at burst information rates of 64 kbps, 384 kbps, 768 kbps, 1,544 Mbps (T1), 3,152 Mbps and 51,84 Mbps.

The transmit power level will be 2W for data rates up to 3,152 Mbps with antennas ranging from 0,7 to 3 metres diameter. The smaller antennas will be used in drier regions of the world whilst the larger antennas will be used where there are severe thunderstorms. The 51,84 Mbps links require power levels up to 60 W and antennas up to 3 metres for extended availability. Uplink power control will be used to minimize potential interference.

Uplinks employ FMD/TDMA.

Downlinks employ TDM at a burst information rate of 92,16 Mbps.

QPSK modulation is used with forward error correction and a BER objective of 10 e-10.

8.4.1.5 Mobility

The system is primarily intended for servicing fixed earth terminals.

8.4.1.6 Gateways and network interfaces

The Celestri Architecture is designed to allow seamless connection using a variety of networking standards, including ATM, Frame Relay and TCP/IP.

8.4.1.7 Co-existence with other systems

Interference issues between systems are being addressed within the US by the FCC as part of the licensing process. Internationally, the ITU-R Joint Task Group 4-9-11 is addressing the suitability of the provisional hard limits adopted at the WRC-97 as well as other mechanisms for sharing between GSO/NGSO and NGSO/NGSO systems. Motorola is actively participating in these groups.

8.4.1.8 Applications

The architecture is being developed to be compatible with as many as possible known applications and to minimize constraints that might be placed upon future applications.

Generally, applications will interface to the system through established standards. The architecture, however, supports the generation of protocol conversions allowing non-standard interfaces.

8.4.1.9 Satellite component of UMTS

No information supplied.

8.4.1.10 Licensing

Application for authority to construct, launch and operate the Celestri GEO System was filed with the FCC in July 1997.

Motorola is presently participating in an industry Advisory Group in the US addressing blanket licensing of GSO terminals operating in the Ka band.

8.4.1.11 Standardization

Celestri is interested in standardization of spectrum emissions and possibly the radio interface, which is planned to be open; there may be IPR associated with the radio interface.

Motorola is presently participating in relevant standardization work within ETSI.

8.4.2 Celestri Multimedia LEO

The Celestri LEO system is one cornerstone of the complete Motorola Celestri Architecture, providing global point-to-point real-time end-user communications with low delay, essentially equivalent to terrestrial communication systems.

8.4.2.1 Target market

The Celestri LEO System will offer two categories of service:

- First through Service Providers, to non-business and consumer end-users for accessing and retrieving content in real time. This class of service will provide bandwidth-on-demand access at data rates from 64 kbps up to 10 Mbps.
- Second, interconnection services primarily using the 51,84 Mbps (OC-1) and 155,52 Mbps (OC-3) data rates, enabling multinational corporations and terrestrial carriers to aggregate voice and data signals.

8.4.2.2 Satellite constellation

The Celestri Multimedia LEO System comprizes 63 active satellites, plus up to 7 in-orbit spares. They are dispersed in 7 circular orbital planes at an altitude of 1 400 km inclined at 48° with respect to the Equator, each with 9 active satellites.

Each satellite will have 432 uplink beams and 260 downlink beams. The communications links employ a right-hand circular polarization and utilize a 7-cell cluster size to achieve the required frequency reuse. The minimum earth station elevation angle is 40°.

The satellites have on-board switching and 6 optical inter-satellite links (ISL).

The projected satellite operational lifetime is 8 years.

8.4.2.3 Frequency bands

The Ka band frequencies are used:

- Downlink: 18,8 to 19,3 GHz; 19,7 to 20,2 GHz.
- Uplink: 28,6 to 29,1 GHz; 29,5 to 30,0 GHz.

8.4.2.4 Terminals

The Celestri Architecture will provide a standard interface definition that will allow manufacturers to develop a broad range of compatible Customer Premizes Equipment products.

Lower data rate CPE terminals support bandwidth-on-demand through use of a Time Division Multiplex (TDM) Demand Assigned Multiple Access (DAMA) protocol and fractional allocations of the peak information rates.

A variety of customer selected options are anticipated e.g. protocol adapters, configurations to support asymmetric data rates, configurations to expand data rates by using multiple channel frequencies.

Three types of user terminals are proposed:

- Corporate Terminal: provides access for enterprise networking and provisional private lines at an OC-1 rate. As an option, where exceptionally high availability is required, large antennas and site diversity can be used with this option.
- Small business Terminal: is a VSAT class terminal, with a nominal 0,75 metre mechanically steered antenna.
- Direct-to-Home Terminal: is a VSAT class terminal designed to provide multimedia and telecommuting services. It uses a small electronically scanned array antenna, with a larger mechanically steered antenna as an option.

Terminals will be equipped to provide activation by smart card Subscriber Identity Modules (SIMs); this will allow public access to the network as well as limited subscriber mobility.

Doppler correction is required for efficient spectrum usage, and is managed by co-operative processing between the satellite and the terminal.

The terminal also actively and co-operatively participates in beam-to-beam and satellite-to-satellite handover processes.

8.4.2.5 Mobility

Celestri operates in the fixed satellite service; however use of SIM card technology provides user mobility functionality.

8.4.2.6 Gateways and network interfaces

The architecture is designed around virtual networks. Multiple independent networks may coexist within the architecture. Networks may be managed by, e.g. PTTs, corporations, service providers or application providers.

Gateways will be interconnected through the satellite architecture and through existing terrestrial telecommunications infrastructures.

Gateway terminals will provide all required multiple access functions internally and will connect to the constellation using a straightforward TDM DAMA format.

The Gateway Terminal provides an interface to the PSTN at OC-1 (51,84 Mbps) and OC-3 (155,52 Mbps) rates.

By appropriately placing distributed antenna facilities, a gateway terminal can have an availability of 99,99% or greater.

8.4.2.7 Co-existence with other systems

Interference issues between systems are being addressed within the US by the FCC as part of the licensing process. Internationally, the ITU-R Joint Task Group 4-9-11 is addressing the suitability of the provisional hard limits adopted bat the WRC-97 as well as other mechanisms for sharing between GSO/NGSO and NGSO/NGSO systems. Motorola is actively participating in these groups.

8.4.2.8 Applications

The Celestri architecture is designed to interface seamlessly to existing networks and equipment protocol interworking functions include ATM, TCP/IP and Frame Relay.

Applications such as email, compressed video, home shopping and electronic banking will be supported.

8.4.2.9 Satellite component of UMTS

No information supplied.

8.4.2.10 Licensing

The application for authority to construct, launch and operate was filed with the FCC in June 1997; the system has been advance published with the ITU by the United States.

8.4.2.11 Standardization

Celestri is interested in standardization of spectrum emissions and possibly the radio interface, which is planned to be open; there may be IPR associated with the radio interface.

Motorola is presently participating in relevant standardization work within ETSI.

8.4.3 Millennium

Millennium is a regional geostationary orbit satellite system operating in the fixed satellite service. The system will provide direct access for subscribers to advanced, broadband communications services, almost real-time, in much of the Western hemisphere. The system also complements existing and anticipated ground infrastructures by providing high data rate transport services for businesses.

The Millennium architecture supports dynamic allocation of satellite resources (bandwidth on demand). This feature allows users to pay only for the bandwidth they need, and assures efficient use of the spectrum. From an end-user perspective, requests for bandwidth will be transparent.

The network architecture for Millennium is based on an ATM-like packet routing protocol. Subscribers gain access to the network through bi-directional links between subscriber terminals and satellites with packet routing accomplished through a baseband switch in each satellite.

8.4.3.1 Target market

The Millennium system will provide broadband services to the United States, including Puerto Rico and the US Virgin Islands, Canada, Mexico and most of Central and South America. The intention is to provide "any person, any time, any where" communications in the fixed satellite service.

The Millennium system will operate as a non-common carrier, as the space segment capacity will be marketed wholesale to an established base of retail providers rather than directly to the public.

8.4.3.2 Satellite constellation

The Millennium GEO system is comprized of four geostationary orbit satellites. The orbital slots assigned by the FCC in May, 1997 are at 91° W.L; 87° W.L; 77° W.L; 75° W.L. to cover the Americas from Canada to Chile.

The 750 MHz of service link spectrum is divided into six frequency sub-bands. Each satellite has 32 downlink beams, each using two of six frequency sub-bands of the 750 MHz service band spectrum. 25 of the beams use dual orthogonal circular polarization to provide re-use patterns that effectively double the bandwidth. By this arrangement, system capacity is multiplied by 9,5 over the coverage area for each satellite, with each supporting a peak throughput rate of over 7,5 Gbps.

The placement of the four satellites into distinct orbital slots permits the same bandwidth to be used for each satellite, resulting in a system re-use factor of 38 and an effective total system bandwidth of 28 500 MHz.

Network connectivity is provided by two full duplex intersatellite links per satellite using dual orthogonal circular polarization, providing a data rate up to 1 244 Gbps.

The projected satellite operational lifetime is 10 years.

8.4.3.3 Frequency bands

Service links use non-contiguous bands of 500 MHz and 250 MHz of spectrum in each direction in the Ka band:

- Downlink: 1 8,55 to 18,80 GHz and 19,70 to 20,20 GHz.
- Uplink: 28,35 to 28,60 GHz and 29,5 to 30,00 GHz.

Intersatellite links use 2 000 MHz of spectrum in the 60 GHz band:

- Intersatellite link: 59,50 to 60,50 GHz and 62,50 to 63,50 GHz.

Telemetry, Tracking and Control (TT&C) uses 6 MHz of spectrum in each direction in the 4/6 GHz band during launch, deployment and transfer orbit operations.

8.4.3.4 Terminals

In order to support the anticipated variety of applications, the subscriber equipment will incorporate protocol adapters to encapsulate data into packets suitable for routing through the system so that point-to-point data transfers can take place seamlessly and regardless of the application and the interface to the subscriber's equipment.

The bandwidth-on-demand feature enables subscribers to pay only for the system resources they need. From an end-user perspective, requests for bandwidth are transparent i.e. instantaneous bandwidth usage is governed by communications between the subscriber's terminal and the satellite. In the case of larger terminals providing services to multiple end-users, blocks of bandwidth reserved to support their anticipated peak demand can be adjusted as variations in the instantaneous demand develop.

The Millennium system will support FDM/TDMA multiplexed information rates on individual ground-to-satellite links of 64 kbps, 384 kbps, 768 kbps, 1,544 Mbps (T1), 3,152 Mbps (DS1C) and 51,84 Mbps (OC-1).

The transmit power level will be 2W for data rates up to 3,152 Mbps with ground antennas ranging from 0,7 to 3 metres diameter. The 51,84 Mbps links require power levels up to 60W and ground antennas up to 3 metres for extended availability. Uplink power control will be used to minimize potential interference.

The TDM satellite-to-ground links operate at 92,16 Mbps.

QPSK modulation is used with forward error correction and a BER objective of 10^{-10}.

Low-end terminals will be a desk-top package consisting of a video port and a PC port.

High-end terminals may include a variety of optional protocol adapters to support a variety of user demands, and may combine several channels to support higher data rates.

The minimum earth station elevation angle is 20°.

8.4.3.5 Mobility

Millennium operates in the fixed satellite service.

8.4.3.6 Gateway and network interfaces

The Millennium architecture is designed to allow seamless connection using a variety of networking standards, including ATM, Frame Relay and TCP/IP.

8.4.3.7 Co-existence with other systems

Interference issues between systems are being addressed within the US by the FCC as part of the licensing process. Internationally, the ITU-R Joint Task Group 4-9-11 is addressing the suitability of the provisional hard limits adopted bat the WRC-97 as well as other mechanisms for sharing between GSO/NGSO and NGSO/NGSO systems. Motorola is actively participating in these groups.

8.4.3.8 Applications

Residential services will include: work-at-home interconnection between home and office computers; educational services linking students and teachers around the hemisphere; medical information access bringing together patients and doctors; home shopping and service information products; customized news, sports, financial and other information products; on-line and Internet access; point-to-point or multipoint communications with other users including collaborative opportunities; pay-per-view video; games; magazines; newspapers and other special events.

Business services will include: financial transaction processing; collaborative communications; LAN-to-LAN communications; training and education, and health care services.

8.4.3.9 Satellite component of UMTS

Not relevant.

8.4.3.10 Licensing

An application for authority to construct, launch and operate Millennium was filed with the FCC in September 1995; an order and authorization for four geostationary satellite slots was issued by the FCC in May, 1997.

Motorola is presently participating in an industry Advisory Group in the US addressing blanket licensing of GSO terminals operating in the Ka band.

8.4.3.11 Standardization

Millennium is interested in standardization of spectrum emissions and possibly the radio interface, which is planned to be open; there may be IPR associated with the radio interface.

Motorola is presently participating in relevant standardization work within ETSI.

8.4.4 M-Star

The M-Star system comprizes a constellation of interconnected low earth orbit satellites providing global point-to-point real-time end-user communications. This permits the use of relatively small, low-power and low-cost ground terminals and ensures that delays experienced by end-users are essentially equivalent to conventional terrestrial services. For interference avoidance the system employs space diversity, allowing multiple NGSO systems to operate co-coverage and co-frequency in the FSS bands.

It will facilitate the growth of existing and anticipated wireless communications infrastructures by providing a readily available means for the interconnection of cell sites, Mobile Telephone Switching Offices (MTSO) and system control facilities. It will also provide high capacity global transport services for enterprise networking and other private data services.

8.4.4.1 Target market

The M-Star System will offer two categories of service:

- First category: will include voice and data transport to service providers and business customers. This class of service will provide 2,048 Mbps to and from multiple remote sites which can be backhauled to a hub at 51,84 Mbps. It can provide a two-way backhaul service or one-way point-to-multipoint or multipoint-to-point service.

- Second category: will include interconnection services at up to 51,84 Mbps to enable terrestrial carriers to aggregate voice or data signals.

8.4.4.2 Satellite constellation

The M-Star LEO System comprizes 72 active satellites, plus orbiting spares. They are dispersed in 12 circular orbital planes at an altitude of 1 350 km inclined at 47° with respect to the Equator, each with 6 active satellites.

Each satellite contains multiple bent-pipe transponders, spot beam antennas pointed towards the earth and inter-satellite link antennas pointed to each of four adjacent satellites.

Each satellite will have 32 beams for user service links.

The communications links employ either Right-Hand or Left-Hand Circular Polarization (RHCP/LHCP).

The projected satellite operational lifetime is 8 years.

8.4.4.3 Frequency bands

The system design requires 3 GHz of spectrum in both the uplink and the downlink.

- Downlink: 37,50 to 40,50 GHz; LHCP.

- Uplink: 47,20 to 50,20 GHz; RHCP.

The intersatellite crosslinks are in paired bands, either RHCP or LHCP:

- Inter-satellite links: 59,00 to 61,35 GHz and 61,65 to 64,00 GHz.

The precize assignment of polarization and transmit/receive pairings is dependent on the specific location of the satellites in the constellation.

8.4.4.4 Terminals

Two types of customer ground systems are proposed, each with their associated Customer Premizes Equipment:

- The first is a wireless backhaul interface system for a Wireless Access Group (WAG). A WAG ground system includes two types of CPE:
- The first type of CPE is a high capacity MTSO interface unit which controls the group and processes the data from remote sites at information rates up to 51,84 Mbps.
- The second type of CPE in a WAG is a set of low-cost remote cell site interface units which operates in MTSO-directed mode, allowing information rates up to 2,048 Mbps. The WAG CPE architecture allows the MTSO interface unit to communicate with remote cell sites via a FDMA/TDMA format. A WAG is nominally sized to support 25 cell sites, each communicating with the MTSO at a data rate of 2,048 Mbps (E-1), however the wireless system operator has the facility to redistribute the capacity by modifying the frame.
- The second type of customer ground system uses variations of one fundamental type of CPE a High Bit Rate Terminal (HBRT) that supports information rates up to 51,84 Mbps (OC-1). The fundamental HBRT provides a standard OC-1 interface with SONET/SDH framing and formatting that allows manufacturers and customers a broad range of options in developing CPE installations. In addition it is expected that other CPE configurations will be developed with other standard telecommunications interfaces.

All CPE terminals use directional antennas with at least two independent beams to support make-before-break handoffs. Antenna sizes range from 0,66 metres for individual cell sites to 1,5 metres for the MTSO interface and OC-1 links.

8.4.4.5 Mobility

M-Star operates in the fixed satellite service.

8.4.4.6 Gateways and network interfaces

Terminals will support a wide variety of interfaces, such as: E-1, T-1 OC-1, T-3, Ethernet, FDD1, and network interconnection standards such as ATM, ISDN, X.25, Frame Relay, TCP/IP etc.

8.4.4.7 Co-existence with other systems

The system employs space diversity to avoid interference and allow multiple NGSO systems to operate co-coverage and co-frequency in the FSS bands.

8.4.4.8 Applications

The M-Star system will provide a global communications infrastructure for the interconnection of real-time voice and data services.

First category of service will include voice and data transport to service providers and business customers.

Second category of service will include: two-way backhaul service; one-way point-to-multipoint; one-way multipoint-to-point, to enable terrestrial carriers to aggregate voice or data signals.

8.4.4.9 Satellite component of UMTS

Not relevant.

8.4.4.10 Licensing

The application for authority to construct, launch and operate was filed with the FCC in September 1996; the system has been advance published with the ITU by the United States.

8.4.4.11 Standardization

It is not clear at this time what standardization activity will apply to this system.

8.5 SES-ASTRA

Société Européenne des Satellites (SES-ASTRA) is a Transport Provider, and have two projects to provide broadband satellite multimedia services: ASTRA-NET and ASTRA Return Channel System (ARCS). ASTRA-NET is already operational and ARCS is at the specification stage of development.

The ASTRA-NET system uses the existing ASTRA Satellite System to transmit a wide range of services to PCs in businesses and homes at substantially increased speed compared to standard telephone lines. These services can be received with a small 50 to 60cm, fixed, single feed dish, at up to 38 Mbps directly to a high-end server or at up to 6 Mbps directly into a high performance PC. For the time being the return channel for ASTRA-Net is provided via terrestrial facilities.

ARCS will offer the combination of Ku-band reception, at speeds up to 38 Mbps, with a Ka-band return channel, at speeds up to 150 kbps (on antennae as small as 60 cm). Higher user data rates of up to 2 Mbps and beyond can be achieved through larger 120 cm dishes. Service is expected to begin in 1999. The ARCS return channel is via satellite at the orbital position of 19,2° East, using Ka-band payloads on ASTRA 1H (to be launched before year-end 1998) and on ASTRA 1K (scheduled for launch in the year 2000).

8.5.1 Target market

No information supplied.

8.5.2 Satellite constellation

The ASTRA Satellite System consists of eight satellites at two orbital locations on the geostationary arc, at an altitude of 36 000 kilometres. By co-locating their satellites, SES makes optimal use of the available orbital slots, a scarce natural resource: co-location ensures that all the channels broadcast via ASTRA can be received on one single-feed, fixed parabolic dish.

ASTRA currently provides 120 transponders which transmit more than 90 analogue and more than 220 digital TV channels as well as more than 180 analogue and digital radio channels to viewers and listeners all over Europe.

The ASTRA Satellite System features internal back-up capacity. Each ASTRA satellite, in addition to its active transponders, carries back-up capacity for other ASTRA satellites which can be activated on demand.

ASTRA 1G, the seventh spacecraft of SES, was co-located at the orbital position of 19,2° East on December 3rd 1997. Before the end of 1998, SES will add three new spacecraft to its fleet. ASTRA 1H will join the existing ASTRA fleet at 19,2° East.

ASTRA 2A, scheduled for launch in the first quarter of 1998, will open a second orbital position for SES at 28,2° East.

ASTRA 2B will be co-located at 28,2° East before the end of 1998.

ASTRA 1K, the eleventh satellite in the ASTRA series, will be deployed at the orbital position of 19,2° East by the end of the year 2000.

ASTRA 1H will include a Ka-band payload opening a high-speed return path directly via satellite, thus providing the ASTRA system with the full interactivity needed for the transmission of multiple media content.

All ASTRA satellites are "bent pipe", and without inter-satellite links.

8.5.3 Frequency bands

The ASTRA Satellite System "Low Band" transmits between 10,70 GHz and 11,70 GHz.

The ASTRA Satellite System "High Band" transmits between 11,70 and 12,75 GHz.

ARCS will use the 29,5 to 30,0 GHz frequency band.

8.5.4 Terminals

The ASTRA single-user terminals are outdoor type earth stations with dishes between 50 cm and 120 cm diameter, connected to a "Universal LNB" which selects either the ASTRA "Low Band" or the ASTRA "High Band" and the appropriate horizontal or vertical polarization.

A Universal Twin LNB is also available which has two outputs that can be controlled independently of each other by two digital receivers, one digital receiver and one analogue receiver or two analogue receivers.

The ASTRA communal (SMATV) antenna system is available for service to blocks of houses or apartment blocks with up to 100 households and more. The signals are received at a central point (head-end) and distributed via coaxial cables. With this system dishes are between 60 cm and 180 cm diameter. The SMATV Universal LNB has four outputs which simultaneously provide both polarizations and frequency bands: Vertical Low Band, Vertical High Band, Horizontal Low Band and Horizontal High Band. The outputs of the LNB are connected to a multi-switch for distribution to multiple receivers.

For ARCS, three terminal types are proposed, with Ka band uplink data rates of 150 kbps (60 cm dish), 384 kbps and 2 048 kbps (120 cm dish), and will be to an open radio interface standard.

The Ku band downlink channel will be DVB compliant and will offer data rates up to 38 Mbps.

The terminals will support IP over ATM.

The modulation scheme on the radio interface is QPSK on Multi frequency TDMA.

The terminal installation will be performed by professionals,

8.5.5 Mobility

ASTRA operates in the fixed satellite service; there are no plans to support non-fixed terminals.

8.5.6 Gateway and network interfaces

A single gateway is required to serve the target market share of up to some hundreds of thousands of users.

Interconnection with other networks will be via SDH and direct to satellite.

8.5.7 Co-existence with other systems

ASTRA SES expects that compatibility problems with other systems using the same spectrum will arize and will need to be resolved through a frequency co-ordination process.

8.5.8 Applications

ARCS will be optimized for efficient, high-speed, bandwidth-on-demand, asymmetric 2-way communications, i.e. for broadcasting and multicasting with return channel capabilities, with storage and hosting of multimedia content.

8.5.9 Satellite component of UMTS

No information supplied.

8.5.10 Licensing

SES-ASTRA regard licensing as a critical issue. A serious problem is the complicated patchwork of different and sometimes quite restrictive licensing regimes in Europe.

8.5.11 Standardization

SES-ASTRA considers the following to be relevant issues for standardization:

- EMC;
- RF spectrum emissions;
- Control and Monitoring;
- Safety;
- Radio interface: access scheme and signalling;
- IF interfaces and/or antenna interfaces **(**indoor unit to outdoor unit**)**.

SES-ASTRA thinks an ETSI standard for type approval would be helpful.

8.6 SkyBridge

SkyBridge Limited Partnership (LP) is developing the SkyBridge system of LEO satellites to provide global (± 68° latitude) cost-effective access to high speed multimedia services, with initial operation planned for the end of year 2001 and the full operational service to be made available over the course of the year 2002.

The SkyBridge system uses LEO satellites while sharing and reusing the same frequency bands as that of geostationary and fixed terrestrial systems (Ku band).

SkyBridge is an access network that provides, in the terminology of the terrestrial environment, the "last mile" connectivity. SkyBridge will not compete with terrestrial systems, but rather complement them in terms of coverage.

The SkyBridge system provides service to:

- Residential users; antenna diameter 50 cm: uplink up to 2,5 Mbps; downlink up to 20 Mbps;
- Professional users; antenna diameter up to 1 meter: uplink up to m x 2,5 Mbps; downlink up to n x 20 Mbps.

The global system capacity is > 200 Gbps.

SkyBridge LP is a US company based in Delaware. The general partner of SkyBridge (SkyBridge GP) is Alcatel. The current partners are: LORAL Aerospatiale, Mitsubishi, Toshiba, SPAR, Sharp, CNES and SRIW.

The SkyBridge cost is $US 4,2B. This includes the space segment with an in-orbit delivery, the ground control segment and the complete engineering and development of the telecommunications infrastructure (e.g. gateway earth station, subscriber earth station, network management etc.).

8.6.1 Target market

The target market is up to 24 million business and residential subscribers from a projected market of 400 million users world-wide over the next decade.

8.6.2 Satellite constellation

The SkyBridge system comprizes 80 active satellites plus 4 on-ground spares. They are dispersed in 20 circular orbital planes at an altitude of 1 469 km inclined at 53° with respect to the Equator, each with 4 active satellites.

Each satellite has a maximum of 24 downlink beams.

For each satellite, the maximum uplink capacity is 2 Gbps and the maximum downlink capacity is 6 Gbps.

The satellites are "bent-pipe" and do not have on-board switching or Inter-Satellite Links (ISL).

The projected satellite operational lifetime is 8 years.

8.6.3 Frequency bands

The full Ku band granted to NGSO FSS will be used, according to the needs.

8.6.4 Terminals

The SkyBridge terminals are "roof-top" style earth stations consistent with use in the fixed satellite service. An open platform oriented towards a multi-vendor scenario is the reference taken.

There are three residential types, with 2W PA: individual; collective for buildings; collective for housing estates.

Antenna gain requirements are:

$(36 - 25\log\theta)$ dB for $\theta < 48°$; - 6 dB for $\theta > 48°$.

For a residential type, the maximum uplink capacity is 2,5 Mbps and the maximum downlink capacity is 20 Mbps.

The target price of the individual residential terminal is about $ 700. Local operators will decide to subsidize or not according to their market strategy and the services they want to provide.

There are two professional types, with 6W PA: individual; collective. Antenna gain requirements are:

$(32 - 25\log\theta)$ dB for $\theta < 48°$; - 10 dB for $\theta > 48°$.

For a professional type, the maximum uplink capacity is m x 2,5 Mbps and the maximum downlink capacity is n x 20 Mbps.

The outdoor unit contains the antenna and RF parts. The antenna subsystem tracks on satellite ephemerides.

The SkyBridge reference installation will be performed by professionals, though it remains possible in some cases that the users install the terminal themselves. In this case, the terminal will still need to be positioned correctly, although inherent in the terminal design, there are ways for the terminals to adjust to the installation inaccuracies. The impact will be in terms of a longer time required by the terminal to get the correct references for pointing.

According to designs the modem can be outdoor or indoor. The indoor unit contains the rest and delivers interfaces to the end-user such as: S0 or G.704 TDM mux, USB, Ethernet 10BT or 10B2, Frame-Relay, PPP multilink or even ATM if the market requires it.

The modulation scheme on the radio interface is CDMA with 80 codes per carrier in the downlink and 40 codes per carrier in the uplink.

8.6.5 Mobility

SkyBridge operates in the fixed satellite service; there are no plans to support non-fixed terminals.

8.6.6 Gateways and network interfaces

202 gateways are required to serve the target market share of up to 24 million users. They will be interconnected by terrestrial WANs, where available, and by satellite links. Interconnection with other networks will be via ATM switches.

SkyBridge will interface seamlessly with existing terrestrial networks. Furthermore, SkyBridge is a LEO system, the delay of which will be compatible with all known multimedia applications, including those based on service protocols such as TCP/IP.

Gateways are made up of classical ISDN local exchanges, routers and RANs with IP QoS control and of ATM switches for dispatching the traffic between the access network and the terrestrial WAN. This provides the means for integrated services and network management.

The system supports ISDN, IP over PPP, Frame-Relay and ATM (PVC trunking and MPOA or MPLS). Asynchronous Transfer Mode (ATM) is used on the radio interface and may not be visible externally. Quality of Service (QoS) is guaranteed by classical ATM processes.

For each gateway, the maximum uplink capacity is 870 Mbps and the maximum downlink capacity is 2,4 Gbps.

The gateways will be operated by a local telecom operators and service providers.

8.6.7 Co-existence with other systems

SkyBridge is a system that re-uses the radio spectrum. One of its innovative features is to reuse the same spectrum as the geostationary satellites and fixed services. This innovation has been discussed in the CEPT and ITU forums, and it has been recognized that geostationary satellites can be protected from other NGSO systems given certain interference limitations, which have been defined by the WRC as hard limits. These limits have in principle been established by considering what the potentially interfered systems (e.g. GSO, FS,..) could handle. This concept being new, Administrations have accepted to endorse the principle of limits, to be included in the radio regulations (article S22.2), and to accept provisional values for the limits. These values will be reviewed at the next Conference after a study period.

At the WRC 97, the ITU defined the conditions under which NGSO FSS systems such as SkyBridge can operate in the Ku band. WRC 2000 will finalize the values of the equivalent or aggregated power flux density (epfd or apfd) limits that NGSO FSS systems will need to respect. SkyBridge foresees no difficulty whatsoever in this respect.

8.6.8 Applications

The SkyBridge system is designed to be transparent to most broadband applications. It is specially designed to be compatible with terrestrial applications supported by transmission systems such as ADSL and fiber-optic networks. It is not designed to provide broadcast applications based on MPEG-2, though technically could support such services.

The principle applications that are considered for the residential user are the following:

- high-speed Internet access;
- telemedecine;
- interactive applications (e.g. video games);
- online services;
- videophony.

For the professional users the applications are:

- INTRANET;
- remote connection to INTRANET;
- LAN to LAN connection.

For professional users working at home or away from the office:

- telecommuting;
- remote access to enterprises.

8.6.9 Satellite component of UMTS

SkyBridge is not involved with S-UMTS.

8.6.10 Licensing

Request has been made to obtain a global license to launch and operate the space segment at the FCC (USA).

SkyBridge has filed with the FCC for a license in February 97. An amendment has been submitted in July 97 with a petition for a domestic "rulemaking". Following the WRC 97, the FCC has submitted to the ITU an APS4. Recently (end of May 98) a request for co-ordination has been submitted to the ITU.

France has also submitted FSATMULTI-1B APS4, as well as requests for co-ordination.

SkyBridge is working to encourage a suitable licensing regime for the ground segment with a minimum of regulatory constraints and with maximum harmonization.

8.6.11 Standardization

Considering that there are already several systems operating in different frequency bands with different space technologies, it will be difficult to achieve an end-to-end standard such as GSM. However some parts of the system could be standardized in order to facilitate the regulatory regime of each system. For instance, SkyBridge is in favour of a volunteer standard for the terminal, gateway and satellite radio segments.

SkyBridge considers the following to be relevant issues for standardization:

- frequency sharing and re-use;
- avoiding harmful interference to users;
- open interfaces;

SkyBridge thinks an ETSI standard for type approval would be helpful.

In addition, SkyBridge supports the type approval regime currently being established in Europe with the new Type Approval Directive. The GMPCS MoU Arrangements, to which SkyBridge is a signatory, should also apply in the EU and in CEPT countries.

There are a number of areas where ETSI standardization is not considered required or applicable for SkyBridge:

- Air interface: this interface is by essence specific (and proprietary);
- IF and/or antenna interfaces: these interfaces may not be accessible in the SkyBridge system;
- User, application and computer interface: the interfaces used by SkyBridge are, or will be, standardized.

8.7 Teledesic

Teledesic LLC is establishing the Teledesic Network of Low Earth Orbit satellites to provide fibre-like (low latency, low error-rate, high availability) broadband communications to all parts of the world, with initial operation planned for the year 2003.

The projected budget for the spacecraft, launch, ground terminal development and OA & M is $US 9B. The principal shareholders are: Craig McCaw, Bill Gates, Motorola, Boeing Corporation and Prince Alwaleed bin Talal. The major technical partners are: Motorola, Boeing Corporation and Matra-Marconi.

8.7.1 Target market

- Business entities for telecommunications network access and enterprise networks (e.g. intranets).
- Telecommunications network operators for thin route back-up, trunking and remote area service.
- Residential users, as well as maritime and aviation users, mainly for network access.

8.7.2 Satellite constellation

The constellation consists of 288 active satellites, plus 36 in-orbit spares. They are dispersed in 12 circular orbital planes at an altitude of 1 375 km and at 84,7° inclination, each with 24 active satellites.

Each satellite will have 725 uplink beams, with 1:7 frequency re-use. The minimum earth station elevation angle is 40°.

The satellites have on-board switching and optical inter-satellite links (ISL), with RF ISLs reserved as a back-up solution.

Fixed earth mapping of uplink beams enables traffic to be directed to whatever satellite beam is providing geographic coverage for the corresponding transmit earth station. Downlink beams are pointed to specific points on Earth as a function of traffic requirements from the satellite currently responsible for the coverage of that area.

The projected satellite operational lifetime is 7 years.

8.7.3 Frequency bands

The Ka band frequencies are used:

- Downlink: 18,8 to 19,3 GHz.
- Uplink: 28,6 to 29,1 GHz.

These bands have been FCC licensed to Teledesic in the USA; frequency assignments are already registered in the ITU Radiocommunication Bureau MIFR (Master International Frequency Register), with complete notification information submitted to the ITU on 20 October 1995.

8.7.4 Terminals

The terminals use a combination of Multi-Frequency Time Division Multiple Access (MF-TDMA) on the uplink and Asynchronous Time Division Multiplexing (ATDM) on the downlink. The modulation schemes will be QPSK and 8-psk.

The Teledesic Network provides transport and access facilities to:

- Standard terminals: symmetrical on-demand 16 kbps to 2,048 kbps, with downlink data rates up to 64 Mbps.
- Broadband terminals: symmetrical up to 64 Mbps;

with target bit error rate < 10^{-10}.

The maximum EIRP is quoted as approximately 45 dBW with a PA operating at 10 W, in heavy rain conditions and substantially less during clear sky conditions. The rain margin is quoted as:

- Uplink: 10,5 dB (with power control);
- Downlink: 5,5 dB.

Availability for a standard terminal in New York City is 99,9 %.

Standard terminals will use a flat, phased array or small (30 cm) dishes that simply need to be mounted in a horizontal plane. There are no other user installation adjustments.

The standard user terminal equipment will be designed to be installed by non-professionals, therefore mandatory regulation and certification of installation is not required. However, it is anticipated that the equipment would be certified according to the method being defined as part of the GMPCS forum.

Terminals will, to the greatest extent possible, autonomously detect and correct faults. Teledesic will work in close collaboration with its Service Provider partners to otherwize prevent system-level interference.

Standard terminals will be as complex and cost about the same as a laptop computer. Broadband terminals will cost proportionally more.

Electronically and/or mechanically steered antennas will be used.

User terminal transmissions will be pre-compensated for Doppler.

8.7.5 Mobility

The system is primarily intended for servicing fixed earth terminals, but will be capable of supporting mobile terminals installed on ships and airplanes with the same broadband services. For systems such as UMTS it will usefully serve for base station backhaul in areas lacking cost or performance-competitive terrestrial service.

The standard terminal antennas are small enough to be mounted on vehicles (surface, ship or aircraft), if authorized on a national basis.

8.7.6 Gateways and network interfaces

There is no distinction between gateways and user terminals. Terminals can be used to provide interconnection to other networks as required.

Terminals operating as gateways will be interconnected through existing and future Service Provider networks via standard interfaces.

The Teledesic network supports any standard network interface, including IP, ATM, Frame Relay, and telephony services, and is application independent, so the most effective interface will be decided by the user.

8.7.7 Co-existence with other systems

Co-frequency operation with other FSS systems in the bands 18,8 to 19,3 GHz and 28,6 to 29,1 GHz is governed by RR S5.523A (WRC-97). Frequency co-ordination between satellite networks will be performed as required under S9.11A/Res 46 (WRC97) of the ITU Radio Regulations.

Co-frequency operation with terrestrial fixed-service systems are governed by the general ITU rules applied to sharing between FSS and FS. Given that the Teledesic system will have ubiquitous deployment of terminals, inefficient use of the spectrum will result if FS systems are ubiquitously deployed in the same bands. Therefore, although bilateral co-ordination is possible between Teledesic terminals and FS stations, the high cost of this and the limitations on growth inherent to band sharing will lead to a band segmentation solution in many countries. By reserving the bands 18,8 to 19,3 GHz and 28,6 to 29,1 GHz for NGSO FSS use, these countries will guarantee access to the full benefits that only NGSO FSS technology can deliver to all their citizens.

8.7.8 Applications

The Teledesic network can be used for any application requiring from 16 kbps to several hundred Mbps.

The Teledesic interface is application independent. For example, a PC based application would connect to the satellite network through an interface card (analogous to a modem) to communicate. The other end of the satellite network will direct the traffic through an appropriate interface to restore the communication protocol required by the corresponding PC.

Applications will not need any satellite specific features to work properly; in particular, delays will be comparable to the best terrestrial networks.

The system is not suited to broadcast applications those are more economically implemented over GSO networks.

8.7.9 Satellite component of UMTS

Insofar as UMTS is directed to 3 GHz service links, Teledesic is not involved. There is a definite commonality of interest in the provision of services requiring more than voice bandwidths.

8.7.10 Licensing

The FCC licensed Teledesic on March 14, 1997 to construct, launch and operate a (global) NGSO FSS satellite system to provide domestic (US) and international service.

The major remaining issue for Teledesic is country-by-country licensing.

8.7.11 Standardization

Teledesic will have open specifications, and is interested in standardization of:

- spectrum emissions;
- user interface;
- application interface;
- computer interface;
- IF interfaces;
- antenna interfaces.

Teledesic also notes that it may be desirable to incorporate broadband NGSO FSS provisions in other telecommunications standards.

Teledesic is currently involved in standardization activities in ITU-R, FCC and ETSI.

Teledesic thinks an ETSI standard for terminal RF characteristics would be valuable for terminal type approval purposes.

8.8 WEST

The system Wideband European Satellite Telecommunications (WEST) is at the specification/design stage of development and is an initiative by Matra Marconi Space who are equipment manufacturers.

Since 1995, Matra Marconi Space has dedicated significant resources to the design of this multimedia network. This effort is efficiently supported by both the European Space Agency and the Centre National d’Etudes Spatiales. Active cooperation with major players of Telecommunications networks has also been given major emphasis by MMS in the development plan of WEST.

8.8.1 Target market

WEST will provide several million users in the populated areas of the Earth with fixed multimedia services through very small terminals (typically 70 cm) and through enhanced terminals with a higher antenna size and improved performances.

The whole WEST system is a hybrid system of GEO and MEO satellites which will be deployed in phases: the first phase consists of a few GEO satellites which will serve the early regional markets concentrated over the highly developed regions (Europe, North America, Developed Asia). The second phase corresponds to the launch of MEO satellites which will serve new regions on the one hand and provide with new and more interactive services on the other hand.

8.8.2 Satellite constellation

The whole WEST system will provide a global access from any source to any destination.

The GEO component of WEST comprizes several satellites, each with 53 beams.

The MEO component of WEST may comprize 18 satellites, each with 256 beams, on 2 ground tracks.

WEST satellites will have regenerative payloads, with an on-board ATM switch, and optical intersatellite links between GEO and MEO satellites.

Satellite projected lifetime is 15 years.

Table 5: WEST GEO networks

Advance Publication: Reception by the BR Publication		**April 10, 1997 November 18, 1997**
Request for Co-ordination: reception by the BR		**October 10, 1997**
Name	**Orbital Position**	**AR11 number**
WEST-GEO-A	1°E	2066
WEST-GEO-B	32°E	2067
WEST-GEO-C	40°E	2068
WEST-GEO-D	52°E	2069
WEST-GEO-E	63°E	2070
WEST-GEO-F	85.5°E	2071
WEST-GEO-G	111°E	2072
WEST-GEO-H	120°E	2073
WEST-GEO-I	107°E	2074
WEST-GEO-J	71°W	2075
WEST-GEO-K	61°W	2076
WEST-GEO-L	19.5°W	2077

Constellation parameters for the WEST MEO satellites are available in the ITU filing.

8.8.3 Frequency bands

The WEST System will use the Ka frequency band.

8.8.4 Terminals

WEST terminals will provide the end-user with a multi-rate and a multi-connection environment.

The user terminals have antennas with very small apertures (0,7 m).

The on axis EIRP for the userlink is 36 dBW. Uplink Power Control is considered.

QPSK and TCM modulations are used.

Maximum useful rate for terminals: 136 Mbits/s (forward link), 6 Kbit/s to 6 Mbits/s (return link).

Required bit error rate (for each kind of link):10^{-10}.

Targeted availability for terminals will be higher than 99,5 %.

System-level interference will be managed by monitoring of user terminal transmission characteristics.

8.8.5 Mobility

WEST will serve firstly fixed users. It will also offer services to transportable terminals.

Further development may allow to provide mobile services.

8.8.6 Gateway and network interfaces

WEST is a standalone satellite system which interfaces with terrestrial networks. It is designed to be compatible with the existing global terrestrial infrastructure and with telecommunications standards. It is thus seamlessly integrated with existing networks.

The gateways are the entities which interconnect WEST to other (terrestrial) public networks.

The gateways have antennas with a 5 m aperture.

The on axis EIRP defined for the Megalink is 60,5 dBW. Uplink Power Control is considered.

QPSK and TCM modulations are used.

Maximum useful rate for terminals: 136 Mbits/s (forward and return links).

Required bit error rate (for each kind of link): 10^{-10}.

Targeted availability for gateways: > 99,95 %.

8.8.7 Co-existence with other systems

If levels of inter-system interference agreed at ETSI are definitively accepted and applied to GEO Ka-band satellites (see EN 301 358 [6] and EN 301 359 [5]), the WEST GEO component won't have any problem of coexistence with other Ka-band systems.

MEO satellites will implement a GEO arc exclusion zone technique to avoid interference with/from GEO satellites.

8.8.8 Applications

The multimedia capability offered by terrestrial and satellite infrastructures can be expected to be exploited by business, government, and the consumer public for a wide variety of applications. Among the more desired applications, as expressed by separate business and consumer focus groups, are file transfer, World Wide Web browsing and e-mail, enhanced with high-bandwidth video, sound, and graphical content.

Consumers also place importance on downloading of software and movies, personal telecommerce, and personal videophone, whilst business groups place importance on multimedia videoconferencing, remote LAN access which could be used for training, marketing and other corporate communications. It is also possible that the availability of multimedia capability could be the key to the success of socially important applications such as distance learning and telemedicine, which have eluded widespread implementation to date.

WEST will offer the possibility to transmit a wide range of applications here above, with very different constraints of data rates and delay requirements to customers with different profiles.

The system will allow direct uplinking by individual service providers and accounts for delegated management of the offered services.

8.8.9 Satellite component of UMTS

No information supplied.

8.8.10 Licensing

ITU filing of the WEST GEO component.

ITU filing of the WEST MEO component: F_SAT_ICO-WEST.

ITU-R Publications: advance publications and co-ordination requests of the WEST GEO Network have been made through the French Administration. MMS through the Agence Nationale des Fréquences has filed for 12 orbital positions in Ka-band on the geostationary arc.

ITU Filing: the ApS4 filing of F-SAT_ICO-WEST system was submitted to ITU on 16th January 1997 by French Administration.

8.8.11 Standardization

RF part standardization is relevant for broadband satellite multimedia communication. In particular, it allows to find a consensus between all the planned and existing systems, thus ensuring the same chance to exist to every system initiatives.

WEST considers the following to be relevant issues for standardization:

- spectrum emissions;
- application interface.

WEST currently participates in ETSI TC-SES on the Ka band Working Group, and thinks that an ETSI standard for type approvals would be helpful.

8.9 CyberStar™, L.P.

CyberStar™, L.P. is a broadband service provider that delivers several fast and effective data communications services, including high speed Internet access, data streaming and wide-band file transfer for both enterprize and consumer markets. The service is a satellite based communications carrier that employs Ku-band transponders and will eventually utilize Ka-band satellite broadband services as well. CyberStar™ is a limited partnership managed by Loral Space & Communications Corporation. Alcatel is a limited partner of CyberStar™ L.P.

The CyberStar™ system is an open protocol, digital telecommunications system that provides a variety of low-cost, high-speed data and telecommunications services to the U.S. using Ku-band satellite transponders on the Loral Skynet Telstar 5 spacecraft. While the service initially is satellite broadcast/multicast to the user with a terrestrial return link, soon CyberStar™ will introduce a return link over the satellite that will provide connectivity capability to anyone within the satellite service area.

8.9.1 Target market

CyberStar™ addresses the enterprize and consumer markets that depend on access to information in a reliable and timely fashion. These are markets that desire increased productivity and more competitive approach to conducting business or simply want a faster, more varied and faster information access capability. CyberStar™ works to combine the benefits of satellite technology with existing land-based networks to transport data and to provide a plaftorm for a variety o new applications and services, including point-to-multipoint broadcasting (multicasting), content streaming, electronic commerce ahd high-speed file transfer and Internet access. CyberStar™ states that research by Anderson Consulting predicts that by 2002 the total worldwide broadband market for transport services will be worth $US 65 billion. Approximately 12 % or $US 8 billion will go to satellite based communications. By 2005, the satellite share will reach $U S 16 billion.

Industry experts estimate that the cost os a satellite connection would average about $US 1,100 for the initial installation, plus $ US 50 per month. This compares with $US 2,500 installation and $US 1,000 monthly fee for a T-1 line and $US 300 installation and $US 50 monthly fee for a lower speed ISDN line.

8.9.2 Satellite constellation

The CyberStar™ Ka-band satellite constellation will consist of three flight GEO satellites at 110° West, 93° West and 105,5° East.

The CyberStar™ Ka-band satellites are FS-1300 class, three-axis stabilized spacecraft. Each satellite will have:

- 27 regional spot beams, varying in size depending upon average rain distribution and traffic density expectations;
- on-board processing and switching capability;

- Travelling Wave Tube Amplifiers (TWTA) with output power of 60 Watts, arranged in eight rings, six of 9-for-7 and two of 8-for-6 for redundancy purposes;
- 1 Gb/s east and west 60 GHz inter-satellite links;
- total capacity of 4,9 Gbps.

The transmission will be QPSK with FDM/TDMA for uplink and TDM for downlink. The uplink will have a total bandwidth of 750 MHz, with each user transmitting at a data rate of 384 kbps. Using a larger ground antenna, higher data rates of 1,544 Mbps and 3,088 Mbps can be achieved. Downlink signal transmission will use a data rate of 92 Mbps. Both uplink and downlink will employ frequency reuse using spatial separation and orthogonal polarization.

8.9.3 Frequency bands

CyberStar™ will use the following frequencies in all areas:

- Uplink: 28,35 to 28,6 GHz and 29,25 to 30,0 GHz.
- Downlink: 17,8 to 18,8 GHz and 19,7 to 20,2 GHz.

8.9.4 Terminals

CyberStar™ does not anticipate entering the business of designing, manufacturing or distributing ground terminals; they will work with manufacturers during the Ka-band satellite design and manufacturing phase to ensure that the products they develop will be compatible with the satellite system.

Adaptec, a computer networks product company manufacture Ku-band satellite-to-PC adapter cards that provides the connection between PCs and servers and small-dish antennas. News Datacom System Ltd (NDS) provides conditional access cards.

It is anticipated that adequate suppliers of standardized equipment components will be available to satisfy global requirements.

8.9.5 Mobility

CyberStar™ operates in the fixed satellite service.

8.9.6 Gateways and network interfaces

CyberStar™ is a GSO system that will expand its gateway concept as required to provide terrestrial connections to the users. The initial complement will comprize approximately eight to ten gateways.

8.9.7 Co-existence with other systems

CyberStar™ will work with geosynchronous and non-geosynchronous satellite systems and with fixed terrestrial systems to address interference issues in both Ku and Ka-bands.

8.9.8 Applications

CyberStar™ will carry voice, data and video at high data rates. It will provide a range of high-speed customizable data communications service, such as:

- multicasting, to simultaneously broadcast a file from one location to many;
- data streaming, to allow continuously updated information to be streamed to users;
- high speed Internet access, even to users in remote locations.

CyberStar™ offers security and reliability comparable to land-based solutions; as satellites have been trusted to carry highly sensitive voice and data communications crucial to national defense, security and reliability have been paramount to their development.

8.9.9 Satellite component of UMTS

CyberStar™ does not have involvement in S-UMTS.

8.9.10 Licensing

CyberStar™ is licensed through the US for its Ka-band system and is co-ordinating through the FCC with other administrations. CyberStar™ has actively participated in the GMPCS MoU and will continue to work with regulators on a global basis to maintain the timely, compliant rollout of the service.

8.9.11 Standardization

CyberStar™ is a global system that will benefit from standardization generally; they are addressing standardization issues both within the US and globally.

8.10 HISPASAT

HISPASAT S.A. is a satellite operator providing space capacity for satellite communications. Among them, special interest on broadband satellite multimedia services is being pursued making use of the development of the satellite digital TV and the interest on high speed interactive traffic services.

During the last years HISPASAT has headed several projects on satellite broadband systems based on interactive TV. These are DIGISAT and S3M.

DIGISAT and S3M will provide interactive digital TV to individual and collective installations using a Ku DVB channel of up to 38 Mbps combined with a return channel of user data up to 2 Mbps. The designed system follows an open architecture able to work with the existing HISPASAT Satellite System in 30° W in Ku band and with future HISPASAT payload in Ka band, just changing the outdoor unit of the user terminal.

8.10.1 Target market

Prosumer (professional users), or SOHO applications as well as consumer market both types of installations individual and collective.

8.10.2 Satellite constellation

The HISPASAT system has two fully operational satellites that were put into orbit in 1992, HISPASAT 1A and in 1993 HISPASAT 1B. In other words, both satellite are halfway through their expected lifetime.

HISPASAT satellites are GSO located in the orbital position 30° West, approximately in the middle of the Atlantic. Both satellites have almost identical features with a Eurostar 2000 platform, stabilized on three axes, with a total power 3 792 W. The HISPASAT system can have a total of 25 transponders operating simultaneously which provide a wide capacity to offer a wide variety of satellite communications services.

The HISPASAT system incorporates a significative amount of backup which guarantees service continuity, and thus allows to be overcome possible incidents. The HISPASAT satellite platforms are also perfectly designed to guarantee full effectiveness of all their transponders, even during eclipses.

In addition, HISPASAT-1C will be put into operation before the end of 1999. This satellite will provide a capacity of 24 transponders covering Europe and America. This capability has been designed to accommodate the existing and future broadband multimedia services in Ku band. Furthermore, HISPASAT is in the process of designing the fourth satellite of the series, so called HISPASAT-1D which will incorporate specific payload for the provision of broadband multimedia services.

Both satellites will be collocated in the same orbital location at 30° W.

8.10.3 Frequency bands

HISPASAT 1A and 1B uses 14 to 14,5 GHz and 17 to 17,3 GHz for the uplink and 11,45 to 11,7 GHz, 12,5 to 12,75 GHz and 12,1 to 12,5 GHz for the downlink in both coverages Europe and America.

HISPASAT 1C will use 13,0 to 13,25 GHz for uplink in Iberia and Europe coverages and 13,75 to 14,0 GHz for America uplink coverages. For the downlink, the band 11,7 to 12,2 GHz will be used.

HISPASAT 1D will provide back-up for 1A and 1B and will use the bands 12,75 to 13,0 GHz and 13,75 to 14,5 GHZ for the uplink and 11,2 to 12,2 GHz (or 10,7 to 11,95 GHz) for the downlink.

8.10.4 Terminals

The HISPASAT terminals for reception of multimedia digital TV are earth stations from 40 cm to 1,2 m of diameter connected to an universal LNB switchable between Low Band And High Band and Horizontal and Vertical Polarization.

For community installations (SMATV) different solutions developed by the DIGISAT project allow the distributions of multimedia digital TV in the collective installations. These systems, SMATV-DTM TDT, SMATV-IF or SMATV-S connected to the outdoor unit equipped with a four output LNB allows the distribution of the HISPASAT digital channels to all the users in the building in a transparent way.

For the near future interactive systems through HISPASAT, the users will be equipped with a Satellite Interactive Terminal (SIT) for individual users or with a Satellite Master Interactive Terminal for collective installations. These terminals will be composed of a dish of 60 to 120 cm and with a transmitter from tenths of Watts to 1 or 2 Watts.

8.10.5 Mobility

HISPASAT operates in the broadcasting and fixed satellite services bands. Although most of the terminals are fixed there are a number of them classified as nomadic which conceives to the system a certain mobility characteristic optimum for the provision of Digital SNG and other professional applications.

8.10.6 Gateway and network interfaces

A single gateway is required.

Interconnection with other networks will be made through standard interfaces.

8.10.7 Coexistence with other systems

HISPASAT expects that the problems raized from the coexistence with other systems and services using the same frequency bands will be solved through a frequency co-ordination process.

8.10.8 Applications

The interactive system will be able to support asymmetric high speed interactive traffic associated to digital TV services.

8.10.9 Satellite component of UMTS

Not applicable

8.10.10 Licensing

The current multimedia digital TV services are operational in the HISPASAT satellite system and the required licenses have been obtained from the correspondence national and international authorities.

For the future interactive digital services, licensing is a key point to be explored and envizaged.

8.10.11 Standardization

HISPASAT considers the following aspects as the most relevance for standardization:

- air interface (modulation, coding, framing etc.);
- spectrum emissions;
- safety;
- IF interfaces and/or antenna interfaces.

8.11 Intelsat

International Telecommunications Satellite Organization (INTELSAT), a spacecraft capacity provider, is actively developing a global geostationary broadband multimedia system at Ka frequency band.

The system would provide full connectivity among all users by its on board processing capabilities. Seamless interfacing with terrestrial systems would also be supported.

8.11.1 Target market

- Interactive Multimedia Services.
- Small Business.
- Large Corporate.
- Service Providers.
- Terrestrial Public Networks.

8.11.2 Satellite constellation

Five orbital locations are foreseen to provide global connectivity to INTELSAT 's customers worldwide. Satellites co-location may be used.

- 66 deg. E;
- 137,7 deg. E;
- 243,1 deg. E;
- 307,0 deg. E;
- 359,0 deg. E.

Each location will provide coverage for one or two geographical regions.

8.11.3 Frequency bands

Four-fold frequency reuse will be used in the following frequency bands:

User Terminals:

- Uplink: 29,4 to 30,0 GHz.
- Downlink: 19,6 to 20,2 GHz.

Gateways:

- Uplink: 28,2 to 29,4 GHz.

- Downlink: 18,4 to 19,6 GHz.

8.11.4 Terminals

Three type of terminals are foreseen for INTELSAT 's Ka-Band network:

- Low Data Rate Terminals:
  - 512 Kbps: With HPA Power of 1, 2,5, 5 Watts;
  - 2 Mbps: With HPA Power of 2,5, 5, 10 Watts;
  - 8 Mbps: With HPA Power of 5, 10 Watts.
- Medium Data Rate Terminals:
  - 32 Mbps: With HPA Power of 40 Watts.
- High Data Rate Terminals:
  - 155 Mbps: With HPA Power of 90 Watts.

Professional installation would be required for Medium Data Rate and High Data Rate terminals. Low Data Rate terminal architecture would not require professional installation.

8.11.5 Mobility

Initial targeted market is for fixed users services. Mobile service for Low Data Rate terminals would be considered in future developments.

8.11.6 Gateways and network interfaces

Up to 3 Gateways (Medium Data Rate and High Data Rate Terminals) might be placed in each beam.

Inter Gateways links might be through INTELSAT satellites in each region, or terrestrial links between Gateways in different regions.

Interconnection with other networks would be at local service nodes. Seamless interfacing with terrestrial protocol would be guaranteed trough the use of networking standards, including ATM and TCP/IP.

The Gateways will be operated by INTELSAT Signatories and/or Service Providers. Global and Regional Network Centers would be operated by INTELSAT.

8.11.7 Coexistence with other systems

Filings were sent to ITU in 1995 and 1996.

Intersystem co-ordination has been initiated for the planned orbital locations.

8.11.8 Applications

INTELSAT system would provide flexible offering to support a large range of applications. Different quality of service requirements (real time and non real time) will be supported with the associated billing structure and service management.

8.11.9 Satellite component of UMTS

No information supplied.

8.11.10 Licensing

INTELSAT Signatories would guarantee landing rights when applicable.

8.11.11 Standardization

INTELSAT participates in different standardization forums including ETSI, and would like to influence the development of the standards ETSI will produce.

8.12 Inmarsat

Inmarsat is currently an intergovernmental organization presently with 84 member countries. It provides land, mobile, maritime and aeronautical satellite communications.

Inmarsat operates a GEO satellite system which is used by signatories and their service providers to provide Global communications.

Inmarsat has been providing mobile high bandwidth solutions since 1991.

In 1991, global service at 64 kbit/s could be provided on the Inmarsat-A platform, followed in 1995 by the Inmarsat-B digital platform. These dial up services have, and will continue to enable many leading organizations to use all types of business applications in both land mobile and maritime theatres:

- Internet access and web browsing;
- Intranet;
- Email;
- Software/data/newspaper/fax/traffic report/audio/video/DGPS distribution;
- Tele-medicine, tele-education, tele-expert services;
- SNG/ENG;
- Wireless LAN and remote LAN extensions, etc.

Inmarsat has embarked on a strategic plan addressing both the short term and the long term requirements for developing its Broad Band Satellite Multi Media services:

In the short term Inmarsat will introduce a product (Inmarsat M4) that will combine the assets of the most successful services of:

- Inmarsat-B, providing 64 kbit/s dial up service;
- Inmarsat mini-M, providing a small portable, energy efficient package for true mobile communications on land and sea; and
- the spectrum efficiency of packet data service,

to provide the Inmarsat multi media terminal, M4. Service is expected in the first half of 1999.

In the long term Inmarsat Horizons is Inmarsat’s next generation mobile satellite communications system. It is unique in its ability to provide a complete range of Multimedia services to small portable and mobile terminals. Service is planned to begin 2002. At least three variants of terminal will be available with the following indicative attributes:

- supports data rates up to 64 kbit/s;
- supports data rates up to 144 kbit/s;
- supports data rates up to 432 kbit/s.

The rest of this submission will therefore concentrate on these new products M4 and Horizons.

Finally, as the only MSS operator with 15 years experience, Inmarsat intends to continue to play a role in regulatory and standardization organizations to ascertain that in S-UMTS a true portability of business applications will exist. For example, Inmarsat plays a leading role in SG16 to make certain that digital video standards (H.320, H.324, MPEG-4) can meet the challenge provided by mobile satellite communications. In addition Inmarsat participates in EU-ACTS projects that provide an S-UMTS testbed for the evolution of multimedia services for MSS, over a range of 64 kbit/s up to 2 Mbit/s.

8.12.1 Target market

- Journalists and broadcasters.
- Health teams and dizaster relief workers.
- Government workers, national emergency and civil defence agencies.
- Business users and heads of state.
- Rural users and mining/exploration companies.

Horizons primary market consists of land users of standard PCs who require global connectivity, and spend considerable time inside areas that are not covered by terrestrial mobile systems. Also included are the UMTS users. They are occasional users of the Horizons system when the terrestrial cellular coverage is not available. Horizons offers users remote office operation.

8.12.2 Satellite constellation

The M4 system will operate over the existing Inmarsat constellation of GEO satellites.

Each satellite utilizes a maximum of seven spot beams and one global beam. The number of spot beams will be chosen according to traffic demands. The satellites produce up to 48 dBW of EIRP

Spacecraft 3F1 Launched April 3, 1996 on Atlas Centaur IIA:

- Lift off from Cape Canaveral;
- On-station location 64,0 degs east;
- In-service date 11th May 1996.

Spacecraft 3F2 Launched September 6, 1996 on Proton D-1-E:

- Lift off from Baikunur;
- On-station 15,5 degs west;
- In service date 06:00 13th October 1996.

Spacecraft 3F3 Launched December 18, 1996 on Atlas Centaur IIA:

- Lift off from Cape Canaveral;
- On-station location 178 degs east;
- In service date 17:50 25th January 1997.

Spacecraft 3F4 Launched June 3, 1997 on Ariane 4:

- Lift off from Kourou, French Guiana;
- On-station location 54 degs west;
- In service date 26th July 1997.

Spacecraft 3F5 Launched February 3, 1998 on Ariane 4:

- Lift off from Kourou, French Guiana;
- On-station location 25 degs east.

The Horizons satellite system combines powerful satellites. The space segment includes 3 GEO satellites positioned over Land masses at:

- 20,0 E;
- 110,0 E;
- 90,0 W.

Additionally one in orbit will be positioned at 170,0 W. The combined footprint ensures coverage of all major land masses.

8.12.3 Frequency bands

M4 Terminals:

- Uplink: 1 626,5 to 1 660,5 MHz.
- Downlink: 1 525 to 1 559 MHz.

8.12.4 Terminals

M4 is based on the Inmarsat mini-M system design, and includes a number of new features such as 64kbit/s circuit switched and packet data services.

The full range of potential services:

- Voice;
- 2,4 kbit/s group-3 fax;
- 2,4 kbit/s data;
- ISDN services:
  - UDI;
  - 3,1 kHz audio;
  - Speech;
  - 56 kbit/s V.110 data;
  - ISDN supplementary services;
- Personal Mobility (using SIM card);
- Inmarsat Packet Data Service, using shared bearers.

Horizons terminals will be of at least 3 variants:

- an A5 (15 x 20 cm), 0,5kg, palmtop compatible terminal, supporting data rates up to 64 kbit/s;
- an A4 (30 x 20 cm), 1 kg, laptop compatible terminal, supporting data rates up to 144 kbit/s;
- an A3 (30 x 40 cm), 2 kg, transportable terminal supporting data rates up to 432 kbit/s.

A complete range of applications will be supported:

- www browsing;
- email;

- File Transfer;
- Intranet access;
- Video Conferencing;
- Video Broadcast;
- High quality Voice and Fax;
- Full access to all terrestrial services.

8.12.5 Mobility

The Terminals are intended for Land mobile, portable hand carried, permanent or semi permanent installations. It is intended that no professional services are required for deployment/installation, and that this should addressed by the end user (although some fixed and mobile products may require seem skilled installation technicians).

8.12.6 Gateways and network interfaces

The M4 system will use the same Land Earth Stations (gateways) which provide the current Inmarsat mini-M services.

8.12.7 Co-existance with other systems

M4 will operate in the same Bands as existing Inmarsat equipment.

8.12.8 Applications

M4: It is intended that applications that currently operate over ISDN should operate over the M4 system, also all current applications used on the Inmarsat B and Inmarsat A HSD platforms, subject to the inherent delays.

Horizons: terminals will offer a full range of potential services:

- all standard PC applications supported seamlessly.

8.12.9 Satellite component of UMTS

Horizons is positioned as a satellite component of UMTS/IMT200. Inmarsat is therefore interested in influencing the development of the S UMTS standards and has participated.

(Inmarsat also participates in EU-ACTS projects that provide an S-UMTS testbed for the evolution of multimedia services for MSS, over a range of 64 kbit/s up to 2 Mbit/s.)

8.12.10 Licensing

Inmarsat participates in the GMPCS MoU.

Current licenses are obtained on a National basis from the appropriate National Regulatory Authority.

8.12.11 Standardization

Inmarsat participates in all standardization forums applicable to its business, including the relevant work within ETSI.

Areas that would will benefit from standardization are:

- EMC certification; and
- Type Approval of MSSs.

9 Information gathered on BSM systems

This clause contains information found on various sources on the Internet, basically official web pages for the different systems as well as the http://www.fcc.gov/ib web site.

Primarily it is information on satellite systems that ETSI has not received any information on through the questionnaire that was produced. However, in some cases additional information on systems ETSI has received information on is placed here, so that the sections under the chapter containing received information can be kept as equal as possible in form. It is also important to note that in such cases, the information presented here in this clause may not be completely accurate, as it may be of older date.

Not the same type of information is available for all systems, but these sections present some of what is available. Different policies from the different system vendors govern how much information is released relating to the different systems.

9.1 EchoStar

EchoStar Satellite Corporation has received FCC authority to construct, launch and operate two GEO satellites at 121° W.L. and 83° W.L. EchoStar proposes to offer services such as video telephony, video-conferencing, voice communications, computer access to on-line information and entertainment services and medical and technical tele-imaging over the United States. Each satellite will carry 48 transponders / spot-beams, and the system will provide a video, audio and data services at transmission rates ranging from 384 kbit/s to 1,544 Mbit/s. The system is estimated to cost US$ 340 million.

EchoStar intends to offer some available transponders on both a common and non-common carrier basis

The system will have both narrow and wide spot beams, on-board signal processing, on-board switching, cross-link capabilities between satellites, and small ground terminals. EchoStar proposes to use right and left hand circular polarization. The maximum EIRP of each satellite is 63,3 dBW, and satellite antenna design includes cross-polarization isolation of 30 dB and co-polarized, co-frequency spatial separation assuring at least 20 dB isolation.

EchoStar plans to use inter-satellite links to connect its two satellites at 59 GHz. They do not yet have a licence for this.

Headquartered in Englewood, CO, EchoStar Communications Corporation is a public company employing over 2,000 people. The company and its subsidiaries deliver direct-to-home satellite television products and services to customers worldwide.

Table 7: Echostar summary of information

Parameter	Value	Unit
Cost	340 million	USD
System Coverage	USA	
Cost per 64 kbps equivalent	?	USD
No. satellites at Ka band	2	GEO
Orbit Location	121 W.L., 83 W.L.	degrees
Modulation and access	TDMA	
System Throughput	?	Gbps
Data Rates	0,384-1,544	Mbps
FCC Status	Approved May 97	
Terminal EIRP		Watts
Terminal Antenna Size	70-200	cm
EchoStar		
Web URL	www.echostar.com	

9.2 KaStar

KaStar will launch Ladybug I and II and provide two-way interactive, high speed, digital bandwidth on-demand to businesses and individuals. Ladybug I and II will cover the entire U.S., Central and South America as well as parts of

Europe and Mexico with spot beams from the locations of 73° W.L. and 109,2° W.L. Ladybug 3 at 52° E.L and Ladybug 4 at 175° W.L are not yet approved, but will provide world-wide coverage.

KaStar also claim to be able to use dinner-plate size antennas for their GEO Ka-band system, which means they believe they can get use smaller antennas than other, similar systems, yet fighting the same attenuation. They offer no information on their rain margin.

The system will utilize ATM network protocol, and provide two-way, digital satellite capacity on-demand.

Capacity will be sold to strategic partners and brokers, and support services such as:

- Internet service providers (ISPs);
- Direct broadcast systems (DBS) providers;
- Personal communication systems (PCSs);
- Wireless local area networks (WLANs);
- Tele-medicine;
- Gaming/gambling.

Each satellite generates a 48 spot beam pattern so both will cover the service area. A twelve times reutilization of the 500 MHz band for each satellite will be achieved, implying a K=4 reuse pattern, leading to an effective system bandwidth of 12 000 MHz for two satellites. Every location within CONUS will have continuous coverage by four to six beams, providing an effective bandwidth of 480 or 720 MHz at each location. The two satellites in their separate orbital locations will be directly interconnected by a microwave inter-satellite link (ISL).

KaSTAR Satellite Communications Corporation was incorporated in April of 1995 in Colorado. The principal of the company is one of the two original founders of EchoStar Satellite Corporation. The principal and affiliates of the company own various television and radio stations in Colorado, Florida, and Alaska and have extensive knowledge and expertize in the broadcasting, cable and satellite industries.

Table 8: KaSTAR summary of information

Parameter	Value	Unit
Cost	517 or 645 million	USD
System Coverage	Global land mass	
Cost per 64 kbps equivalent	5 504	USD
No. satellites at Ka band	2	GEO
Orbit Location	109,2 W.L.; 73 W.L.	degrees
Modulation and access	TDMA	
System Throughput	7,5	Gbps
Data Rates	0,384-1,544	Mbps
FCC Status	Approved May 97	
Terminal EIRP		Watts
Terminal Antenna Size	66-200 or smaller?	cm
Ka Star		
Web URL	www.kastarcom.com	

Table 9: KaSTAR key system characteristics (from www.kastarcom.com)

Satellite	Orbital Location	Launch Vehicle	Design life
LADYBUG-1	73° West	Ariane, Atlas, Long March	15 Years
LADYBUG-2	109,2° West	Ariane, Atlas, Long March	10 Years

Transponder Configuration

Frequency Band (GHz)	Transmit	Receive
Primary	S/C#1 19,2 - 19,7 S/C#2 19,7 - 20,0	29,0 - 29,5 29,5 - 30,0

Number of Transponders: 48 per satellite
Inter Satellite Link Frequency Band: 120 MHz @ 60 GHz
HPA power: Primary: 30W ISL: 15W
HPA redundancy: Primary: 54 for 48 ISL: 2 for 1
Receiver redundancy: 54 for 48 ISL: 2 for 1
Coverage: Each KaSTAR satellite will cover all 50 states as well as parts of Mexico and the Caribbean.

KaStar Satellite Overview

Satellite Manufacturer:	Lockheed Martin
Launch Service Provider:	TBD
Design Life:	10 years
Structure Height:	3,6m
Structure (DxW):	2,0m x 2,0m
Overall Length (Solar arrays deployed):	24,0m
Total weight at launch (Ariane 4):	3 217 kg
Dry Weight:	1 692 kg
Liquid propellant weight:	1 525 kg
Power Available (end of life):	6 606W
Batteries:	Nickel Hydrogen
Stationkeeping:	± 0,050 degrees box
Attitude Control:	Three axis Stabilization
Command and Telemetry Frequency:	C- and Ka- band

Ka-Band Reflector Antennas: 4 spotbeam transmit, 4 spotbeam receive, 1 CONUS transmit and receive ISL Antenna 1 transmit and receive
Omni Antennas: 1 dual deployed

9.3 Hughes Spaceway

Hughes / Spaceway is granted 1 GHz of uplink spectrum in 29,25 to 30,0 and 28,35 to 28,60 and 1 GHz of downlink with 500 MHz in the 19,7 to 20,2 GHz band and 500 MHz in the 17,7 to 18,8 GHz bands. For ISL. Hughes proposes the following frequencies: 22,55 to 23,55; 32,0 to 33,0; 54,25 to 58,2 and 59 to 64 GHz band for these operations, but these are not yet granted.

Spaceway, a Hughes Communications system, will begin with four Ka-Band satellites covering North America and Asia, eventually expanding to more satellites for global coverage. The system is scheduled to be available in the year 2000, capacity will be sold or leased on a non-common carrier basis.

The service will offer upstream data rates (depending on antenna size) of:

- 384 Kbps;
- 1,5 Mbps; or
- 6 Mbps; and
- Downlink speeds of 92 Mbps.

Each Galaxy/Spaceway satellite will support 68 simultaneously active transponders on both uplink and downlink, with 64 transponders of 125 MHz for user terminals and four of 250 MHz bandwidth for gateways. The satellites will further have multiple spot beam coverage, on-board processing, digital transmission at medium and high data rates, orthogonal polarization and steerable antennas. F/TDMA is to be used for terminal uplinks, and TDM on terminal downlinks. The downlink rate will be 130 Mbps.

Their FCC proposed constellation will be comprized of 21 satellites located in 16 orbital locations around the world. The actual positions Hughes is allocated are given in the table 10 below. The following list shows their application requests:

- Hughes proposes two Ka-band only satellites at each of the following locations: 101° W.L., 99° W.L., 49°W.L.; 25° E.L., and 111° E.L.
- It also proposes to operate one Ka-band-only satellite at each of the following locations: 101° E.L., 54° E.L., and 164° E.L.
- One hybrid Ka/Ku-band satellite would be located at each of the 36° E.L.; 40° E.L.; 48° E.L.; 124.5° E.L; 149° E.L;173° E.L. and 67° W.L. orbit locations.
- In addition, Hughes requested one Ku-band satellite at 135° E.L.

Galaxy/Spaceway as a GEO constellation has been filed several times before the FCC: the first time in December 1993 (2 satellites, US$ 660M cost), then in July 1994 (9 - to -17 satellites, US$ 3,2 B to US$ 6,4 B cost), and in September 1995.

Now Hughes Communications is filing two new applications with the FCC at the Ka-band. These are

- The SPACEWAY EXP™ filing, which outlines an eight-satellite system operating at GEO orbit, providing high data rate transport services. It will focus on the high data rate transport market using GEO satellites operating from four orbital locations. Hughes Communications has requested authorization at 117°, 69° and 26,2° West longitude, and 99° East longitude.
- The SPACEWAY NGSO™ filing describes a 20-satellite system operating in NGSO orbit, that will add to overall system capacity, providing advanced interactive broadband multimedia communications services in high traffic markets globally. The NGSO constellation will consist of four planes with five satellites in each plane, inclined at 55 degrees with respect to the equator and in circular orbits at an altitude of 10 352 km. (MEO) Satellites will have ISLs.

Hughes has created the Galaxy constellation, the DirecPC system, and owns the majority of PanAmSat.

Table 10: Spaceway summary of information

Parameter	Value	Unit
Cost	5,171 billion	USD
System Coverage	Global land mass	
Cost per 64 kbps equivalent	3 760	USD
No. satellites at Ka band	20	GEO
Orbit Locations	49° W.L.; 25° E.L.; 36° E.L.; 40° E.L.; 48° E.L.; 54° E.L.; 101° E.L; 111° E.L; 124.5° E.L; 149° E.L; 164°E.L.; and 173° E.L. Additional locations at 101° W.L., 99° W.L., and 67° W.L.	degrees
Modulation and access	QPSK, FDM/TDMA uplink, TDM downlink	
System Throughput	88	Gbps
Data Rates	0,0016-6,176	Mbps
FCC Status	Approved May 97	
Terminal EIRP		Watts
Terminal Antenna Size	65 - 120	cm
Spaceway	In operation from 2001	
Web URL	http://www.hcisat.com/	

Table 11: Spaceway web-site data

Capacity per Satellite		Family of Spaceway Terminals	
	Simultaneous Simplex Circuits		
16 Kbps	276 480	Standard USAT	66 cm, 384 Kbps Uplink burst
128 Kbps	34 560	Enhanced USAT	1,2 m, 1,5 Mbps Uplink burst
384 Kbps	11 520	Broadcast	3,5 m, 6 Mbps Uplink burst
1,544 Kbps	2 880	Downlink on All	108 Mbps
2,048 Kbps	2 304		
3,088 Kbps	1 440		
6,176 Kbps	720		
Satellites			
Type		HS 702	
Lifetime		15 years	
Eclipse Capacity		100 %	
Bandwidth		500 MHz	
Satellite Effective Bandwidth		6 GHz	
Number of Communication Beams		48	
Communications Beam Bandwidth		125 MHz	
BER Performance		1×10^{-10}	
Transmitter Redundancy		64 for 48	
Modulation		QPSK	
Data Stream		FDM/TDMA uplink, TDM downlink	
Data Throughput		4,4 Gbps	
Downlink Data Rate		92 Mbps	
Downlink EIRP (note)		61 (dBW) peak; 56 edge	
NOTE: As measured by Hughes facilities in Southern California			

9.4 GE*Star / GE Americom

GE Americom has filed with the FCC for authority to construct, launch and operate a constellation of nine GEO satellites (from Alcatel) located in five orbit allocations around the world. They will cover North and South America, Europe, Asia, Western Pacific, and the Caribbean. The system will be designed to offer broadband high speed communications to small ground stations, including direct-to-home antennas and feeder stations, including video, audio, teleconferencing. GE Americom, a New York corporation, filed an application for its "GE*Star"system in September 1995, and was awarded a licence in May 1997.

- Frequency Uplink: 1 000 MHz of spectrum in the 28,35 to 28,6 and the 29,25 to 30,0 GHz band.
- data speeds from 384 kbits to 40 Mbit/s.
- Downlink: 500 MHz in the 19,7 to 20,2 GHz band, and later some 500 MHz somewhere in the 17,7 to 18,8 MHz band.
- The GE*Star system will allow symmetric and asymmetric data communications transmission rates ranging from 384 Kbps to 40 Mbps.
- 17° W.L., 56° E.L., 114.5° W.L.,105° W.L., and 85° W.L orbital locations

The satellite in the GE*Star system will use 44 spot beams over its respective coverage areas. All satellites are proposed to be practically identical in design except for differences in their antenna coverage.

ISL were not originally planned, but GE has filed an application to modify its authorization to construct, launch and operate a Ka-band satellite system, seeking authority to permit the use of inter-satellite links among the satellites.

The satellites will provide 11 times frequency reuse through the use of spatially diverse satellite beams. Satellites will operate using orthogonal polarizations.

Each satellite will have a peak effective isotropically radiated power (eirp) of 54,0 dBW.

Table 12: GE*Star summary of information

Parameter	Value	Unit
Cost	2,676 billion	USD
System Coverage	Global land mass	
Cost per 64 kbps equivalent	3 892	USD
No. satellites at Ka band	9	GEO
Orbit Locations	17° W.L., 56° E.L., 114.5° W.L.,105° W.L., and 85° W.L	degrees
Modulation and access	QPSK, FDM/TDMA uplink, TDM downlink	
System Throughput	44	Gbps
Data Rates	0,0384 - 40	Mbps
FCC Status	Approved May 97	
Terminal EIRP		Watts
Terminal Antenna Size	65 - 120	cm
GE*Star	In operation from 2002	More capacity from 2004
Web URL	www.ge.com/capital/spacenet	Provides no info?

9.5 Morning Star

Morningstar Satellite Company, LLC, has received FCC authority to construct, launch and operate four GEO satellites in four orbital slots, covering the Americas, Europe, Asia, the Middle East, Australia and New Zealand. They have been given the 147° W.L, 62° W.L, 30° E.L., and 107,5° E.L. orbital locations. The FCC has allowed MorningStar to operate over 300 MHz in the 28,35 to 28,6 and/or 29,25 to 30,0 GHz bands, and 500 MHz of spectrum at 19,7 to 20,2 GHz.

Morningstar is designed to provide high speed voice and data communications as well as on demand entertainment programming to small satellite dishes. These services will be offered to a wide range of commercial and residential customers through the use of small aperture terminals.

Morning Star proposes to offer services on a non-common carrier basis. The system is estimated to cost US$ 936 million

Each satellite in the Morning Star system will have two payload sub-systems, each with associated uplinks and downlinks. The forward path will receive up to ten broadband digital carriers from the backhaul station through a steerable spot-beam antenna and will convey 16 high speed (30MBit/s) Quadrature Phase-Shift Keyed (QPSK) modulated signals using 24 MHz of bandwidth.

Morning Star's proposed satellite return path will relay user requests for service to the control center and can be used to convey bursts of information from user's terminals at 56 or 64 Kbit/s using QPSK modulation. The same steerable antenna on the spacecraft will be used for both reception of distributed Ku-band signals and transmission of information at Ka-band.

The schedule given by the FCC is:

	Commenced	Completed	Launch
First satellite	May 1998	April 2002	May 2002
Next satellites	May 1999	April 2002	May 2002

Morning Star is a limited liability company organized under the laws of Delaware. It filed an Ka band FCC application for its system in September 1995.

Table 13: Morning Star summary of information

Parameter	Value	Unit
Cost	936 million	USD
System Coverage	Global land mass	
Cost per 64 kbps equivalent		USD
No. satellites at Ka band	4	GEO
Orbit Locations	147° W.L, 62° W.L, 30° E.L., and 107,5° E.L	degrees
Modulation and access	QPSK, FDM/TDMA uplink, TDM downlink	
System Throughput		Gbps
Data Rates	56 or 64 kbps return 30 Mbps forward	Mbps
FCC Status	Approved May 97	
Terminal EIRP		Watts
Terminal Antenna Size		cm
MorningStar	In operation from 2002	More capacity from 2004
Web URL	www.morningstar.com	With little info so far

9.6 NetSat 28

Netsat 28 Company, LLC, filed for and received FCC authority to construct, launch and operate one GEO Ka-band satellite covering the continental United States. The satellite would have 1 000 antenna beams and be able to serve over 500 000 simultaneous users with fully interactive 1,544 Mbit/s service. Total cost is estimated at US$250 million.

NetSat Express has two corporate parents: Hughes Network Systems and Globecomm Systems, and NetSat describes itself as a full-service satellite Internet provider. It brings Internet to places where the terrestrial telecommunications infrastructure has not yet developed or is unable to support Internet communications at an adequate data rate.

The technology is based on taking the Hughes DirecPC hardware and basically making an international product out of it by adding a satellite uplink. The satellite uplink will typically be 19,2 Kbps, and the downlink is always at 400 Kbps.

In addition, NetSat Express will provide Internet access in places outside the United States where the terrestrial telephone infrastructure is developed, by offering a 400 Kbps NetSat Express Internet satellite downlink, via Hughes DirecPC system.

The space segment will be provided by a range of suppliers. The current phase of the service will be carried on a Eutelsat satellite. NetSat also plans to ally with Orion to carry the service. The hardware will mostly come from Hughes.

Table 14: NetSat summary of information

Parameter	Value	Unit
Cost	250 million	USD
System Coverage	USA	
Cost per 64 kbps equivalent		USD
No. satellites	1	GEO
Orbit Location	95 W.L.	degrees
Modulation and access	TDMA / QPSK or 8-PSK	
System Throughput	772 ?	Gbps
Data Rates	0,0016 - 8,448	Mbps
FCC Status	Approved May 97	
Terminal EIRP		Watts
Terminal Antenna Size	65 - 120	cm
Web URL	www.netsatx.com	

9.7 Loral Orion

Orion is granted FCC authority to construct, launch and operate six GEO satellites in six orbital slots, to provide transoceanic international fixed communications with data rates as high as 155 Mbit/s per transponder.

Each satellite is estimated to cost US$260 million, with a total system cost estimated at U S$ 1,6 billion.

NOTE: On February 26th, 1998, the FCC has granted the transfer of control of Orion to Loral Ltd.

Loral Orion, based in Rockville, Md., is an international satellite communications company that provides high-speed Internet connections for corporations and Internet Service Providers (ISPs) and private, multimedia network communications services directly to multinational businesses via small receiving antennas. It also transmits video communications for television and other program distribution services. Orion Network Systems, the operators of the Orion series of satellites, has begun offering volume access to the Internet into Central and Eastern Europe, at speeds of up to 8 megabits per second (Mbps).

Loral Orion owns and operates the Orion 1 satellite, placed in service in January 1995, covering the European, transatlantic and U.S. markets, and has two additional satellites under construction. Orion's transponder capacity will increases with the launching of Orion 3, scheduled for service in January 1999, covering the Asia Pacific region, and Orion 2, which will serve the Americas and Europe beginning in June 1999. The three-satellite constellation will be capable of providing services to over 85 % of the world's population by 1999. In addition, Orion has authorization for valuable domestic and international orbital slots, including certain slots for the provision of Ka-band service. Loral Orion serves a customer base of 300 multinational businesses and Internet service providers in 50 countries via approximately 680 installed terminals (earth stations or very small aperture terminals [VSATs]) that receive networked value-added services from Orion 1. The company also operates a tracking, telemetry and control (TT&C) facility in Mount Jackson, Virginia.

Table 15: Loral Orion summary of information

Parameter	Value	Unit
Cost	[2,7 billion]	USD
System Coverage	Global land mass	
Cost per 64 kbps equivalent	8 716	USD
No. satellites at Ka band	6	GEO
Orbit Locations	127 W.L.; 98 W.L.; 81 W.L; 47 W.L.	degrees
Modulation and access	FDM or SCPC / TDMA	
System Throughput	20	Gbps
Data Rates	0,0016 - 1,544	Mbps
FCC Status	Approved May 97	
Terminal EIRP		Watts
Terminal Antenna Size	65 - 120	cm
Orion	www.OrionNetworks.net	
Web URL	www.loral.com	

9.8 PanAmSat (Hughes)

PanAmSat has received FCC authorization to operate Ka-band satellites in nine orbital slots.

PanAmSat's strategy is to take an evolutionary approach toward the use of Ka-band frequencies. The company intends to place satellites into international orbital slots that primarily will build upon PanAmSat's current global services using the C-band and Ku-band frequencies.

PanAmSat Corporation, was formed in May 1997 by the merger of the previous PanAmSat Corporation and the Galaxy Satellite Services division of Hughes Communications, Inc. PanAmSat operates a global network of 16 satellites providing services in the C-band and Ku-band frequencies.

Table 16: PanAmSat summary of information

Parameter	Value	Unit
Cost	1,658 billion	USD
System Coverage	Global land mass	
Cost per 64 kbps equivalent		USD
No. satellites at Ka band	9	GEO
Orbit Locations	125 W.L.; 58 W.L.	degrees
Modulation and access	TDMA	
System Throughput	?	Gbps
Data Rates	0,0064 - 2,048	Mbps
FCC Status	Approved May 97	
Terminal EIRP		Watts
Terminal Antenna Size	100	cm
Web URL	www.panamsat.com	

9.8.1 PanAmSat V Stream

PanAmSat Corporation has in 1997 requested authorization from the U.S. Federal Communications Commission (FCC) to launch a 12-satellite global network that will provide digital transmissions services in the V-band frequencies. The system is called V-Stream, and is expected to provide high-power broadcast and telecommunications services (well) after the year 2000.

The V-Stream system will consist of 12 geostationary satellites that use 3 GHz of spectrum in the 50/40 GHz band of frequencies. Key components of the system will include inter-satellite links, on-board processing and high-powered spot beams. Through the use of these technologies, the V-Stream system is expected to be capable of efficiently providing a full range of digital satellite services on a global basis. PanAmSat has requested FCC authorization to operate the global V-band network in 11 orbital slots, ranging from 99 degrees West Longitude for service over North America to 124,5 degrees East Longitude for service over the Asia-Pacific.

9.9 Lockheed Martin / Astrolink

Astrolink is a new communications network employing advanced satellites to provide digital communication services anywhere in the world. More than just a global Internet, Astrolink's built-in security mechanisms insure the privacy of communications and positive user authentication and validation. Astrolink will enable global users to perform multimedia applications over virtual private networks at high speed.

Users will have seamless connectivity to both public and private networks with a wide range of choices in service levels and user data rates. Bandwidth is allocated on demand; users pay for what they use without the fixed cost of leased lines.

Beginning service in the year 2002.

The space-based component of Astrolink's network is a global constellation of nine Ka band satellites. These nine satellites occupy five orbital slots:

- terminal installation to be done by professionals;
- ATM is used a transport medium for IP;
- the constellation will support ISL;
- mobility from 2005.

Astrolink has replied to the ETSI questionnaire. The information here is additional information, mainly from the official Astrolink Homepage.

9.9.1 Space segment

- Nine Lockheed Martin A2100 Satellites in geostationary orbit.

- Launches beginning in 2001. System operational after first satellite in orbit. Global coverage with five satellites. Additional four to meet later demand.
- Orbital Locations:
  - Americas 97° W;
  - Atlantic 21,5° E;
  - Europe 2° E;
  - Asia 130° E;
  - Oceania 175,25° E.
- Transmission:
  - System operates in the Ka band (30/20 GHz);
  - 6 Gbps capacity per satellite;
  - Subscriber Uplink: 44 continuous beam uplink, Hybrid FDMA/TDMA, QPSK modulation, one 53 byte ATM cell per packet, 29,5 to 30,0 GHz;
  - Subscriber Downlink: 44 downlink beams which can have up to 110 Mb/s data rate, Coded and error corrected TDMA, QPSK modulation, four 53 byte ATM cells per packet 19,7 to 20,2 GHz. 155 Mb/s data rate;
  - Gateway link: 14 hopped TDM beams: uplink frequencies are 29,25 to 29,50 and 28,35 to 28,60; downlink frequencies are 18,3 to 18,8;
- Inter-satellite links: 440 Mb/s data rate; Optical.
- Onboard processor (DSP): Resource control, channelization, demodulation, decoding/encoding, Asynchronous Transfer Mode (ATM) fast pack switch.

9.9.2 Ground segment

- Terminal Family:
  - Small Office Home Office (SOHO): data rates up to 416 kb/s, 100 cm dish, 2 watts power, terminal EIRP up to 49 dBW, G/T is 18 dB/K.
  - Medium enterprise: data rates up to 2,08 Mb/s, 100 cm dish, 12 watts power, terminal EIRP 56 dBW, G/T is 18 dB/K.
  - Major enterprise: Data rates up to 10,4 Mb/s, 1,8 m dish, 15 watts power, terminal EIRP 62 dBW, G/T is 24 dB/K.
  - Regional Gateways: Data rates up to 110 Mb/s, 3 m to 5,5 m (depending on geographic location)
  - Up to 100 gateways will connect Astrolink to terrestrial networks worldwide.
- Network Control:
  - resource management and planning;
  - call control and user authentication;
  - traffic management;
  - fault isolation and recovery;
  - accounting and billing;

- security management;
- one network Control Centre per region;
- system access and user-to-user authentication through public key and smart card technology. Optional session encryption available, depending on local regulations.

Table 17: Astrolink summary of information

Parameter	Value	Unit
Cost	2 Billion	USD
System Coverage	Global land mass	
Cost per 64 kbps equivalent	4 190	USD
No. satellites at Ka band	Nine in five slots	GEO
Orbit Locations	97° W, 21,5° W, 2° E, 130° E, 175,25° E	degrees
Modulation and access	QPSK/OQPSK, F/TDMA, TDM	
System Throughput	60	Gbps
Data Rates	16 kbps - 0,416/2,08/10,4	Mbps
FCC Status	Approved	
Terminal EIRP	2 - 15	Watts
Terminal Antenna Size	100 - 180	cm
Web URL	www.astrolink.com	

9.10 L.P. Loral / CyberStar™

CyberStar™ has received FCC authority to construct, launch and operate a constellation of three GEO satellites to provide wideband data service to fixed users. The system is called CyberStar™, and the proposed system is designed to provide video, video-conferencing and tele-imaging to commercial and residential users, via low cost home terminals. The FCC has assigned the 105,5° E.L., 93°WL and 110,5° W.L. orbital locations, with 750 MHz in the frequency bands 19,7 to 20,2; 28,35 to 28,6 and 29,5 to 30,0 GHz, and another 250 MHz when it has determined exactly which 250 MHz it wishes to use in the 17,7 to 18,8 GHz band.

CyberStar™ is taking a phased approach to delivering its services, starting with GEO-based Ku-band satellite transmissions and eventually encompassing all the satellite transmission options. The CyberStar™ system is a GEO-based, open protocol system that will offer a variety of low-cost, high-speed, data and telecommunications services worldwide from leased Ku-band satellite transponders from late 1997, complemented by a dedicated constellation of geosynchronous Ka-band satellites beginning after the year 2000.

CyberStar™ uses open standards like, DVB and MPEG, for their Ku-band systems. The Ka-band satellites would be interconnected through inter-satellite links and cover North America, Asia and Europe. CyberStar™ has been examining the possibility of ISLs with SkyBridge and its own Telstar and Orion satellites, but leaning away from the technology because of technical problems associated with multiple space-borne hops and the fact that ISLs use up critical power that could be directed toward the earth.

In the FCC application, Loral wrote that:

- each satellite in the CyberStar™ ka-band system will have on-board processing and switching capabilities to promote maximum communication flexibility;
- each satellite will provide antenna coverage with 27 regional beams;
- CyberStar™ will use right-hand and left-hand circular polarization; and
- Frequency Division Multiple (FDM)/Time Division Multiplexed (TDM) protocol for uplink and TDM for downlink;
- inter-satellite links between adjacent CyberStar™ satellites will be used to provide connectivity between the coverage regions of different satellite orbit locations. ISL will be in the 60 GHz band.

The Ka-band service in phase 2 will support:

- 500 Kbps uplink; and
- 3 to 6 Mbps downlink.

The Ku-band broadcast service will include smart-card based authenticationand the DVB common scrambling technique.

9.10.1 Terminal pricing

It is expected two-way PC terminal conversions and equipment for the Ku-band CyberStar™ system to cost about $US1 300, and about $US 300 for receive-only units. For large businesses the company is exploring using cheap [$US 150] PCI cards to communicate with a central receive dish. Server-based communications are also being considered.

9.10.2 Business issues

The ka-band system is estimated to cost $US 1,050 billion in the FCC filing Loral states on the web-page the complete services including Ku-band transponders will cost $US 1,6 billion.

- CyberStar™ has announced the use of Broad Logic's PC receiver adapter card (Satellite Express ABA-1040) to facilitate the connection of a user's PC to receive CyberStar™'s service including data, audio, video and multimedia content. CyberStar™ is based in Mountain View, CA, and is a limited liability partnership created and managed by Loral Space and Communications Ltd. (NYSE:LOR) headquartered in New York City. Loral has an edge with its affiliation with Space Systems Loral, which is able to buy launch vehicles in bulk.
- Loral plans to phase in its CyberStar™ broadcast services through leased facilities over the Skynet satellites it purchased from AT&T for $478,1 million. It should be ready for full service broadcast at 29 Mbps. Loral Skynet has three Telstar satellites in service and two more scheduled for launch and service in the late 1998, early 1999 time frame. Three more satellites are planned for 1999 through 2001. Loral Orion has a trans-Atlantic satellite in operation and a trans Pacific and an additional trans Atlantic satellite scheduled for launch and service in 1999.
- Orion already serves about 260 private businesses and ISPs in 47 countries. Loral's also has a 75 percent stake with Telefonica Autrey in Satellites Mexicanos, S.A. de C.C. (SatMex) and a 39 percent stake in Globalstar SatMex has three satellites in operation with a high-power replacement scheduled for launch and service in 1999. Through a [$US 30 million] cross investment with Alcatel SkyBridge LEO constellation, Loral plans to pursue integrated marketing to better serve real-time and interactive applications.

Table 18: Loral CyberStar™ Ka-band satellites and terminals

Satellite		Terminal	
Lifetime:	12-15 years	USAT: 0,7m	384Kbit/s
Ka-band spectrum:	750 MHz	VSAT: 1,5m	1,544 Mbit/s
Data Throughput	4,9 Gbit/s	Broadcast Terminal: 3 m	3,084Mbit/s
Number of Beams:	27 (dual polarized)	Downlink data rates:	92 Mbit/s
Uplink Access:	FDM/TDMA		
Downlink:	TDM		

Table 19: Loral CyberStar™ Ka-band summary of information

Parameter	Value	Unit
Cost	1,6 billion	USD
System Coverage	Global land mass	
Cost per 64 kbps equivalent	20,89	USD
No. satellites at Ka band	3	GEO
Orbit Location	28° E.L., 105.5° E.L., and 115° W.L.	degrees
Modulation and access	F/TDMA, TDM	
System Throughput	4.9	Gbps
Data Rates	0,384; 1,554; 3,084 / 92	Mbps
FCC Status	Approved May 97	
Terminal EIRP		Watts
Terminal Antenna Size	70, 150, 300	cm
Web URL	www.CyberStarTM.com	

9.10.3 Loral CyberPath

Recently, Loral applied to the FCC for higher frequencies (V-band) for its CyberPath, a $1,2 billion system of 10 GEOs (four were included in the application) that would rely on $1 500 earth stations for broadband communications.

9.11 VisionStar

VisionStar, Inc. a New York corporation , is authorized to launch and operate one GSO FSS satellite to provide fixed-satellite service in the United States in the frequency bands 19,7 to 20,2 GHz; 28,35 to 28,6 GHz and 29,25 to 30,0 GHz at the 113° W.L orbital location.

The VisionStar satellite was said to carry 48 transponders, each of which is to be 40 MHz in bandwidth and either 60 watts or 90 watts, but only 30 Ka-band broadcast transponders will be used according to the press release from Orbital Sciences, who will build the satellite. The schedule aims for launch in Q2/2002.

VisionStar requested authority to use 1 000 MHz of spectrum in the 28,35 to 28,6 and 29,25 to 30,0 GHz bands for service uplink operations and the bands 18,55 to 18,8 and 19,45 to 20,2 GHz for service downlink operations. VisionStar also proposed to operate its tracking, telemetry and command ("TT&C") operations during transfer orbit in the Ku-band. At present, VisionStar has no plans for spatial frequency reuse.

- VisionStar proposes a video distribution service with interactive capability intended to serve consumers, particularly in urban areas, in conjunction with Cellular Vision's Local Multipoint Distribution Service (LMDS).

- VisionStar proposes to use its satellite to deliver over 100 national television channels, and supplement this national coverage with local and regional television programming through the use of earth stations utilizing LMDS technology.

- It also proposes a broadband infrastructure offering distance learning, high-speed Internet services, interactive data and e-mail and video conferencing abilities.

- VisionStar proposes to offer services on a non-common carrier basis.

VisionStar Inc., awarded a US$260 million contract to Orbital Sciences Corporation for two Geostationary Earth Orbit (GEO) communications satellites and launch services. The satellites are to have 30 Ka-band broadcast transponders.

Table 20: VisionStar summary of information

Parameter	Value	Unit
Cost		USD
System Coverage	USA	
Cost per 64 kbps equivalent		USD
No. satellites at Ka band	1	GEO
Orbit Location	113° W.L.	degrees
Modulation and access	[F/TDMA, TDM]	
System Throughput		Gbps
Data Rates		Mbps
FCC Status	Approved May 97	
Terminal EIRP		Watts
Terminal Antenna Size		cm
Web URL		

9.12 Orblink

Orblink is a MEO system at V-band.

Orbital Sciences Corporation announced in September 1997 that it has applied to the FCC for a license to construct and operate a global satellite network, called the OrbLink system, at the V-band, providing broadband FSS communications services. Orbital's OrbLink network is based on seven operational satellites in a medium-altitude (9 000 Km) equatorial orbit (MEO). The goal is close to world-wide coverage. Subject to FCC approval, the OrbLink network could begin service already in 2002.

Orblink will take advantage of advances in orbital architectures, satellite performance and wireless technology, and claims to be able to offer high-speed data transmission services with much greater access and at a fraction of the cost of current terrestrial and satellite alternatives.

The system will support several of high-speed data communications services, including video conferencing, computer networking, Internet access, image transmission as well as broadband data transmission in general.

- OrbLink aims to use the 65,0 to 71,0 GHz band for inter-satellite communications (ISL) with intercontinental capacity of up to about 15 Gbps.

- V-band frequencies in the 37,5 to 38,5 GHz and 47,7 to 48,7 GHz bands are to be used to/from earth. They will offer two-way digital connections between terrestrial users within each continent at speeds between 1,5 Mbps and 1,25 Gbps, with total regional capacity in excess of 150 000 T-1 high-speed circuits.

- Operating with regional gateway platforms serving as data concentrators over metropolitan areas, or alternatively with other satellite systems that serve as high-speed relays, OrbLink will provide high-speed connectivity to systems which offer even greater capacity in high-density regions.

The OrbLink satellites will be based on Orbital's STARBus lightweight geostationary spacecraft platform, which the company acquired as part of its recently-completed purchase of CTA Incorporated's space system business. These satellites represent a new generation of small and powerful spacecraft technology. The seven operational and one on-orbit spare satellites in the OrbLink network each will generate approximately 4 kilowatts of electrical power.

- Satellites will have 100 spot beams for space-to-ground transmissions, along with two east-west inter-satellite links.

- The satellites are to be designed for a 9 year lifetime. Weight: approximately 3 000 pounds in orbit.

- They can be launched two or three at a time on Delta 3, Atlas 2 or Ariane 4 vehicles, or four at a time on larger vehicles. Individual satellites also can be launched on a Taurus-derivative launch vehicle.

The estimate of the total investment necessary to develop, construct and deploy the OrbLink global network is approximately 900 million USD. (An interesting comparison is that that cost is comparable to the cost of two trans-Atlantic fiber cables, having less than 10 % of OrbLink's total trunking capacity). Orbital plans to add technology and distribution partners to the OrbLink project, assuring a strong position for its services in domestic and international markets.

Coverage is said to be only between approximately 50° North and South latitudes, encompassing about 95 % of Earth's population. If this actually is the case, this excludes areas in Europe north of France.

Orbital is a space and information systems company that designs, manufactures, operates and markets space infrastructure systems, satellite access products and satellite-provided services, including launch vehicles, satellites, sensors and electronics, satellite ground systems and software, satellite-based navigation and communications products, and satellite-delivered fixed and mobile communications and Earth observation services. The company also stand behind the Orbcomm two-way low data rate mobile messaging system, along with Teleglobe Inc. of Canada and TRI Inc. of Malaysia. Orbcomm consists of a constellation of up to 36 small, low-Earth-orbiting satellites.

Reference: http://www.orbital.com/

9.13 Alenia Aerospazio / Euro Skyway

The EuroSkyWay is a Satellite System for Interactive Multimedia Services. EuroSkyWay will offer "bandwidth on demand" to service Providers, such as Telecom Operators, TV Broadcasters and Internet Access Providers, who can expand their network infrastructure and reach new customers.

EuroSkyWay will use the 20/30 GHz Ka-Band and on board processing. The technologies have already been demonstrated by the two Italsat satellites (designed and built by Alenia Aerospazio), which have been operational since 1991.

The EuroSkyWay network will offer an aggregate capacity of 45 Gbps through a cluster of 5 geostationary satellites. The system allows the use of technology from commercial DVB receivers, while modem and codec can be implemented with inexpensive CMOS technology.

EuroSkyWay user terminals are PC-based with an outdoor antenna dish, able to receive up to 32 Mbps Three categories of terminals are foreseen:

- portable (lap top size) with 144 Kbps upstream speed;
- standard (PC-size) with 512 Kbps upstream speed;
- high capacity (PC-size) with 2 Mbps upstream speed.

EuroSkyWay plans a phased introduction of multimedia services via satellite:

1) beginning in 1998 tele-education, telemedicine and fast Internet services will be offered to selected user groups by the ISIS and Shared satellite platforms presently under development;
2) the first EuroSkyWay satellite will be launched early in the year 2000 and a second satellite is scheduled in 2001. The initial configuration covers Europe and the Mediterranean Basin;
3) later, three more satellites will be added, extending the coverage areas to Africa, Eastern Europe and Asia.

EuroSkyWay will also bring broadband services to mobile users by offering communication links at a speed up to 200 times higher than traditional cellular phones. Cost of transmission per Mbyte will be much lower than for current satellite systems.

EuroSkyWay mention the following applications for their system:

- Fast Internet Access;
- Telemedicine;
- Tele-Education;
- Electronic Commerce.

EuroSkyWay is the Finmeccanica company, co-ordinated by Alenia Aerospazio, that will design, procure and operate the network. EuroSkyWay is already licensed as a multimedia operator in Italy and holds the necessary orbital slots to reach the targeted markets. Alenia AeroSpazios' EuroSkyWay claims to be the first European satellite network for delivering two-way broadband communications to everybody everywhere via a simple and compact dish antenna terminal.

Reference: Alenia Info: http://www.alespazio.it.

Table 21: EuroSkyWay satellites and terminals

Satellite		Terminals	
Lifetime:	5 years	End User Satellite Terminal (SaT):	Portable 21 x 40 cm, 144 Kbit/s-2 Mbit/s 0,45 - 6,2 W (99 % availability)
Ka-band spectrum:	680 MHz	Service Provider Terminal:	1,7 m, 6,144 Mbit/s (99,9 % availability)
Data Throughput:	5,25 Gbit/s	Gateway Terminal:	2,7m, 32,668 Mbit/s (99,9 % availability)
Number of Beams:	32	Downlink data rates:	32,668 Mbit/s
Communication beam bandwidth:	170 MHz (up) 232 MHz (down)		
Downlink data rate:	(32) Mbps		
Downlink EIRP:	54,2 dBW,		
Uplink Access:	MF-TDMA		
Downlink:	TDM		

Table 22: EuroSkyWay summary of information

Parameter	Value	Unit
Cost	1,2 billion	USD
Cost per 64 kbps equivalent	1 706	USD
No. satellites	5	GEO
Orbit Locations	5, 13, 22, 30, 39 E.L.	degrees
Modulation and access	TDM/MF - TDMA / QPSK	
System Throughput	45	Gbps
Data Rates	0,144 - 32	Mbps
FCC Status	N/A	
Terminal EIRP	0,45 - 6,2	Watts
Terminal Antenna Size	21 x 40 - 60	cm
EuroSkyWay	Alenia AeroSpazio	
Web URL	http://www.alespazio.it	

9.14 Alcatel / Loral Europe*Star

Europe*Star is a multiple geostationary satellite system that will provide broadcast and telecommunications services to nearly half the world from Western Europe to Southeast Asia, including Eastern Europe, the Middle East, South Africa and India. Europe*Star was first initiated by Dr. Schulte-Hillen, chairman of Scientific Consulting GmbH in Cologne, Germany, who filed for orbital positions with German authorities in 1991. Alcatel joined the project in early 1996.

The multi satellite Europe*Star system, located between Europe and Asia at 43 degrees, 45 degrees, and 47.5 degrees, will be the first European Ku-band satellite system to be able to directly connect Europe and Asia in one single hop -- providing telecommunications, high-rate data interchange (Internet, on-line service access), and television and distribution services.

The first satellite will have a 30 Ku band transponders capability, with a power of 9,5 kW and a launch mass of approximately 3,6 tons. The first satellite will be launched mid 2000 and placed at 45°E. The launch vehicle provider is under selection. Plans for the second satellite are already underway.

Overall project costs for the first satellite are estimated at approximately $US 300 million.

Loral and Alcatel has formed strategic partnership to develop Europe*Star as a part of a global network of operating companies that will use a common marketing strategy to provide customers "one stop shopping" for local, regional, and global satellite services. Europe*Star will join Loral's global alliance, a sales and marketing coalition comprized of

Loral Skynet, Satellites Mexicanos, S.A. de C.V. (SatMex), and Loral Orion which will provide global satellite coverage and connectivity.

Alcatel Espace of Toulouse, France, is the prime contractor of the Europe*Star turnkey system. Space Systems/Loral, a wholly-owned subsidiary of Loral Space & Communications, will build the bus, and test and integrate the satellites at its Palo Alto, California, facility. Alcatel Espace will provide the payload.

9.15 Intelsat / New Skies

The governing bodies of Intelsat has agreed to create an independent spin-off company, temporarily called New Skies Satellites, N.V, as part of its overall restructuring plan.

Intelsat will transfer six of its existing satellites to New Skies, along with the broadband Ka-band frequency registrations in two key orbital locations. All in all Intelsat has available 10 GEO slots for Ka-band satellites.

New Skies will be incorporated in The Netherlands and will have a diluted ownership via an initial public offering.

The current phase of the Intelsat Ka-band project is that is in its study and design phase.

9.16 Alcatel SkyBridge

SkyBridge is a European initiative being proposed by Alcatel for an 80 satellite LEO system operating in the 10 to 18 GHz bands open to NGSO/FSS services. The satellites will be fairly simple, and be of the bent-pipe type, i.e. no on-board switching. (An earlier version of the proposal, which was initially known as Sativod, called for 64 satellites and lower capacity). The budget cost is US $4,2 billion. The costs include development of prototypes; manufacturing and launching the constellation; on-ground satellite spares; development and installation of the satellite control segment; insurance, and the complete engineering and development of the telecommunications infrastructure (e.g. gateway earth station, subscriber earth terminal, network management, etc.).

SkyBridge will provide bandwidth on demand at very competitive prices for residential and business customers, ranging from high-speed Internet access to highly interactive real-time services including worldwide enterprise networking and video-conferencing.

SkyBridge is scheduled to enter service in 2001 with a half satellite constellation, increasing during 2002 to the full 80-satellite constellation. The services of SkyBridge will be delivered worldwide to final users through local and regional service providers. The SkyBridge system can handle over 20 million users worldwide with bandwidth on demand. Total system capacity amounts to over 200 Gbps.

The link between end-users and the system is asymmetrical, with data rates of up to $n \times 20$ Mbps to the user and up to $m \times 2,5$ Mbps on the return link. Increments in data rates are in 16 kbps steps, thereby providing the user with bandwidth on demand.

Local capacity totals up to 1 Gbps over an area of 350 km in radius when only one satellite is visible, and up to 3 Gbps with 3 satellites visible. Each gateway can handle up to 330 000 users per visible satellite. The SkyBridge satellites are around 1 200 kg, with about 2 700 watts of power, and an operational lifetime of 8 years. Spot-beams are generated by active antennas.

SkyBridge communications includes:

- the SkyBridge gateways;
- the user terminals;
- the management of the network/communications system.

The SkyBridge system will require around 200 gateways; designs being derived from existing terrestrial broadband network architecture. A gateway consists of:

- an RF subsystem, with up to four satellite-tracking antennas;
- an access subsystem; a switching and routing subsystem, providing interfaces with terrestrial IP networks such as Internet, broadband and narrow-band switched networks and leased lines;

- a service access point with associated management functions;
- a gateway management subsystem.

SkyBridge users will have low-cost terminals composed of a small, low-power RF outdoor unit and a standard indoor part. Two types of terminals are envizaged:

- personal terminals for individual subscribers will feature a small 50 cm diameter radome and 2 W power;
- multi-user terminals for corporate and communal residential use will be able to serve several dozens of users with a radome ≤ 1 meter;
- the repeatability of the passage of the SkyBridge satellites in relation to the location of the terminal simplifies terminal design along with installation and initial commissioning.

The SkyBridge project is designed for rapid implementation, with service to be rolled out by the end of 2001. This is possible because:

- the use of 10 to 18 GHz frequency bands limits the amount of development both on board and on the ground;
- with all routing and switching located on the ground, simple and transparent satellites are involved;
- maximum use of state-of-the-art technology has been built in to the development of the system;
- the lifetime of the first-generation satellite constellation is projected out to 2009.

The main steps in the technical and industrial development program are/have been:

- 1993/1994: Preliminary studies;
- 1995/1996: System definition;
- ITU Filing;
- 1997: FCC filing; WRC approved introduction of NGSO/FSS systems into Ku band;
- 1998: Final system specifications;
- 1999 to 2001: Development and manufacturing of the space segment;
- 2001 to 2002: Satellites launching.

9.16.1 Regulatory issues

SkyBridge has filed with the FCC (Q1/1997) to operate a NGSO Fixed Satellite Service system on various frequencies within the 10 to 18 GHz bands. Subsequently (Q3/1997) SkyBridge amended its application to request that its NGSO FSS system be allowed to operate in the United States on a co-primary basis with GEO satellite systems and terrestrial systems in the 10,7 GHz to 12,7 GHz; 12,75 GHz to 13,25 GHz; 13,75 GHz to 14,5 GHz and 17,3 GHz to 17,8 GHz bands. At the same time, SkyBridge filed a petition for Rulemaking to permit such NGSO FSS operations.

In order to assist the FCC in developing a complete record on which a well reasoned decision can be made given the complex technical, legal and policy issues that the SkyBridge application raizes, the FCC modified some of the specific procedures (Q2/1998) by applying the disclosure requirements of FCC rules section 1.1206 for *ex-parte* presentations relating to the SkyBridge application or Petition.

In its initial application, the system filed called for employment of a constellation of 64 satellites in two sub-constellations of 32 satellites each. Each sub-constellation will have 8 planes, and 4 satellites per plane. A recent amendment (Q2/1998) increases the number of satellites to 80, but with no changes to the proposed frequency bands:

- SkyBridge requests 1,05 GHz of spectrum within the 12,75 GHz to 13,25 GHz; 13,75 GHz to 14,5 GHz and 17,3 GHz to 17,8 GHz frequency bands for Earth-to-space transmissions with discrete frequency bands within these band segments for gateways and terminals.

- SkyBridge also requests to use a total of 1,05 GHz in each spot-beam within 10,75 GHz to 12,75 GHz (10,7 GHz to 12,7 GHz in ITU Region 2) for space-to-Earth transmissions. For example, the small antenna ubiquitous user terminals to be located at customer premizes would use the 14,0 GHz to 14,5 GHz band for uplinks and the 11,7 GHz to 12,7 GHz band for downlinks. For its Tracking, Telemetry, and Control (TT&C) functions, SkyBridge requests 20 MHz of uplink spectrum and 5 MHz of downlink spectrum within these same frequency ranges.

The proposed SkyBridge use of some of the frequency bands noted above is not covered by FCC rules for current domestic or international allocations, and several of these proposed frequency bands are allocated on a co-equal basis with other services or contain restrictions with respect to NGSO operations. In order to establish technical rules governing NGSO FSS operations in these bands, SkyBridge, in its petition for rulemaking, proposes amendments and clarifications to the FCC rules.

SkyBridge furthermore requests a waiver on FCC rules established to ensure the operation of GSO systems at 2-degree orbital spacing. According to the existing rules, the SkyBridge residential user terminals are nominally non-compliant. Given that the minimum distance between a GSO satellite and a SkyBridge satellite is 10 degrees, SkyBridge questions whether these rules are technically applicable, and provides a proposal for operation which guarantees protection. However, to the extent that the Commission nevertheless deems the existing rules applicable, a limited waiver is requested.

9.16.2 Spectrum re-use

Through careful system designs and without expense or complexity SkyBridge's NGSO system can, by utilizing the space beyond the geostationary-satellite orbit, re-use scarce spectrum resources with GSO and terrestrial licensees and not pose any threat of interference to their systems.

SkyBridge is requesting to operate on a co-frequency basis with the satellite and terrestrial systems operating within the requested bands in the10 to 18 GHz frequency range. SkyBridge states that it will not interfere with, and is not requesting protection from interference caused by any existing system, as such systems are currently operated, including terrestrial (fixed and mobile) services, FSS, Direct Broadcast Satellite Service and government operations. This is defined to mean that the SkyBridge system will cause no degradation in the quality of service of these systems, or the availability of satellite or terrestrial communications links, and will impose no operational constraints on the satellite and terrestrial operators. However, SkyBridge takes the position that the burden of co-ordination between future terrestrial systems and SkyBridge should be shared, with both parties required to take reasonable measures to avoid interference. With respect to future NGSO systems, SkyBridge expects that any such systems would be required to operate on a non-interference basis with respect to the SkyBridge system (as well as to GSO and terrestrial systems).

9.16.3 Business issues

The SkyBridge venture is being led by Alcatel and includes a consortium of investors, which as of end of 1997 are: Loral Space & Communications Corporation (USA), Toshiba Corporation, Mitsubishi Electric Corporation, and Sharp Corporation (Japan), SPAR Aerospace Limited (Canada), Aerospatiale and CNES (France), and the Société Régionale d'Investissements de Wallonie (Belgium).

The Alcatel partnership agreement with Loral includes cross investments in Loral's geostationary (GEO) satellite-based CyberStar project. Each company will participate in the development of the two projects, initially committing to invest $30 million in the other's respective project. Each project will be managed separately, but the two companies have agreed to a co-ordinated approach to the two networks, including integrated marketing.

Table 23: SkyBridge summary of information

Parameter	Value	Unit
Cost	4,2 billion	USD
Cost per 64 kbps equivalent		USD
No. satellites	80	
Orbit	LEO, 1 469 km	
Modulation and access	QPSK/BPSK, FDMA/TDM/CDMA QPSK/BPSK, FDMA/TDMA/CDMA	Forward Return
System Throughput	>200	Gbps
Data Rates Professional Data Rates Residential	Forward: 0,016 - n $\times$ 20,48 Return: 0,016 - m $\times$ 2,56 Forward: 0,016 - 20,48 Return: 0,016 - 2,56	Mbps
FCC Status	Application pending	
Terminal EIRP	34,5 - 43,8	dBW
Terminal Antenna Size	Residential $\leq$ 50, Professional $\leq$ 100	cm
Web URL	www.skybridgesatellite.com	

References: http://www. Skybridgesatellite.com

http://www.fcc.gov

9.17 Inmarsat

ETSI has not received or found any information on Inmarsat's plans for broadband multimedia communications. However, Inmarsat has advized that information will become available on their web-page, http://www.inmarsat.org.

Two or three projects are known that can be related to broadband, namely the M4 (Multimedia mini-M) / IPDS, and the Horizons system.

9.17.1 M4 / IPDS

M4 can deliver 64 kbps of data to mobile terminals.

IPDS can deliver from 8 to 64 kbps in steps of 8 kbps to mobile terminals.

Both services will be available over the Inmarsat-3 satellites.

9.17.2 Horizons

Horizons will deliver 144 kbps of data, with QoS and a form of ATM-like protocol.

9.18 Asia Sky-Link

ASIA Sky Link will utilize Ka band throughout the Asian region spanning from 60 degree south to 60 degree north. The system will support ATM.

The onboard processing system will consist of two units. Recombining function and ATM switching function shall be incorporated, at an aggregate of more than 52 Gbps and to be distributed into a) 29.8 Gbps HDR OBP and b) 22,4 Gbps MDR/LBR-OBP .

The available frequency band from each Asian country could be different. In Japan, the available band for Ka band GSO satellite is only 750 MHz. Asia SkyLink assumes that 750 MHz to 1,5 GHz band is available.

The design is so far only a preliminary design concept of wideband satellite network for delivering broadband access and gigabit pipes applicable for the Asia-Pacific region. It will allow for an urgent ability in the developing countries for broadband access which cannot be fulfilled by terrestrial system in view of such a large and sometime harsh areas to be covered.

The approach currently being taken as an exercize includes:

- multiple-spot beams;
- repeated frequency reuse for uplink and downlink;
- orthogonal linear polarization;
- beam hoping for low density areas and otherwize fixed beam will be in use;
- major trunking channel having enough beam separation will use the same frequency spectrum, at smaller size beams.

Each of the High Data Rate (HDR) beams will represent 2 x STM-1, STM-4 or STM-8 rate links.

ASIA Sky-Link will have the following type of terminals:

- High Data Rate Terminal at 1,244 Gbps rates that can serves as digital pipes bridges amongst major economic centres in a meshed network basis;
- Medium Data Rate Terminal at 155 Mbps, for multi media communications;
- Low Data Rate Terminal at 2 to 12 Mbps for voice, facsimile and data at 2 to 12 Mbps;
- Portable Brief Case Terminal at 64 kbps to 2 Mbps: a single channel BRA ISDN portable (mobile).

The design for the High Data Rate will based on a 16 QAM with coding rate at 7/8 using pragmatic trellis code and Reed Solomon error correction coding. Test results find that Eb/N = 10,3 dB is required for BER of less than 10^{-9}. The 1,244 Gb/s will then need about 350 MHz bandwidth, it is claimed, mentioning noting about the roll-off factor of pulse shaping filters. QPSK will be applied for MDRT, while BPSK modulation will be designed for the two lowest rate terminals. It is unclear why QPSK is not used for all user terminals, like most other Ka-band systems will do. Link budget calculations suggest an output power of 50 Watts per beam per carrier at 375 MHz each.

The coverage will span from ± 60 degrees. At the Ka-band, this will represent extremely severe propagation variation, from rain intense tropical condition, to low slant angle range subtropical range. One approach is to have a permanent fading margin associated at the link involving the tropical region's terminal, but this is not a good solution for most areas. Other approaches would be to apply power control or adaptive modulation.

The concept of ASIA Sky-link is a proprietary of PT Telekomunikasi Indonesia.

Ref: ASIA Sky-Link: A Wideband Satellite Network for Multimedia information Service among Asia Pacific Region, by Arifin Nugroho and Tonda Priyanto.

9.19 Milstar / EHF (Lockheed Martin, TRW, Hughes)

The Milstar military communications network is a series of advanced satellites linked to mobile ground terminals. EHF frequencies and highly directional antennas reduce the probability of jamming and intercept, assuring secure, reliable communications. Lightweight portable terminals on land, aboard ships and aircraft can be easily moved during tactical operations.

Milstar aims to assure command and control to U.S. forces world-wide. The system provides undeniable connectivity, anti-jam communications and interoperability for multiservice co-ordination. These features are crucial to successful operations on the modern battlefield and are not available through existing military communications networks. On-board processing can reconfigure networks to suit changing requirements, and ISL and onboard point-to-point routing offer direct connectivity between Commanders-in-Chief and troops in the field.

Milstar 1 only supports Low Data Rates (LDR). On Milstar II there will be a Medium Data Rate (MDR) ability with capacity up to T1 or 1,544 Mbps on each of 32 uplink channels. A pair of nulling antennas enable operation in the presence of in-beam jammers; six distributed user coverage antennas provide access to geographically dispersed users.

Table 24: Milstar specifications

LDR (Milstar I)		LDR and MDR (Milstar II)	
Frequency	EHF (44Ghz) uplink; (20 GHz) SHF downlink	Frequency:	EHF (44 GHz) uplink; SHF (20 GHz) downlink
Data Rates	75 - 2 400 kbps	Data Rates:	75 - 2 400 kbps (LDR); 4,8kbps-1,544 Mbps (MDR)
Channel Capacity	192 (100 at 2 400 kbps)	Channel Capacity:	192 (100 at 2 400 kbps) LDR; 32 (MDR)
Antenna Coverage	1 uplink, 1 downlink 5 uplink agiles, 1 downlink agile 2 up/downlink narrow spots 1 up/downlink wide spot	Antenna Coverage LDR	1 uplink 1 downlink 5 uplink agiles 1 downlink agile 2 up/downlink narrow spots 1 up/downlink wide spot
		Antenna Coverage MDR	2 uplink nulling spots 2 coincidental downlink spots 6 up/downlink spots (distributed user coverage)
ISL	2 per satellite (1 each direction), Compatible with LDR requirements	ISL	2 per satellite (1 each direction), compatible with LDR and MDR requirements

Reference: http://www.trw.com/seg/sats/MILSTAR.html

9.20 Teledesic

Teledesic has advized that further information is available from their web-page, http://www.teledesic.com.

9.21 Related Non-Satellite Systems

9.21.1 SkyStation

US-based Sky Station Inc. has developed balloons kept stationary by small jet engines, at about 20 km above the earth. The specific 47 GHz frequency band is 47,2 to 47,5 GHz stratosphere-to-earth and 47,9 to 48,2 GHz earth-to-stratosphere. The payload will provide T1/E1 access to millions of users in each service area with low power requirements and low latency. Each service area will be centered over a metropolitan area, but can extend over suburban and into rural areas. Each carrier will be capable of up to 10 Mbps.

The FCC has approved use of the 47 GHz band for high-speed, stratospheric transmissions, particularly Internet transmissions. Sky Station stratospheric telecommunications service utilizes lighter than air platforms which will remain fixed above major metropolitan regions using recently developed technologies as:

- super-efficient solar cells;
- new lightweight composite materials;
- advanced fuel cells and propulsion systems; and
- global positioning systems.

The strength of these low altitude platforms compared to satellites lie in the ability to produce smaller spot-beams and thus have better frequency reuse then satellites. While a GEO satellite generates typically one spot beam per metropolitan area using typical state-of-the-art antenna apertures of 5 m at 20/30 GHz, a single stratospheric telecommunications platform at 21 km altitude can generate approximately 700 to 1 000 spot beams within a single metropolitan area. A NGSO satellite at 500 km altitude could generate 6-9 spot beams out to 100 km from the centre of a metropolitan area. The stratospheric architecture thus yields approximately 100 times greater metropolitan area capacity than the non-geostationary satellite orbit architecture.

Sky Station terminals, priced at about $100, are required to use the service, with some computers requiring a PCMCIA card to connect to the terminal.

Sky Station platforms can be of variable size depending on market demand. The average platform will be approximately 157 m long and 62 m in diameter at the widest point. Ultimately there can be more than 250 Sky Station platforms, one above every major city in the world. There may be more around large population centers. Additional platforms can be added to increase capacity over specific regions. Because each platform will utilize the same telecommunications payload, and due to the portable nature of our service, users could have same service when they travel everywhere there is coverage.

9.21.1.1 Advantages

The platforms do not require a launch vehicle, they can move under their own power throughout the world or remain stationary, and they can be brought down to earth, refurbished and re-deployed. Each platform can be retrieved, updated, and re-launched without service interruption.

Once a platform is in position, it can immediately begin delivering service to its service area without the need to deploy a global infrastructure or constellation of platforms to operate.

The altitude enables a higher frequency reuse and thus higher capacity than other wireless systems.

The low cost of the terminal, platform and gateway stations make it cheap.

The platforms are environmentally friendly, being powered by solar technology and non-polluting fuel cells.

9.21.1.2 Business issues

Joint venture companies and government authorities located in each country will control the Sky Station platforms serving their region to ensure the best service offerings tailored to the local market. Offerings can change as a region develops.

The Sky Station system is being designed and developed by an industrial team with members such as:

- Aerospatiale of France for the airship;
- Finmeccanica S.p.A. Alenia Aerospazio for the communications payload;
- Thomson-CSF for the ground electronics and user terminals;
- Dornier Satellitensysteme GmbH in Germany a corporate unit of Daimler-Benz Aerospace is the supplier for several critical subsystems;
- COMSAT Laboratories of Maryland is the communications network integrator;
- Thomson-CSF Communications of France is the gateway earth station manufacturer and payload sub-contractor. United Solar Systems Corp. of Michigan is the supplier of lightweight photo-voltaic modules;
- Stanford Telecom of California is one of the contractors for user terminals;
- All of these companies' efforts will be co-ordinated by NASA's Jet Propulsion Laboratory (JPL), who will provide end-to-end system integration.

Reference: http://www.skystation.com

9.21.2 ConSolar / Rotostar Project

This project is another balloon-based telecommunications platform project, based in Israel. It has both civil and military applications. No details of the telecommunications payload is available.

There is reason to believe that this project will not aim for a global, or even a European, coverage, but rather is aimed for specific use in Israel. However, it is interesting from the fact that it shows that SkyStation is not a one-of-a-kind project, and that the technical issues involved are worked on by a larger group of companies and institutions. A few fact on the project are given below, found at the Rotostar website.

The Rotostar is a solar powered heavier than air stratospheric platform; a surrogate satellite capable of geostatic hover at ca. 20 km over a fixed point with several months endurance. It is also described as an unmanned aircraft consisting of a central platform with a set of smart wings orbiting it, powered by an integral solar dynamic power system, or by microwave power beamed up from the ground. A simpler, gasoline engine powered version's endurance would be 4 days. A rotating wing unmanned airborne vehicle, the Rotostar is designed to take off from ground level and fly itself to an altitude where it can remain over a fixed location for six months or more.

The Rotostar platform is capable of telecommunications and monitoring missions performed by geostationary or low earth orbit satellites with applications given such as:

- mobile & fixed telephone platform;
- high speed Internet;
- television;
- synergy with satellite systems, complimenting global communications systems like Iridium;
- data messaging (high speed Internet etc.) telecommunications platform;
- television relay platform;
- forest fires prevention;
- coastal fishing zone monitoring;
- contraband and Drugs interdiction.

Also military applications like:

- telecommunications relay;
- long range reconnaissance SAR, RADAR, Electro-optic;
- electronic Warfare;
- air Traffic Control;
- cruise & ballistic missile early warning.

The participating project members include a company called Silver Arrow, the Tel-Aviv University and Weizmann Institute of Science.

http://www.magnet.consortia.org.il/consolar/spsp.html

9.21.3 HALO - Angel Technologies

The HALO (High altitude long operational aircraft) project aims to use long operational air planes at 15 to 20 km altitude. The small planes are only about the size of a corporate jet. It may be of interest to note that in South Vietnam, the US Forces flew "Operation Blue Eagle" with airborne television broadcast from 1966 to 1972, so the idea is not completely new. The HALO Network will have an initial transactional capacity greater than 16 Gigabits per second. The HALO aircraft has a fixed-wing airframe with twin turbofan propulsion. It operates in a flight regime pioneered in the 1950's. Aircraft will be certified by the Federal Aviation Administration (FAA) for piloted commercial operation. Each site is serviced by a fleet of three aircraft which operate in overlapping shifts around-the-clock. A piloted, FAA-certified High Altitude Long Operation (HALO) aircraft will provide the "hub" of the network.

As for the SkyStation system, the major advantage is the closeness to earth, allowing better frequency reuse and less power (eirp) to be spent on transmission. The antenna footprint will be 80 to 120 km in diameter. HALO can complement satellite systems by transmitting local or regional content, and by serving as a local concentrator of data traffic. The HALO aircraft is 10 to 1 000 times closer to the user than a satellite, with 10 times the available electrical power. Consequently it can allocate additional capacity directly to specific regions. The system can also be financed one market at a time, and as opposed to satellites, the aircraft can be steadily enhanced with emerging technologies resulting from world-wide competition.

Also at the Ka-band, the high signal power available from HALO helps combat heavy rain-fading better than satellites can. Angel plans to provide broadband services to businesses and consumers utilizing already licensed high-frequency spectrum allocated for terrestrial broadband applications. Angel says it is currently in discussion with a number of spectrum holders.

Initial consumer data-rates range from 1 to 5 Mbps, but plans are to increase the rates later. Business users will be offered connection speeds ranging from 5 to 12,5 Mbps, and high capacity users at 25 Mbps and higher .The Network will offer access and dedicated point-to-point connections.

The terminal is designed for rapid installation and ease of use, with the auto-tracking antenna being self-pointing when mounted with a clear view of the aircraft.

HALO claims it will be able to offer low prices for communications. Initial subscriber capacity will be able to support around 5 000 simultaneous users with DS1 capacity.

Angel Technologies aim to create a wireless broadband "super-metropolitan area" network to interconnect tens to hundreds of thousands of subscribers at multi-megabit per second data rates. HALO Networks will be financed and deployed to select markets, on a city-by-city basis, around the world.

The main company behind the project is Angel Technologies, and the Board of Directors of Angel includes Edward F. Tuck, who also proposed Teledesic.

Reference: http://www.angeltechnologies.com.

10 Received BSM standardization issues

The following tables bring together the statements made on standardization by the companies which provided questionnaire responses.

Table 25: recommendations for standardization

System Proponent	Recommendations for Standardization
Astrolink	Astrolink considers landing rights, blanket licensing, and host nation agreements to be the most relevant issues for standardization. Astrolink thinks an ETSI standard for type approval would most probably be helpful, depending on details of type approval. They would be interested in influencing the development of the standards ETSI will produce for type approval.
EUTELSAT	EUTELSAT considers the following to be relevant issues for standardization: RF spectrum emissions; Application interface (see DVB-MHP); Radio interface; IF interfaces and/or antenna interfaces. EUTELSAT participates in standardization work, mainly within the DVB project.
ICO	The standardization of the satellite component of UMTS reflects many parallels with that of Satellite Personal Communications Networks (S-PCN); it has been recognized that system standards for global satellite systems are not appropriate and provide little or no added benefit. Areas which would benefit from standardization, however, would be: type approval of user terminals (for adoption as harmonized standards); standards for EMC certification; certain elements related to the interconnection and interworking of the core network of satellite UMTS with the core network(s) of the fixed and terrestrial mobile UMTS systems. It is envizaged that these would be undertaken in co-operation with the development of standards for the terrestrial networks.
Motorola	Motorola is interested in standardization of spectrum emissions and possibly the radio interface, which is planned to be open; there may be IPR associated with the radio interface. For M-Star, it is not clear at this time what standardization activity will apply to this system. Motorola is presently participating in relevant standardization work within ETSI.
SES-ASTRA	SES-ASTRA considers the following to be relevant issues for standardization: EMC; RF spectrum emissions; Control and Monitoring; Safety; Radio interface: access scheme and signalling; IF interfaces and/or antenna interfaces **(**indoor unit to outdoor unit**)**. SES-ASTRA thinks an ETSI standard for type approval would be helpful.
SkyBridge	Considering that there are already several systems operating in different frequency bands with different space technologies, it will be difficult to achieve an end-to-end standard such as GSM. However some parts of the system could be standardized in order to facilitate the regulatory regime of each system. For instance, SkyBridge is in favour of a volunteer standard for the terminal, gateway and satellite radio segments. SkyBridge considers the following to be relevant issues for standardization: - frequency sharing and re-use; - avoiding harmful interference to users; - open interfaces; solid IPR which are globally respected. SkyBridge thinks an ETSI standard for type approval would be helpful. In addition, SkyBridge supports the type approval regime currently being established in Europe with the new Type Approval Directive. The GMPCS MoU Arrangements, to which SkyBridge is a signatory, should also apply in the EU and in CEPT countries. There are a number of areas where ETSI standardization is not considered required or applicable for SkyBridge: - Air interface: this interface is by essence specific (and proprietary); - IF and/or antenna interfaces: these interfaces may not be accessible in the SkyBridge system; - User, application and computer interface: the interfaces used by SkyBridge are, or will be, standardized.

System Proponent	Recommendations for Standardization
Teledesic	Teledesic will have open specifications, and is interested in standardization of: Spectrum emissions; User interface; Application interface; Computer interface; IF interfaces; antenna interfaces. Teledesic also notes that it may be desirable to incorporate broadband NGSO FSS provisions in other telecommunications standards. Teledesic is currently involved in standardization activities in ITU-R, FCC and ETSI. Teledesic thinks an ETSI standard for terminal RF characteristics would be valuable for terminal type approval purposes.
WEST	RF part standardization is relevant for broadband satellite multimedia communication. In particular, it allows to find a consensus between all the planned and existing systems, thus ensuring the same chance to exist to every system initiatives. WEST considers the following to be relevant issues for standardization: Spectrum emissions; Application interface. WEST currently participates in ETSI TC-SES on the Ka band Working Group, and thinks that an ETSI standard for type approvals would be helpful.
CyberStar™	CyberStar™ is a global system that will benefit from standardization generally; they are addressing standardization issues both within the US and globally.
HISPASAT	HISPASAT considers the following aspects as the most relevance for standardization: - Air interface (modulation, coding, framing etc.); - Spectrum emissions; - Safety; - IF interfaces and/or antenna interfaces.
Intelsat	INTELSAT participates in different standardization forums including ETSI, and would like to influence the development of the standards ETSI will produce.

11 Regulation and standardization

11.1 Regulation of satellites

11.1.1 ITU - The International Telecommunication Union

The ITU, based in Geneva, Switzerland, provides a forum for international co-ordination of the use of the radiofrequency spectrum. It is an organization within the United Nations and is the oldest international organization still in existence.

Ever since the advent of wireless communication, one of the major responsibilities of the ITU has been to regulate the use of radio frequencies. The work of the ITU is vital for such services as mobile telephony, microwave radio-relay, satellite imaging, television broadcasting, AM, FM and short-wave radio, maritime or aeronautical communications, wireless computing, and a wide variety of other kinds of radio-based networks such as those used by the police, ambulance service, taxis, and so on.

Throughout its history, the ITU claims it has demonstrated a capacity to adapt. None of its [133] Member States has ever resigned, and the ITU itself has survived two world wars during which its Secretariat has continued to function.

The ITU divides the world into three Regions:

- region 1 includes Europe, the Former Soviet Union, Africa and parts of the Middle East;
- region 2 includes the entire Western Hemisphere;
- region 3 includes Asia and Oceana.

Use of spectrum is regulated by frequency band and service type. The regulations usually prescribe the frequencies at which certain services can operate, the maximum power at which they may transmit, the maximum interference they may cause to other users, and the minimum amount of interference they are obliged to endure. Frequency bands are allocated to the various radio-communication services on either an exclusive or a shared basis. There are three categories of service:

1) primary;

2) secondary; and

3) permitted.

International allocations and rules for their use are set out in a treaty known as the Radio Regulations. Such allocations may be made world-wide or be limited a region of the world. The Table, and the Radio Regulations of which it forms part, can be amended only by a World Radio communication Conference to which all Member States are invited. Amendments are introduced following negotiations between the national delegations aimed at reconciling the demand for frequencies with the capacity of the spectrum. The conferences are comprized of delegations from roughly 180 countries around the world. Adoption of allocations and regulations is done by majority vote, with each country getting one vote.

11.1.1.1 The ITU and the Ka-Band

The frequency bands 17,7 - 21,2 and 27,5 - 31 GHz have been allocated by the ITU for the use of systems in the FSS as well as for other space and terrestrial services on a shared basis. The Ka band is shared between various services defined by the ITU. Within the Ka band allocated to the FSS, different sub-bands are shared with different services, leading to constraints in system design and operation. Spectrum sharing amongst different satellite systems requires detailed co-ordination, and includes consideration both for the placement of terminals, and also of the frequencies used by the radio carriers in the various systems which might be affected.

BSM systems have been proposed for operations in several frequency bands. The operating conditions and constraints in the international radio regulations that apply to BSM systems are quite complex. Additionally, these provisions vary substantially from one frequency band to another. Readers are referred to the International Radio Regulations and the Final Acts of WRC-97 for more detailed information on the variations in applicable international radio regulations. These variations in regulatory treatment have created differences in the operational requirements of certain BSM systems. These regulatory variations are also likely to raise different standardization issues for the different resulting classes of BSM systems (e.g., those BSM systems to which provisional power limits adopted at WRC-97 apply, and those systems to which they do not). Further consideration should be given to taking account of the different classes of BSM systems in the ETSI BSM standardization process.

11.1.1.2 WRC - World Radio Conference

The World Radiocommunication Conferences (WRC) decides the use of radio spectrum worldwide. The Radio Regulations constitute an international treaty on radiocommunication covering the use of the radio-frequency spectrum by radiocommunication services. World Radiocommunication Conferences (WRCs) may:

- Revise the Radio Regulations and any associated Frequency Assignment and Allotment Plans;
- address any radiocommunication matter of worldwide character;
- Instruct the Radio Regulations Board and the Radiocommunication Bureau, and review their activities;
- Determine Questions for study by the Radiocommunication Assembly and its Study Groups in preparation for future Radiocommunication Conferences.

WRCs are normally convened every two years. The general scope of the agenda is set by a WRC four years in advance. The final agenda is set by the WRC held two years in advance of the conference and is also approved by the ITU Council.

WRC-95 introduced the possibility of using non-GSO systems on an equal priority with GSO systems, allocated 400 MHz of spectrum for NGSO FSS. The WRC-97 allocated another 100 MHz for NGSO FSS.

In the Ku band (10 to 18 GHz), the conference affirmed existing allocations and agreed to new primary allocations to NGSO FSS in the bands between 10,7 to 11,7 GHz; 11,7 to 12,75 GHz (Regions 1 & 3) and 11,7 to 12,7 GHz (Region 2) for downlinks; and 12,75 to13,25 GHz and 13,75 to 14,5 GHz in all Regions for uplinks.

All these allocations are subject to strict power limits for the NGSO FSS, in order to ensure the protection of GSO and other services already operating in those bands. The power limits will be confirmed or modified subject to further studies at the next WRC conference in 2000.

Table 26: Void

11.1.1.3 ITU Space Networks List

The ITU-R Space Network List (SNL) lists all space stations and satellites, among other things, according to frequency. Planned Ka-band satellites can be found here. It can be found at http://www.itu.int/itudoc/itu-r/space/snl.html. The following is a description of the lists that can be found at the ITU-R website.

The annexed list has been prepared with a view to informing administrations in a comprehensive manner of planned or existing space stations giving information on the use of the frequency spectrum, the occupancy of the geostationary orbit as well as on non-geostationary orbits. This list, which is also available on diskette, is updated on a quaterly basis. Subscriptions to it can be ordered from the ITU Sales Service. The list contains the following sections:

Table 27: ITU Space Network List

section 1:	Geostationary space stations communicated in application of the procedures of Articles 11 and 13
Part A:	listed by orbital position and frequency bands
Part B:	listed by orbital position and publications
section 2:	Geostationary space stations communicated in application of Resolution 46
Part A:	listed by orbital position and frequency bands
Part B:	listed by orbital position and publications
section 3:	Geostationary space stations in the Broadcasting-Satellite Service (BSS) communicated in application of Resolution 33
Part A:	listed by orbital position and frequency bands
Part B:	listed by orbital position and publications
section 4:	Geostationary space stations in the Broadcasting-Satellite Service (BSS) (and associated feeder-links) communicated in application of Appendices 30 and 30A (Articles 4 and 5) including Resolution 42
section 5:	Geostationary space stations in the Fixed-Satellite Service (FSS) (by Administrations and publications) communicated in application of Appendix 30B
section 6:	Non-geostationary space stations communicated in application of Articles 11 and 13
Part A:	listed by Administration and frequency bands
Part B:	listed by Administration and publications
section 7:	Non-geostationary space stations communicated in application of Resolution 46
Part A:	listed by Administration and frequency bands
Part B:	listed by Administration and publications
section 8:	Non-geostationary space stations in the Broadcasting-Satellite Service (BSS) communicated in application of Resolution 33
Part A:	listed by Administration and frequency bands
Part B:	listed by Administration and publications
section 9:	List of pending advance publications
section 10	List of pending co-ordination requests

11.1.2 European bodies

11.1.2.1 CEPT

CEPT is the European Conference of Postal and Telecommunications Administrations

The European Conference of Postal and Telecommunications Administrations (CEPT) sprang from the integration movements in Western Europe that marked the 1950s. Its establishment was the result of the efforts of some 20 countries to introduce broad regional co-operation in the field of posts and telecommunications. These efforts led to the creation of an organization flexible and light in structure, open to all European postal and telecommunications administrations of member countries of the Universal Postal Union (UPU) and the International Telecommunication Union (ITU).

Accordingly, CEPT was established by formal Agreement reached at Montreux, Switzerland, on 26 June 1959.

Until the early 1980s, CEPT was essentially involved in activities of an administrative, technical and operational nature. In the past ten years, however, legislative and regulatory tasks have become increasingly important. Also, the postal and telecommunications sectors have grown more noticeably divergent in their development, with the creation in 1988 of both the European Telecommunications Standards Institute (ETSI) and the International Post Corporation (IPC), whose membership includes a number of postal operators from outside Europe.

Since September 1992, CEPT has been an organization of regulators. Under its terms of reference, it is required to consider, in a European context, public policy and regulatory matters relating to posts and telecommunications and to foster the harmonization of regulations. The members of CEPT are the postal and telecommunications administrations which at national level, are competent in these fields.

The main body of CEPT is its Plenary Assembly, which meets once every three years. In the interval, day-to-day business is handled by the Managing Administration. The work is essentially dealt with by the following three Committees:

- European Committee on Postal Regulation (CERP);
- European Committee for Telecommunications Regulatory Affairs (ECTRA);
- European Radio-communications Committee (ERC).

The Committees make up working groups and other bodies. The ERC and ECTRA have each a permanent office in Copenhagen (ERO and ETO).

In the past few years, the geographic area covered by CEPT has expanded eastward with the accession of the administrations of some 16 countries. It is expected that it will soon cover almost all of Europe.

CEPT membership currently comprizes the postal and telecommunications administrations of the following 43 countries:

Albania, Andorra, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Great Britain, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Moldova, Monaco, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, San Marino, Slovakia, Slovenia, Spain, Sweden, Switzerland, The former Yugoslav Republic of Macedonia, Turkey, Ukraine, Vatican.

Every year a CEPT Radio Conference is arranged in order to provide a forum for customers, organizations and other interested parties to meet with the radio regulators of Europe and discuss the developments in the radio regulatory field.

At the Conference the plans and work programme for the forthcoming years are presented. The Conference of course presents an excellent opportunity for interested parties to influence the work and decision making in CEPT through direct contacts with ERC officials and the frequency managers and radio regulators from the national administrations of Europe.

ERO in Copenhagen is the contact point for CEPT (see below).

URL: http://www.thk.fi/suomi/cept/ceptinfo.htm.

11.1.2.2 ERC / ERO

The ERO is the European Radio-communications Office, the permanent office for the CEPT Radio Regulatory Administrations in Europe, and Center of expertize and focal point for consultations on frequency management and radio regulatory matters.

The functions of the ERO are defined in the ERO Convention and include a role in the long term planning of the radio spectrum, liaison with national frequency management authorities, co-ordination of research studies and consultation with interested parties on specific topics or parts of the frequency spectrum. In addition the ERO assists the European Radio-communications Committee (ERC) in carrying out its numerous activities. This latter point is also embodied in our mission statement where it is stated that the ERO will support the ERC to achieve its policy goals and objectives.

The ERC (European Radio-communications Committee) is a forum for Radio Regulatory Administrations in Europe to co-ordinate and standardize the use of radio-communications in Europe.

Another important role of the ERC is to co-ordinate European preparations for the ITU World Radio Conferences taking place every second year. A special Conference Preparatory Group (CPG) co-ordinates European views and proposals for the Conference.

The purpose of the ERC is:

- to develop radio-communications policies;
- to co-ordinate frequency, regulatory and technical matters concerning radio-communications, including the use of the geo-stationary satellite orbit;
- to liaison with other relevant entities within CEPT dealing with regulatory telecommunications matters other than radio;
- to develop guidelines in respect of radio-communication matters in preparation for ITU meetings such as Plenipotentiary Conferences, Council Meetings, Radio Conferences and Radiocommunications Assemblies.

The membership of the ERC consists of the national regulatory authorities in Europe who are members of CEPT. Other participants in ERC affairs include:

- representatives (counsellors) of the European Commission and of the European Free Trade Association Secretariat. The counsellors participate in meetings of the ERC and its Working Groups;
- the representatives of relevant inter-governmental organizations as well as other organizations or Administrations concerned with telecommunications who may be invited by the relevant chairman to participate as observers in meetings of the ERC and its constituent bodies on an ad-hoc basis, unless the ERC decides otherwize;
- members of the European Telecommunications Standards Institute (ETSI) who are entitled to participate as observers in project teams of the Spectrum Engineering Working Group.

URL: http://www.ero.dk

The ERC has produced decisions on:

- Use of frequency bands [2];
- Exemption form individual licenses [3].

Such decisions are also needed for Broadband Multimedia Terminals, especially in regard to exemption from individual licenses.

11.1.3 US American bodies

11.1.3.1 FCC - Federal Communication Commission

The FCC's International Bureau is the main regulator of non-governmental satellite radio-communications in the United States. Satellites are generally licensed by the type of service they provide (e.g. fixed satellite service, mobile satellite service, broadcast satellite service).

In February 1997, the FCC's International Bureau issued separate Orders that granted licenses to thirteen companies for 73 satellites that will provide GEO Fixed Satellite Services (FSS) in the Ka band, as well as issuing an orbital assignment plan for the satellites. Several of these systems propose world-wide services, and therefore the FCC awards are of interest also for the European community.

The FCC claim that these licenses would allow satellite companies to provide consumers with the "next generation" of exciting new satellite communications services that will deliver television, telephone and other data services.

The International Bureau of the FCC took the first step to providing these new types of satellite services in a September 1995 Public Notice that called for satellite applications in the Ka-band. The Commission set aside a portion of the spectrum in the 28 GHz band for these types of systems in a July 1996. In February 1997, the satellite industry completed an agreement on an assignment plan for orbit locations for these satellites, which lead to the FCC approval of the systems.

From FCC, ETSI is informed that:

1) First, the FCC recently conducted a hearing on bandwidth issues, both for wireline and wireless services. There was some testimony concerning satellite services. Transcripts are, or should be shortly, available.

2) Second, the FCC has addressed some basic spectrum allocation and licensing matters, although in varying degrees for different bands. Regulations for C and Ku band geostationary systems are well-established, although considerable work is now underway concerning non-geostationary systems, prompted in part by the SkyBridge proposal. At Ka-Band, a substantial number of standards have been developed, including antenna standards, for the geostationary services. The main requirement is compliance with the 2 degree separation standards currently in force at C and Ku bands. At higher frequencies, standardization is at an earlier stage.

3) Third, the FCC will also initiate, in August 98, an inquiry concerning advanced telecommunications services, which will encompass satellite, other wireless, and wireline services that provide advanced broadband capacity.

Reference: http://www.fcc.gov, Karl Kensinger (Kkensing@fcc.gov)

11.1.3.2 FCC GEO licences

Twelve U.S. firms received licenses May 9, 1997, from the U.S. Federal Communications Commission to provide broadband communication services using GEO satellites. The licenses grant the companies permission to deploy a combined total of 73 satellites. The satellites will provide high-data-rate services including two-way video and Internet access using Ka-band frequencies.

The licensees were:

1) Motorola Inc.;

2) EchoStar Communications Corp.;

3) Ka-Star Satellite Communications Corp.;

4) Hughes Communications Inc.;

5) GE American Communications Inc.;

6) Morning Star Satellite Corp.;

7) NetSat 28 Co. L.L.C.;

8) Orion Network Systems Inc.;

9) PanAmSat Corp.;

10) Lockheed Martin Corp.;

11) Loral Space & Communications Ltd.; and

12) VisionStar Inc.

AT&T also received a license, but has cancelled their plans for the Voicestar system.

In addition, Teledesic holds an FCC license for NGSO Ka-band communications.

Table 28: FCC Ka-Band Orbital Assignment Plan

Location	Company
147° W.L.	Morning Star Satellite Company, L.L.C.
127° W.L.	[under consideration]
125° W.L.	PanAmSat Licensee Corporation
121° W.L.	Echostar Satellite Corporation
115° W.L.	Loral Space & Communications, LTD.
113° W.L.	VisionStar, Inc.
109.2° W.L.	KaStar Satellite Communications Corp.
105° W.L.	GE American Communications, Inc.
101° W.L.	Hughes Communications Galaxy, Inc.
99° W.L.	Hughes Communications Galaxy, Inc.
97° W.L.	Lockheed Martin Corporation
95° W.L.	NetSat 28 Company, L.L.C.
91° W.L.	Comm, Inc.
89° W.L.	Orion Network Systems
87° W.L.	Comm, Inc.
85° W.L.	GE American Communications, Inc.
83° W.L.	Echostar Satellite Corporation
81° W.L.	Orion Network Systems
77° W.L.	Comm, Inc
75° W.L.	Comm, Inc.
73° W.L.	KaStar Satellite Corporation
67° W.L.	Hughes Communications Galaxy, Inc.
62° W.L.	Morning Star Satellite Company, L.L.C.
58° W.L.	PanAmSat Corporation
49° W.L.	Hughes Communications Galaxy, Inc.
47° W.L.	Orion Atlantic, L.P.
21.5° W.L.	Lockheed Martin Corporation
17 W.L.	GE American Communications, Inc.
25° E.L.	Hughes Communication Galaxy, Inc.
28° E.L.	Loral Space & Communications, LTD.
30° E.L.	Morning Star Satellite Company, L.L.C
36° E.L.	Hughes Communications Galaxy, Inc.
38° E.L.	Lockheed Martin Corporation
40° E.L.	Hughes Communications Galaxy, Inc.
48° E.L.	Hughes Communications Galaxy, Inc.
54° E.L.	Hughes Communications Galaxy, Inc.
56° E.L.	GE American Communications, Inc.
78° E.L.	Orion Network Systems, Inc.
101° E.L.	Hughes Communications Galaxy, Inc.
105,5° E.L.	Loral Space & Communications, LTD.
107,5° E.L.	Morning Star Satellite Company, L.L.C.
111° E.L.	Hughes Communications Galaxy, Inc.
114.5° E.L.	GE American Communications, Inc.
124,5° E.L.	Hughes Communications Galaxy, Inc.
126,5° E.L.	Orion Asia Pacific Corporation
130° E.L.	Lockheed Martin Corporation
149° E.L.	Hughes Communications Galaxy, Inc.
164° E.L.	Hughes Communications Galaxy, Inc.
173° E.L.	Hughes Communications Galaxy, Inc.
175,25° E.L.	Lockheed Martin Corporation

11.1.3.3 The satellite regulatory process of the FCC

As the regulatory process of the FCC may be of interest also for European business, this subclause is included for reference.

For service in the US, satellite systems must be licensed by the Federal Communications Commission (FCC).

The FCC publishes a notice in the Federal Register that it is accepting applications for a given service. Applications must then be received by the FCC by a specific date, after which the filing window is shut and other applications are rejected. The FCC then checks for completeness and accuracy of the applications. The entire process sometimes occurs before the FCC has allocated spectrum to the service or adopted rules regarding licensee qualifications and service requirements. Applications are accepted before these rules are adopted due to the needs of the international spectrum use co-ordination process.

Spectrum is allocated through ITU at the WRC conferences at an international level before it is allocated domestically by the FCC. The first step in this co-ordination process is notifying the ITU that a country intends to use a certain satellite frequency band. This initial notification serves as a "place holder" and puts other administrations on notice that they must co-ordinate their use of that spectrum with the notifying administration. By allowing entities to submit applications before spectrum is allocated domestically, applicants can insure an early position in the co-ordination process, thereby protecting their rights against future filings by other administrations.

After applications are accepted for filing within the U.S., the FCC initiates a rulemaking proceeding to implement the international spectrum allocation for the service and also to adopt licensee qualification and service rules. Comments are received from interested parties and the pending applicants and a reply comment period is allowed to give interested parties a chance to reply to the comments received in the initial round. After evaluation of the comments and replies, the FCC adopts the allocation, sometimes with signal power or other usage limitations. Rules governing provision of the service and licensee qualifications are issued either concurrently or in a separate order.

After the service rules are released, applicants are given a short amount of time (usually 60 days) to revise their applications to comply with the newly adopted rules. In the past, these rules have focused on the financial qualifications of applicants and the ability of the applicants to share the available spectrum. If the original applications were mutually exclusive (that is, not all the applicants can be accommodated in the available spectrum), applicants are given the opportunity to resolve mutual exclusivity through the use of engineering or operational solutions.

In non-mutually exclusive situations, licenses are typically issued from 2 to 6 months from the date amended applications are submitted. If the applications are mutually exclusive, the Commission will move to auction the licenses relatively quickly (within 1 to 2 months) and award the licenses immediately upon close of the auction. Licensing of the two Advanced Communications Corporation direct broadcast satellite licenses was completed in less than three days of auctions.

- FCC has modified their rules to allow for use of either orthogonal linear or orthogonal circular polarization by systems operating in the Ka-band;

- the 28 GHz band plan designates the 17,7 to 18,8 GHz and 19,7 to 20,2 GHz bands for GSO FSS operations, with the entire 17,7 to 18,8 GHz band to be shared on a co-primary basis with the fixed service;

- the 28 GHz band plan designates spectrum in the 28,35 to 28,6 and the 29,25 to 30,0 GHz band for uplink GSO FSS operations. Two hundred fifty megahertz of this spectrum at 29,25 to 29,5 GHz is to be shared on a co-primary basis with NGSO MSS feederlinks.

Source: http://www.LTA.com

11.1.3.4 NTIA - National Telecommunications and Information Agency

NTIA co-ordinates government usage of spectrum in the United States. NTIA negotiates with the FCC to ensure compatibility between public and private spectrum uses.

11.2 Standarization bodies and projects

As many of the proposed satellite systems are global, both European and non-European bodies are included in this subclause.

11.2.1 ETSI

This subclause briefly describes some of the bodies within ETSI which may be involved in standardization issues connected with Broadband Satellite Multimedia.

11.2.1.1 TC-ERM

TC-ERM is responsible for the standardization of Electro Magnetic Compatibility (EMC) and radio spectrum matters.

TC ERM was formed in the Spring of 1997 out of a former ad hoc group, to bring together radio and EMC interests from TC Radio Equipment and Systems (RES), TC Satellite Earth Stations and Systems (SES) and Equipment Engineering (EE). To organize its work, the new TC initially established two core Working Groups: one on EMC (ERM-EMC) and the other on radio spectrum matters (ERM-RM). Their remits are to cover activity horizontally across the whole of ETSI.

The radio project work inherited from TC RES was restructured and six Working Groups were set up, dealing individually with maritime, land mobile (three groups), aeronautical and radio site engineering aspects. There are also a number of Task Groups (TGs), reporting directly to TC ERM, to handle specific aspects, such as Global Satellite Navigation.

The ERM-EMC Working Group has a well established working relationship with the European Committee for Electrotechnical Standardization (CENELEC) and the two bodies have been able to successfully resolve a number of disparate interests in EMC activities. ERM-EMC forms the principal interface for ETSI with CENELEC on EMC issues.

Similarly, the ERM-RM Working Group forms the principal interface for ETSI with the European Radiocommunications Committee of the European Conference of Postal and Telecommunications Administrations (CEPT-ERC) on radio spectrum matters, and it is expected that the CEPT-ERC/ETSI Memorandum of Understanding will be revised and updated in 1999.

The activities of the new TC (EMC and Radio spectrum matters) fall largely into five broad areas:

1) studies of the EMC and radio parameters and their methods of measurement taking due account of the work in the international community and specifically IEC;

2) preparation of ETSI deliverables as required by ETSI members, or those to support mandated work from the EC/EFTA in elaboration of EU Council Directives or as requested by CEPT ERC;

3) preparation of ETSI deliverables used to describe the electromagnetic and/or radio environment;

4) co-ordination of ETSI positions on the efficient use of the radio spectrum and spectrum allocations and the administration of the MoU between CEPT ERC and ETSI. These will be carried out in close co-operation with relevant ETSI Technical Bodies;

5) restructuring of the work of TC-RES to provide for a separation between the "horizontal" and "vertical" activities presently undertaken. This requires the new TC to take over the responsibility for all of the outstanding work of the former TC-RES on an interim basis.

TC (EMC and Radio spectrum matters) also provides ETSI with a centre of technical expertize in the radio and EMC fields, able to offer advice to ETSI Technical Bodies, the ETSI Board and the General Assembly.

The working group for EMC has the following responsibilities:

- to prepare draft ETSI deliverables or parts thereof covering EMC requirements and to liaison with other groups as directed by TC ERM;

- to carry out work on methods of measurements for EMC parameters not related to the antenna port of radio equipment as directed by TC ERM.

11.2.1.2 TC-TM

The technical committee TM is, producing specifications for Digital Subscriber Line (DSL) systems for metallic cables. These include Asymmetric DSL (ADSL), High-speed DSL (HDSL) and Very high-speed DSL (VDSL); access techniques complementing or sometimes even competing with satellite access.

The aim of TC TM is to standardize the functionality and performance of transport networks and their elements. Transport networks include everything necessary to provide digital paths between end users and switching nodes, including:

- optical fibre cables and components;

- line systems and multiplexers;
- cross connection equipment;
- end to end performance aspects, including network protection;
- radio relay systems;
- digital subscriber line systems for metallic cables.

Network management aspects are standardized by TC TMN (Telecommunications Management Network).

Network aspects are standardized by TC NA (Network Aspects).

Satellite systems are handled by TC-SES.

11.2.1.3 EP BRAN - Broadband Radio Access Networks

ETSI is to develop specifications for Broadband Radio Access Networks In response to growing market pressure for low-cost, high capacity radio links, the European Telecommunications Standards Institute (ETSI) has announced a standardization project for Broadband Radio Access Networks (BRAN).

This project will provide facilities for access to wire-based networks in both private and public contexts by the year 2000. The BRAN project will address wireless access systems with bitrates of 25 megabits per second or more and operating in either licensed or license exempt spectrum. These systems address both business use and residential access applications. Fixed wireless access systems are intended as high performance, quick to set up, competitive alternatives for wire-based access systems. ETSI's current work on private and business radio networks known under the generic name of HIPERLANs (High Performance Radio Local Area Networks) will be part of the new project.

The specifications to be developed will address the physical layer as well as the data link control layer (with medium access and logical data link control sublayers as appropriate) of broadband systems. Interworking specifications that allow broadband systems to interface to existing wired networks, notably those based on ATM and TCP/IP protocol suites, will also be developed.

The BRAN project is intended to assist regulatory bodies with issues such as the requirements for spectrum and the radio certification specifications that will be required to implement the new broadband radio networks.

To ensure overall coherence with other existing and emerging technologies, close relationships are being established with ATM Forum, IEEE Wireless LAN Committee P 802.11, the Internet Engineering Task Force, the International Telecommunication Union Radio sector (ITU-R) and a number of internal ETSI committees and Projects.

11.2.1.4 TC-SES

The Technical Committee Satellite Earth Stations and Systems (TC SES) is the focal point in ETSI for standardization of Satellite equipment and systems.

TC SES covers the domains related to Fixed Satellite Services (FSS) , Mobile Satellite Services (MSS), Maritime Mobile Satellite Service (MMSS) and Aeronautical Mobile Satellite Services (AMSS).

TC SES prepares standards for regulatory type approval, including specifications limited to essentials requirements, and standards for the specifications of equipment in particular for interworking with the core network of GSM.

TC SES organization comprizes several Working Groups, covering activities such as: Harmonised Standard for Little LEOs, Satellite Interactive Terminals in Ku/Ka bands (SITs), Satellite User Terminal in Ka bands (SUTs), Geostationary Orbit Mobile Radio interface (GMR) interworking with GSM, Satellite Component of UMTS, and will start very soon to work on Non Geostationary Satellite Orbit terminal in Ka bands (NGSO).

TC SES has started to work on European Co-operation for Space Standardization (ECSS) programme.

Regarding the Broadband Satellite Multimedia, TC SES will set up the standardization process following the outputs of the Phase 2 of this Report, by the creation of ETSI Work Items and with the support of at least four full members of ETSI.

11.2.1.5 TIPHON - ETSI work on standardization of voice over the Internet

Project TIPHON (Telecommunications and Internet Protocol Harmonization Over Networks) focuses on interoperability issues. It is making technical recommendations aimed at obtaining full interoperability between different vendors, gateways and gatekeepers and is defining the inter-working between Internet Protocol (IP) telephony and telephony within Switched Circuit Networks (SCNs) It is the aim of TIPHON to be codec independent. The type of coding used should be dynamically chosen by the gateways at call establishment, or even during the call itself if line quality changes. EP TIPHON is working closely with ITU Study Group 16.

At present the following Working Group themes have been identified:

- requirements for service interoperability, technical aspects of charging/billing and security;
- architecture and reference configurations;
- call control procedures, information flows and protocols;
- naming, Numbering and Addressing;
- Quality of Service;
- verification and Demonstration Implementation.

EP TIPHON has six working groups:

- WG 1 deals with requirements, charging and security matters;
- WG 2 deals with architecture models and interfaces;
- WG 3 deals with call control matters;
- WG 4 deals with naming and address translation issues;
- WG 5 deals with quality of service aspects;
- WG 6 deals with verification, demonstration and implementation matters.

11.2.1.6 TC SMG - Special Mobile Group

The TC SMG is responsible for ETSI projects GSM and UMTS.

The mission of SMG is to develop standards for the GSM (Global System for Mobile Communications) family of public digital mobile communications systems with a built-in capability for unrestricted world-wide roaming of users and/or terminals between any networks belonging to this family.

Specifically, its task is to develop and maintain the specifications of the digital cellular telecommunications system operating in the 900 MHz band known as GSM 900 and of its variation in the 1800 MHz band, known as DCS 1800. In addition it is responsible for maintaining the integrity of the GSM platform by close cooperation with ANSI T1P1, who are responsible for the 1900 MHz version, known as PCS 1900.

SMG is also responsible for studying and defining all aspects of third generation mobile systems based on the concept of Universal Mobile Telecommunications System (UMTS), in cooperation with studies by the International Telecommunication Union (ITU) regarding a global system known as the International Mobile Telecommunications 2000 System (IMT 2000).

SMG maintains close working relations with the UMTS FORUM based on the cooperation agreement between ETSI and the FORUM.

The scope of the TB's work is focused to the GSM family. It includes the definition of the GSM services offered and the selection and specification of the most efficient radio techniques and speech coding algorithms including the co-ordination of validation programmes. SMG is also responsible for the elaboration of the GSM network architecture, signalling protocols and conditions of interworking with other networks. SMG deals with all technical aspects of data and telematic services. SMG specifies the appropriate security procedures. In addition SMG is charged with the application of the Telecommunications Management Network (TMN) concept to the GSM network entities. SMG specifies the SIM (subscriber identity module), an intelligent IC card. In addition Base Station and Mobile Station testing is standardized. SMG collaborates with other ETSI TBs, e.g. NA, SPS, and SAGE.

SMG has the primary responsibility within ETSI for co-ordinating with the GSM MoU Association, ECTEL TMS, the UMTS FORUM, ANSI T1P1, the Advanced Communications Technologies and Services (ACTS) mobile project line and Task Group 8/1 of the International Telecommunication Union Radio Sector.

SMG's work can be summed up in just four words advanced personal communications systems. Originally SMG covered only cellular telecommunications but, as mobile terminals became increasingly miniaturized, SMG moved from mobile communications to personal communications.

First known as 'Groupe Spécial Mobile' (TC GSM), the TB's acronym was changed to Special Mobile Group (SMG) when it took on responsibility for the specification work on the next generation of systems known as the Universal Mobile Telecommunications Systems (UMTS) and to cooperate with the ITU work on International Mobile Telecommunications 2000 (IMT 2000).

- SMG Milestones.
- 1982: Formation of the Groupé Spécial Mobile (GSM) committee within Conférence Européenne des Postes et Télécommunications (CEPT) and Chaired by Tomas Haug.
- 1986: The GSM Permanent Nucleus of experts created and located in Paris.
- 1987: GSM Memorandum of Understanding signed.
- 1989: The GSM committee transferred from CEPT to ETSI and became ETSI TC-GSM. The Permanent Nucleus moved to ETSI in Sophia Antipolis, becoming Project Team 12 (PT 12).
- 1990: The GSM Phase 1 specifications were "frozen". GSM Phase 1 comprize of 130 recommendations of which more than 30 became Interm European Telecommunication Standards (I-ETS).
- 1991: First GSM system operational. TC-GSM name changes to TC-SMG.
- 1992: European wide operation of GSM.
- 1993: First DCS (GSM) 1800 system operational.
- 1995: The GSM Phase 2 specifications were "frozen". GSM Phase 2 specifications published as either European Telecommunication Standards (ETS) or ETSI Technical Reports (ETR).
- 1996: Restructuring of ETSI technical Bodies, TC-SMG became Technical Body SMG responsible for ETSI projects GSM and UMTS. SMG began yearly releases of GSM Phase 2+ . GSM MoU ETSI co-operation agreement signed.
- 1997: GSM Phase 2+ implementation. Common specifications agreement with ANSI T1P1, GSM North America.
- 1998: UMTS radio access technology chosen.
- 1998: June, Submission of the UTRA RTT candidate to the ITU.
- 1998-1999: UMTS Phase 1 standards ?

11.2.2 ESA - European Space Agency

An important part of the ARTES-3 programme is the contribution to the setting standards in the satellite multimedia market. In this effort ESA is creating liaisons with the major satellite operators, industry and the relevant standardization bodies.

An Ad Hoc group, comprizing representatives of Eutelsat, Hispasat, Intelsat, SES-ASTRA, Telenor, Telesat, Teracom and ESA, has been meeting over the period September 1997 - August 1998 to initiate development of an open standard for a satellite interactive terminal which would allow operators of different satellite systems offering a DVB forward channel and an interactive return channel to implement different service provisions with the same SIT hardware. The Ad

Hoc Group is preparing a definition of the SIT characteristics including RF, modulation, coding, framing, multiple access protocol and signalling parameters.

ESA has several projects related to broadband multimedia over satellite. More about this in the clause 13 on development programmes.

11.2.3 TIA - Telecommunications Industry Association

The following information is from the TIA web site (http://www.tiaonline.org).

TIA established the Satellite Communications Division (SCD) to meet the continuing need for maintaining communications, interoperability and proper utilization of the spectrum and orbits. Spectrum sharing, spectrum management and interoperability between the Fixed Service (FS), Fixed Satellite Service (FSS) and Mobile Satellite Service (MSS) are becoming more critical when viewed from the perspective of the international telecommunications community. The need to identify and establish standards that will ensure that the integrity of communications networks is maintained is of paramount importance in addressing interoperability, interworking and interconnection issues. The emerging need for collaborative standards development work, to enable interoperability and interconnectivity between the different existing and planned networks and systems, that will eventually result in ubiquitous, anywhere, anytime communications, has become increasingly apparent to the telecommunications industry.

The Satellite Communications Division has been in existence since 1996. Some of its current members include Hughes, Comsat, AT&T Labs, Nortel, Ericsson, Boeing, Alcatel, Bellcore, Lucent Technologies and Motorola. The Division includes two sections, the Communication and Interoperability Sections (CIS) and the Spectrum and Orbit Utilization Section (SOUS).

The Division sponsors TR-34, the Satellite Equipment and Systems Committee, which includes two subcommittees, TR-34.1 and TR-34.2. These two subcommittees have retained the same names as their respective Sections. TR-34.1 established seven Working Groups (WGs) that pursue topics on Asynchronous Transfer Mode (ATM) Speech, ATM Traffic and Congestion Control, ATM Quality of Service, Data Protocols, Call and Connection Management. Interoperability Reference Models, and Common Air Interfaces for Mobile Satellite Systems. The TR-34.2 work program mainly involves spectrum-related issues. These issues include 2 GHz applications, consideration of and response to FCC Notices of Proposed Rule Making (NPRM), such as the 38 to 50 GHz NPRM, US position with respect to World Radio Conference (WRC) issues, Ka band Geostationary Earth Orbit (GEO) licenses, the Blanket Licensing issue, Non-Geostationary Orbit/Fixed Satellite Service (NGSO/FSS) sharing and licensing, etc.

Considerable interest in the establishment of the SCD and in the work of its Sections and Technical Committee and Subcommittees has been shown by the telecommunications industry. The emerging need for collaborative standards development work, to enable interoperability and interconnectivity between the different existing and planned satellite and terrestrial networks and systems, as well as among the various satellite systems and networks, is becoming increasingly apparent to the telecommunications industry.

It is planned for the work products of TR-34 and its subcommittees to be contributed to the International Telecommunication Union. Also, the existing collaboration with the European Telecommunications Standards Institute (ETSI) is expected to become closer, starting in 1998.

- TR-34 Satellite Equipment and Systems

  Responsible for standards for space telecommunication systems. Includes transmitters, receivers, antennas, spacecraft and associated equipment for both space and earth segments, including multiple access and interfaces with other systems, as well as radiation phenomena, characteristics of propagation along the path, and data transmission systems which are an integral part of the space system.

- TR-34.1 Communications and Interoperability

  Encompasses issues such as interoperability among satellite and terrestrial systems and among satellite systems and services. These issues may include, both domestic and global, technical standards which are important to the industry. The TR-34.1 will oversee a structure of Task Groups which may address specific issues. In issues in which there is common interest with organizations outside of TIA, liaisons may be established to jointly determine how these interests may best be represented.

- TR-34.2 Spectrum and Orbit Utilization

  TR-34.2 is responsible for standards and studies related to the efficient use of spectrum and orbit resources for satellite communications systems. The work of TR-34.2 includes both space and earth segments of satellite communications systems and networks.

  TR-34.2 draws on the broad interests and representation of the membership of TIA to create joint industry working groups to study subjects of intense interest to the satellite communications community, such as efficient use of spectrum through inter-service sharing by the new satellite communications services and the existing or new terrestrial services.

ETSI has liaisons with TIA.

11.2.4 ATM Forum

The ATM Forum is an international non-profit organization formed with the objective of accelerating the use of ATM (Asynchronous Transfer Mode) products and services through a rapid convergence of interoperability specifications. In addition, the Forum promotes industry co-operation and awareness.

The ATM Forum consists of a worldwide Technical Committee, three Marketing Committees for North America, Europe and Asia-Pacific as well as the User Committee, through which ATM end-users participate.

The ATM Forum Technical Committee meets 5 times a year in various locations throughout the world. At these meetings, Principal Member companies come together to discuss ATM technology and author ATM specifications. These meetings are open to Principal Members only. ENR Members may attend as liaisons.

The ATM Forum defines ATM standards that any ATM satellite system in practice most probably must comply with.

Worldwide headquarters: 2570 West El Camino Real, Suite 304, Mountain View, CA 94040-1313

info@atmforum.com

Reference: http://www.atmforum.com/

11.2.5 DVB Project

The Digital Video Broadcasting Project (DVB) includes over 220 well known organizations in more than 30 countries worldwide. Members include broadcasters, manufacturers, network operators and regulatory bodies, committed to designing a global family of standards for the delivery of digital television. DVB-compliant digital broadcasting and reception equipment for professional, commercial and consumer applications is widely available on the market. Numerous broadcast services using DVB standards are operational, in Europe, North and South America, Africa, Asia, and Australia.

The DVB system has the capability to utilize a return path between the set-top decoder and the broadcaster. This can be used by a subscriber management system. It requires a modem and the telephone network, or a cable TV return path or even a small satellite up-link. This return path can potentially be used for audience participation, such as voting, games playing, tele-shopping, and tele-banking, and also for delivering messages to the decoder. Although the limited bandwidth envizaged for the return path is unlikely to be suitable for sending moving video images from the home back to the broadcaster, future developments could allow this to happen. DVB already offers a kind of interactivity without the need for a return path, simply by the breadth of programme choice available, e.g. multiple camera sports events and near video on demand.

There is an endorsement by the DVB Steering Board which is a first step in the development of open technical specifications for a Multimedia Home Platform (MHP). These specifications are targeted for completion by mid 1998 will be put forward as proposals for non-mandatory standards to European and International Standards bodies.

The DVB-S system is designed to cope with the full range of satellite transponder bandwidths. DVB-S is the oldest, most established of the DVB standards family, and arguably forms the core of the DVB's success. Services using DVB-S are on-air on 6 continents.

11.2.6 Internet Engineering Task Force - IETF

The Internet Engineering Task Force (IETF) is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet. It is open to any interested individual.

The actual technical work of the IETF is done in its working groups, which are organized by topic into several areas (e.g., routing, transport, security, etc.). Much of the work is handled via mailing lists. The IETF holds meetings three times per year.

The IETF working groups are grouped into areas, and managed by Area Directors, or ADs. The ADs are members of the Internet Engineering Steering Group (IESG). Providing architectural oversight is the Internet Architecture Board, (IAB). The IAB also adjudicates appeals when someone complains that the IESG has failed. The IAB and IESG are chartered by the Internet Society (ISOC) for these purposes. The General Area Director also serves as the chair of the IESG and of the IETF, and is an ex-officio member of the IAB.

The Internet Assigned Numbers Authority (IANA) is the central co-ordinator for the assignment of unique parameter values for Internet protocols. The IANA is chartered by the Internet Society (ISOC) to act as the clearinghouse to assign and co-ordinate the use of numerous Internet protocol parameters.

Reference: http://www.ietf.org/

11.2.6.1 Internet over satellite

The TCP over Satellite Working Group shall produce an informational document which describes the issues affecting TCP throughput over satellite links. It identifies the domains in which each issue applies, including network topology, satellite orbit (LEO, MEO, GEO), and link rates; fixes, both protocol and implementation, that ameliorate reduced throughput; and areas for further research. The purpose of including this information is to direct the research community to the areas in which show promize, not to perform the research or even advocate the results.

The scope of this working group will include consideration of the following:

- transport layer issues affecting TCP over satellite links o Existing TCP options;
- compliant implementations which have some known improved performance over satellite links;
- recommendation of well understood protocol changes;
- identification of protocol changes that are potentially promizing but require more further investigation in order to be well understood.

The working group will consider in depth security issues that are relevant, describing risks and indicating how they may be addressed. It is possible to be put on a mailing list. To Subscribe: majordomo@listserv.trw.com, In body: subscribe tcp-over-satellite.

Reference:

IETF: http://www.ietf.org/html.charters/tcpsat-charter.html

and

NASA: http://tcpsat.lerc.nasa.gov/tcpsat/

The latter includes links to many references to relevant articles on the subject.

11.2.7 UMTS forum

UMTS is the future Universal Mobile Telecommunications System. A number of Telecom Operators, Manufacturers, National Regulatory Agencies, and other organizations within the telecommunications field has decided to create a UMTS Forum.

It is an open and independent forum with the aim to create a definition of the UMTS concept, combining personal communications with multimedia services and applications, built on existing fixed and mobile infrastructures. A common view for the development and implementation of UMTS is based on membership consensus, and contributes towards building the Information Society.

The UMTS Forum will provide advice and recommendations to the European Commission, European Radio-communication Office, European Telecommunications Office, European Telecommunications Standards Institute and National Regulatory Authorities. Representatives from these bodies take part in the work.

The UMTS Forum has calculated the total demand for terrestrial spectrum in 2010 to be 580 MHz. For terrestrial services in Europe, 240 MHz are defined for second generation standards. The Forum has earlier concluded that the full 155 MHz for terrestrial UMTS designated by the ITU should be made available. To meet the UMTS market forecast an additional 185 MHz is required.

The calculated spectrum demand for the satellite component of UMTS is 50 MHz by 2005 and 90 MHz by 2010. There is a need to designate an additional 20 MHz as start-up band for non-public non-licensed in-building low mobility systems. This spectrum will be required from the year 2002 to help build the market for multimedia terminals and to stimulate a demand for public UMTS access.

Reference: http://www.umts-forum.org/index.html

11.2.8 ISOC - The Internet Society

The Internet Society is a non-profit, non-governmental, international, professional membership organization. It focuses on: standards, education, and policy issues.

The Internet Society is a professional membership society with more than 100 organizational and 6,000 individual members in over 100 countries. It provides leadership in addressing issues that confront the future of the Internet, and is the organization home for the groups responsible for Internet infrastructure standards, including the Internet Engineering Task Force (IETF) and the Internet Architecture Board (IAB).

ISOC is engaged in Internet over satellite, and searching their web-site for "satellite" gives several hits.

Reference: http://www.isoc.org/isoc/

11.2.9 NIST National Institute of Standards and Technology (US)

The United States National Institute of Standards and Technology (NIST) was established by Congress "to assist industry in the development of technology needed to improve product quality, to modernize manufacturing processes, to ensure product reliability and to facilitate rapid commercialization of products based on new scientific discoveries."

An agency of the U.S. Department of Commerce's Technology Administration, NIST's primary mission is to promote U.S. economic growth by working with industry to develop and apply technology, measurements, and standards. It carries out this mission through a portfolio of four major programs:

Measurement and Standards Laboratories that provide technical leadership for vital components of the nation's technology infrastructure needed by U.S. industry to continually improve its products and services;

- a rigorously competitive Advanced Technology Program providing cost-shared awards to industry for development of high-risk, enabling technologies with broad economic potential;
- a grassroots Manufacturing Extension Partnership with a network of local centers offering technical and business assistance to smaller manufacturers; and
- a highly visible quality outreach program associated with the Malcolm Baldrige National Quality Award that recognizes continuous improvements in quality management by U.S. manufacturers and service companies.

Reference: http://www.nist.gov

11.3 GMPCS MoU

Memorandum of Understanding to Facilitate Arrangements for Global Mobile Personal Communications by Satellite, Including Regional Systems (GMPCS-MoU) [9]. The GMPCS now also covers fixed satellite services, FSS.

It concerns the need to reach regional, and preferably global, arrangements on issues related to facilitating circulation of user terminals as follows:

- permission to carry a terminal into a visited country but not to use it; and
- permission to carry a terminal into a visited country and to use it within the framework of a licensing scheme (i.e. without the need for obtaining individual authorization for the terminal in the visited country);
- technical conditions for placing terminals on the market.

The Signatories to this Memorandum of Understanding, who include Administrations, GMPCS operators, service providers and manufacturers, agree to cooperage, according to their respective roles and competencies, on the following issues:

- **Article 1 - Type Approval of Terminals:** The Signatories will develop arrangements on the essential requirements necessary for the type approval of terminals, and the means by which such approvals will be mutually recognized. The type approval standards should be based on the relevant ITU Recommendations, and should be impartial with respect to all GMPCS technologies.
- **Article 2 - Licensing of Terminals:** The Signatories will develop arrangements on the means by which licences should be granted based on general licences (e.g. class licences or blanket approvals). Such arrangements will be drawn up and include the means by which these general licences will be mutually recognized.
- **Article 3 - Marking of Terminals:** The Signatories will develop arrangements on the marking of terminals which will permit their recognition and the implementation of the arrangements on mutual recognition of type approval and licensing.
- **Article 4 - Customs Arrangements:** The Signatories will develop recommendations to their competent authorities proposing exemption of GMPCS terminals from customs restrictions when brought into a country on a temporary or transitory basis.
- **Article 5 - Access to Traffic Data:** The Signatories will develop arrangements for GMPCS operators to provide, on a confidential basis, within a reasonable period of time to any duly authorized national authority which so requests, appropriate data concerning traffic originating in or routed to its national territory, and to assist it with any measures intended to identify unauthorized traffic flows therein.
- **Article 6 - Review:** The Signatories will periodically review the results and consequences of their co-operation under this Memorandum of Understanding. When appropriate, the Signatories will consider the need for improvements in their co-operation and make suitable proposals for modifying and updating the arrangements, and the scope of this GMPCS-MoU.

The MoU can be found at http://info.itu.ch/GMPCS/gmpcs-mou/final/mou-e.htm

12 Broadband system comparisons

Table 29: System comparisons (A to M)

System	Primary Backer(s)	Country of origin	Uplink band	Downlink band	GEO Slots	Satellites:			Covers Europe?
						GEO	MEO	LEO	
Afrisat	Not Known	UK	Ka	Ka	4	2			Not Known
Arabsat	Arabsat	Arab League	Ka	Ka	3	4			Not Known
Asiasat K	Not Known	Hong Kong	Ka	Ka	5	6			No
Astra K	SES	Luxembourg	Ka	Ku	21	24			Yes
Astrolink	Lockheed Martin	USA	Ka	Ka	5	9			Yes
Bifrost	Telenor	Norway	Ka	Ka	1	2			Yes
Cansat K	Telesat Canada	Canada	Ka	Ka	5	2			Not Known
Celestri LEO	Motorola	USA	Ka	Ka		5		63	Yes
Chinasat 41-48	Chinese Govt.	China	Ka	Ka	9	11			No
CyberPath	Loral Space	USA	V	V		10			Yes
Cyberstar	Loral Space	USA	Ku / Ka	Ku / Ka	4	4	9		Yes
Dacomsat-4	Dacom	South Korea	Ka	Ka	1	2			No
DB-Sat	Not Known	Germany	Ka	Ka	1	2			Yes
Diamondsat	Not Known	South Africa	Ka	Ka	1	2			No
Echostar	Echostar	USA	Ka	Ka	2	2			No
Euro*star K	Private	Germany	Ka	Ka	3	3			Yes
Euroskyway	Alenia Spazio	Italy	Ka	Ka	7	2			Yes
Eutelsat K	Eutelsat	Europe	Ka	Ku	20	23			Yes
Expressway	Hughes	USA	V	V		14			Yes
Galaxy	Hughes	USA	Ku/ Ka	Ku / Ka					Yes
GE*Star	GE Americom	USA	Ka	Ka	5	9			Yes
GE*StarPlus	GE Americom	USA	V	V	9	11			Not Known
Genesis	DT	Germany	Ka	Ka	6	7			Yes
GESN	TRW	USA	V	V		4	15		Yes
GS-40	Globalstar	USA/Europe	V	V				80	Probably
Hispasat K	Hispasat	Spain	Ka	Ka	1	1			Yes
ICO	ICO	UK	S	S					Yes
Inmarsat	PTTs	International	L / S / Ka	L / S / Ka	5	6			Yes
Insat K	Insat/ISRO	India	Ka	Ka	15	17			No
Intelsat	PTTs	International	Ka	Ka	10	12			Yes
KaStar	Private	USA	Ka	Ka	2	2			No
Koreasat 3	Koreasat	South Korea	Ka	Ka	2	2			No
Kyprosat K	Not Known	Cyprus	Ka	Ka	5	6			Not Known
Logohu	Telikom PNG?	Papua New Guinea	Ka	Ka	7	8			No
Maltasat K	Not Known	Malta	Ka	Ka	3	1			Yes
Measat K	Binariang	Malaysia	Ka	Ka	9	11			No
Medsat	Alcatel.	Mediterranean	Ka	Ka	1	2			Yes
Megasat	Not Known	Mexico	Ka	Ka	10	12			No
Millenium	Motorola	USA	Ka	Ka	4	4			Yes
Milstar	TRW		V	Ka		2+2			Not Known
Morningstar	Private	USA	Ka	Ka	4	4			No
M-Star	Motorola	USA	V	V				72	Yes

Table 30: System comparisons (N to Z)

System	Primary Backer(s)	Country of origin	Uplink band	Downlink band	GEO Slots	Satellites:			Covers Europe?
						GEO	MEO	LEO	
Netsat 28	Private	USA	Ka	Ka	1	1			No
OrbLink	Orbital Sciences		V	V		7			Yes
Orion	Orion	USA	Ka	Ka	6	6			Yes
Paksat K/HDTV	Not Known	Pakistan	Ka	Ka	5	5			No
Palapa K	Palapa	Indonesia	Ka	Ka	3	4			No
PanAmSat	Hughes	USA	Ka	Ka	1	1			Yes
Pentriad	Denali Telecom	?	V	V			13?		No
Q/V-Band System	Lockheed Martin		V	V	5?	9			Not Known
Samsat	Pacific Century	Singapore	Ka	Ka	3	4			No
Sarit	Telespazio?	Italy	Ka	Ka	1	2			Yes
Seysat K	Not Known	Seychelles	Ka	Ka	3	4			No
Sirius 4	NSAB	Sweden	Ka	Ka	1	1			Yes
SkyBridge	Alcatel	France/USA	Ku (/ Ka)	Ku (/ Ka)				80	Yes
Skysat K	Afro-Asian	UK	Ka	Ka	11	2			No
South Africa-sat	Not Known	South Africa	Ka	Ka	1	2			No
SpaceCast	Hughes	USA	V	V	4	6			Not Known
Spaceway	Hughes	USA	Ka	Ka	15	15			No
Spectrum Astro	Aster		V	V		25?			Not Known
StarLynx	Hughes	USA	V	V		4	20		Not Known
Superbird K	SCC.	Japan	Ka	Ka	2	3			No
Teledesic	Gates/McCaw ++	USA	Ka	Ka				288	Yes
Teledesic VBS	Gates/McCaw ++	USA	V	V				72	Yes
Thaicom K	Shinawatra	Thailand	Ka	Ka	5	6			No
Tongasat	Tongasat	Tonga	Ka	Ka	9	11			No
Turksat K	Turksat	Turkey	Ka	Ka	3	3			Probably
V-Band	Leo One USA	USA	V	V				48	No
Videosat	France Telecom	France	Ka	Ka	3	3			Yes
Vinasat	Vietnam	Regional	Ka	Ka	4	5			No
V-Stream	PanAmSat	USA	V	V		12			Yes
West, GSO	Matra Marconi	UK/France	Ka	Ka	12	12			Yes
West, MEO	Matra Marconi	UK/France	Ka	Ka			18		Yes
Yamal	Gazprom	Russia	Ka	Ka	5	2			Not Known
Non-satellite systems									
SkyStation	SkyStation	USA	V	V		Balloons			Probably
Rotostar	Silver Arrow	Israel	Ka?	Ka?		Balloons			Probably
HALO	Angel Technologies	USA	Ka / V	Ka / V		Planes			Probably

13 Major R&D programmes

This clause contains information on some existing or completed relevant R&D projects that relate to broadband satellite multimedia. It is not intended to be a complete survey and description of such projects, but a useful compilation for the generally interested reader. Surely, other projects should or could have been included, but the trade-off that has been made is based on a combination of what the ETSI members of TC-SES has referred us to, as well as what the authors have been able to find out through Internet search.

Major R&D issues relate to:

- propagation studies at the Ka band (and above);
- phased array antennas and cheap antennas for the consumer market;
- cheap tracking antennas for LEO systems. Also securing antenna alignment (GEO, MEO, LEO);
- cheap terminal SSPA with sufficient power for Ka-band systems is important;
- massive launch within a short time-frame of a large number of satellites is important for the LEO systems. So is the more or less continuous replacement of such satellites;
- inter-satellite links in the optical frequency range;

- technology development for terminals in general;
- network architectures and gateway topology;
- ATM over satellite is a major challenge. As most of the broadband satellites systems will support ATM, a common way of implementing ATM over satellite is of significant importance.

Standardization of ATM over Satellite is progressing with several organizations are working in parallel. One organization is the ATM forum, in its Wireless-ATM (WATM) group. Satellite segment constitutes only a minor part of their work. Also, the Telecommunications Industries of America (TIA, www.tiaonline.org) via TR-34.1 has specific working groups on Wireless Asynchronous Transfer Mode (ATM), Internet over Satellite, ATM Speech, ATM Traffic Management and Congestion Control, ATM Quality of Service and Hybrid Reference Models. TIA is also working on a standard air interface for satellites, both for mobile and broadband communications. Further, ESA is working on the subject, which is also true for several universities. Most notably is perhaps the University of Surrey in the UK.

In the eighties the military introduces Ka-band transponders for data transmissions. Japan introduced Ka-band in the early eighties with the Sakura program. In 1991 the first Italsat was launched, a Ka-band only telecommunication satellite; so was ACTS, a NASA satellite launched in 1993.

The following communications satellites are equipped with Ka-band transponders:

ACTS	USA
DFS 1	Germany
DFS 2	Germany
DFS 3	Germany
Italsat 1&2	Italy
NStar A	Japan
Sakura 3A	Japan
Sakura 3B	Japan
Superbird A2	Japan
Superbird B1	Japan

Japan has had Ka satellite systems for 20 years and Italy for 5 years.

A good source of information is Lloyds satellite constellations at http://www.ee.surrey.ac.uk/Personal/L.Wood/constellations/

ATM over satellite links can be found at http://www.atmdigest.com/satellit.htm.

Also, a source of reference is at JPL, at http://msl.jpl.nasa.gov/. This is "the Mission and Spacecraft Library", a public source for information about spacecraft.

13.1 Europe

The two major organizations of interest are probably EU and ESA.

13.1.1 EU projects

13.1.1.1 A summary

During the period 1994-98, all Community RTD activities are carried out under the Fourth Framework Programme (FWP). This subclause summarizes some of these and other EU projects.

1) CORDIS: Community Research and Development Information Services Information about the European programmes and participants can be found on the CORDIS home page http://www.cordis.lu/home.html

2) INFO2000 aims at stimulating the emerging multimedia content industry to recognize and exploit new business opportunities. The central theme is the development of a European information content industry capable of competing on a global scale, and able to satisfy the needs of Europe's enterprises and citizens for information content, leading, on the one hand, to economic growth, competitiveness and employment, and, on the other hand, to individual, professional, social, and cultural development.

3) Information about the INFO2000 programme can be found on their home page http://www2.echo.lu/info2000/infohome.html.

4) ESPRIT is an information technologies programme.

5) ACTS -Advanced Communications Technologies and Services (ACTS).

6) INFOSEC is an initiative of the European Commission concerned with the security of telecommunications and information systems. The initiative has conducted studies and pilot applications addressing legal, regulatory and technical issues surrounding information security.

7) EUREKA promotes pan-European, market-oriented research and development across almost 30 European countries.

8) FAME 2010: Forecasting the Application of Multimedia and its Environment to the year 2010 and beyond (FAME 2010). The study will forecast the technical developments intrinsic to multimedia, then go on to assess the impacts of these across a broad range of social, economic and political fields. It includes focus on *physical enabling technologies* of storage, acquisition, data processing, data exchange, portability and miniaturization; with particular emphasis being given to the development or emergence of *standards*. See http://www.ed.ac.uk/~rcss/fame/WP/WP_Index.html.

9) The ATLANTIC project addresses the requirement for containing the costs and maintaining the Technical Quality of future TV production through the ability to handle and process the video and audio signals as much as possible in compressed form. It includes work on a standardized interface for the compressed signal for studio applications and for *satellite*, cable, and distribution equipment.

10) DESIRE concerns a series of related tasks which extend the technology of the World Wide Web and implement pilot information services on behalf of European researchers. More information from http://www.nic.surfnet.nl/surfnet/projects/desire/.

11) IMPRIMATUR - ESPRIT project. Intellectual Multimedia Property Rights Model and Terminology for Universal Reference.

12) ACCOPI (Access Control and Copyright Protection for Images) and TALISMAN (Tracing Authors' Rights by Labelling Image Services and Monitoring Access Network) are both Digital watermarking projects.

13) MONALISA A virtual studio for live broadcasting. The MONALISA project - Modelling Natural Images for Synthesis and Navigation is a RACE project (R2052) concerned with virtual TV studios and the image mixing necessary to make them work.

14) MUSENET - Media Union Information Society and Education Network

Reference:

EU Projects: http://inf2.pira.co.uk/proj2.htm

ESPRIT: http://www.cordis.lu/esprit/home.html

ACTS: http://www.uk.infowin.org/ACTS/

4^{th} FWP: http://www.cordis.lu/en/src/i_006_en.htm

Most of the current EU projects are under the 4^{th} framework programme. However, the Council of the European Union has formally adopted its common position on the Fifth RTD Framework Programme at its meeting on 23 March 1998. The Council's agreement on ECU 14,000 million over the whole programme would bring considerably lower Community resources to research than the Commission's proposal of ECU 16,300 million and the Parliament's amendment to ECU 16,700 million.

13.1.1.2 ESPRIT

Esprit is an Information Technologies (IT) programme, which is an integrated programme of industrial R&D projects and technology take-up measures. It is managed by the Directorate General for Industry of the European Commission. Esprit forms part of the EU's Fourth Framework Programme (13,215 million EU budget), which runs from 1994 to

1998. Esprit works in close co-operation with other specific programmes, particularly ACTS (telecommunications), IMT (industrial and materials technologies) and Telematics Applications.

Esprit covers, among other things, multimedia systems, and encourages the development of the technologies and tools necessary for industry to implement multimedia end-user systems.

The objective in establishing a network of European Multimedia Support Networks is twofold: to provide a range of services that support the needs of European organizations producing multimedia systems, multimedia content and/or multimedia applications on a continuing basis; and to define and implement best practice as it relates to multimedia support services.

13.1.1.3 ACTS under EU

This programme is not to be confused with the broadband NASA satellite with the same name.

The ACTS Programme was established under the Fourth Framework Programme of European activities in the field of research and technological development and demonstration (1994-1998). The Programme supports research and development in advanced communications in order to facilitate economic development and social cohesion in Europe.

Under the Programme, individual companies, public sector organizations, research institutes, schools and universities work together as individual project consortia, pooling their knowledge and resources in pursuit of specific research objectives covered by the ACTS workplan.

All ACTS research is conducted in the context of usage trials to ensure relevance of the results and to encourage a broadening of awareness of the benefits that advanced communications may bring.

The Programme has a budget of 671 million ECU, which is about 5 % of the total budget available for European research under the Fourth Framework Programme. Given the global nature of the communications business, ACTS encourages participation from non-EU countries. Organizations from anywhere in the world can participate in the Programme without Community funding once their participation is shown to be of mutual benefit to the parties involved.

The web address http://www.infowin.org/ACTS/ANALYSYS/INTRO/annexa.htm provides an overview of the different projects within the fields:

- Interactive Digital Multimedia Services;
- Photonic Technologies;
- High-Speed Networking;
- Mobility and Personal Communication Networks;
- Intelligence in Networks and Services;
- Quality, Security and Safety of Communication Systems and Services;
- Horizontal Actions.

Reference:

http://www.infowin.org/ACTS/RUS/PROJECTS/INFOWIN/PUBLIC/.

There is quite a lot of information available on the ACTS servers.

13.1.1.3.1 DIGISAT

The subtitle of the project is Advanced Digital Satellite Broadcasting and Interactive Services.

The DIGISAT main objectives are:

- to integrate the background technology developed during the previous RACE programme in the field of digital TV broadcasting, in order to demonstrate useful applications for Satellite Master Antenna Television (SMATV) configuration;

- to develop the advanced technology required for the establishment of a return channel via satellite (using existing satellites operating in Ku band) in order to provide SMATV users with interactive capabilities;
- to perform Field Trials with group of users demonstrating the pre-operational phase of DVB services in Europe, especially those based on SMATV systems;
- to contribute to standardization bodies, mainly in the field of interactive services, configurations and interfaces.

The DIGISAT project is developing the required equipment and associated technology to ensure the incorporation of SMATV systems in the new era of digital television and interactive services.

The new Satellite Broadcasting services (non interactive, near interactive and interactive) as well as innovative concepts for the implementation of the return channel via satellite will allow to arrange operational trials with selective user groups in order to assess the feasibility of the new services and related network architectures from several points of view technological, operational and economic.

In order to build the required receiving infrastructure for SMATV installations, complete head-end units (including the Transparent Digital Trans-modulator, either complete or simplified) are being developed. Although oriented to SMATV users, compatibility with DTH and CATV services (and infrastructures) is being pursued. Interactive applications using simultaneously the DVB-S transport stream and the DIGISAT return channel are implemented.

Table 31: List of DIGISAT participants and countries

E	Hispasat	**IRL**	North West Labs
E	Antena 3	**F**	Philips
E	Canal plus	**E**	Philips Telecomunicaciones
E	Corporacion Multimedia	**P**	Portugal Telecom
CH	EBU	**I**	RAI
E	FORTA	**E**	Retevision
D	FUBA	**E**	Robotiker/Fagor
E	IKUSI	**F**	SAT
E	Indra Espacio	**E**	Telecinco
E	Infoglobal	**SF**	Teleste
E	Intelsis	**SF**	Televes
E	Logica Sistemas de Informacion	**E**	TVE
E	MIER	**E**	UPM
E	Multicanal TPS		

Reference: http://www.infowin.org/ACTS/RUS/PROJECTS/ac061.htm

13.1.1.3.2 SECOMS

SECOMS: Satellite EHF Communications for Mobile Multimedia Services / ACTS Broadband Aeronautical Terminal and Experiment.

Project SECOMS/ABATE aims to define the system elements and to develop the related technologies for the future advanced satellite mobile multimedia service operating at Ka and EHF frequency bands and capable to provide the widest class of broadband mobile services also in hostile environment such as the land mobile and aeronautical ones. The 20/30 GHz and 40/45 GHz bands are considered for first and second generation service respectively.

Satellite trials are envizaged to validate the system choices and the developed technologies. Contributions to frequency co-ordination, to Ka / EHF channel model and standards definition are elaborated too.

The payload, allocated on GEO satellites, adopts on-board processing and multi-beam antennas, to achieve efficient use of the satellite resources by using ultra small aperture terminals. The technology developments are aimed at investigating the feasibility, in the framework of the future (second generation) enhanced system and at specifying, designing, developing and testing two user terminal prototypes, for vehicles and planes respectively, to be used in the framework of the first generation system.

The developed technology could be exploited also for LEO and MEO scenarios.

SECOMS/ABATE trials aim to demonstrate interactive mobile multimedia service, supporting video coded sequences, to verify that the technological developments are fulfilled and to characterize the satellite transmission channel.

SECOMS/ABATE is organized in different layers: the first layer is devoted to basic system definition studies, the second layer is devoted to satellite system feasibility studies and the third layer is devoted to terminal technological developments. The last layer is devoted to the definition and assembly of terminal prototypes and demonstrators.

SECOMS/ABATE considers a limited number of GEO satellites.

Compact terminals, of various sizes and capacities (in the range 64 to 2048 Kbps) using small flat array antennas are envizaged: portable terminals, i.e. palmtop, laptop, briefcase types and mobile terminals for utilization on cars, trains, planes for individual as well as collective utilization. Moreover high capacity (32 Mbps links) gateways and service provider terminals allow to interface and to interwork with any kind of terrestrial network. Finally a network control centre performs the system management, control and supervision.

The project is headed by Alenia Aerospazio.

Reference: http://www.infowin.org/ACTS/RUS/PROJECTS/ac004.htm

Table 32: List of SECOMS participants

I	Alenia Aerospazio
E	Alcatel Espacio
F	Dassault Electronique
D	DLR
F	Europ. Aerosp. Cons
UK	INMARSAT
GR	Intracom
USA	Jet Prop.n Laboratory
I	Nuova Telespazio
I	Politecnico di Milano
D	Siemens AG
I	Space Engineering
I	Università di Roma I
I	Università di Roma II
UK	University of Bradford
UK	University of Surrey

13.1.1.3.3 WISDOM

Wisdom: Wideband Satellite Demonstrator of Multimedia Services.

The basic system architecture adopted as a starting point is based on ATM to the user with an ATM switch onboard the satellites. Certain modifications are necessary and these will be discussed. The project firstly undertakes an elaboration of the baseline system architecture and then will develop an end to end system demonstrator with the satellite represented by a FPGA implementation of the satellite processor, including the ATM switching function.

The WISDOM Project main objectives are:

- development from a specific baseline, a satellite multimedia system that it is integrated into the terrestrial ATM networks;
- design and build an end-to-end system demonstrator with a breadboard on-board satellite ATM switch;
- demonstrate the feasibility of the system design and increase the confidence towards the implementation of the real system through a set of laboratory trials;
- demonstrate the payload technology and the specific control algorithms that are integrated into the payload processor;

- contribute to the standardization process.

Wisdom-related publications: Graham Huggins, "WISDOM - A Demonstrator of a Satellite Multimedia Communications System", proceedings of the ACTS Mobile Communications Summit 1998, June 8-11, Rhodes, Greece. This paper provides an overview of a new ACTS project, WISDOM, on satellite multimedia communications systems.

Home page: http://www.ee.surrey.ac.uk/CCSR/ACTS/WISDOM/index.html

Table 33: List of WISDOM participants

Matra Marconi Space UK	United Kingdom
Matra Marconi Space FR	France
NORTEL	United Kingdom
TELESPAZIO	Italy
University of Rome La Sapienza	Italy
University of Surrey	United Kingdom
SPACEBEL	Belgium
Space Hellas	Greece

13.1.1.3.4 ISIS

ISIS aims to Prove Feasibility of Satellite Multimedia Interactivity.

The ISIS Project studies the possibility of accessing via satellite a range of multimedia services independently from one's location. Satellites such as the Hot Bird series will be exploited to implement of service provision.

The ISIS demonstrator platform is a Ku/Ka band satellite system composed by a unique service centre with forward Ku band link capabilities (DVB stream over Eutelsat Hot Bird satellite) and Ka band return channel (Italsat Satellite) for handling the users interactive phases with the DTH terminal. The same system platform will be used to exploit all the foreseen applications and any multimedia interactive application may in principle run on it.

Drivers of the ISIS Project are considered to be:

- optimization of satellite access on the return link in Ka-band (in terms of protocols ,modulation, coding, link budget trade-offs);
- cost effectiveness of the user DTH terminal (RF sub-system and set top box): it is expected that, if mass production is exploited, the end user cost will be less than 1300 USD (96) within 5 years;
- integration of ISIS platform on surrounding multimedia environment;
- optimization of the video server communication layers.

Table 34: List of ISIS participants

I	Alenia Spazio
GR	Balkan Press Ltd
I	CMU
F	EUTELSAT
I	IBM Semea
GR	Intracom
I	Nuova Telespazio
E	Philips LEP
I	RAI
I	SBP
I	Space Engineering
N	TSAT
I	University of Florence
A	University of Salzburg

Reference: http://www.infowin.org/ACTS/RUS/PROJECTS/ac103.htm,
http://www.infowin.org/ACTS/IENM/Newsclips/arch1997/970597it.htm

13.1.2 ESA - European Space Agency

ESA started development of communications satellite systems in 1968. Its first telecommunications satellite, the Orbital Test Satellite (OTS), was launched in 1978. OTS technology opened the European market both for broadcasting to cable feeds and for direct-to-home television.

13.1.2.1 Basic objectives of the telecommunications programme

ESA's space telecommunications programme has two basic objectives:

- Put European industry in a position to acquire as large a share as possible of the World market.
- Promote advanced applications and thereby assist with the development of new markets.

With regard to the first objective, with the trend towards de-regulation within the Member States, and the trade policy of the European Union leading towards procurements that are fully open to worldwide competition, the need for a strong and competitive space industry within Europe has become a question of survival.

As to the second objective, this needs to be addressed in a variety of ways, including maintaining close relationships with operating entities to assess their future needs and carrying out pilot missions in order to continue to prove the benefits and capabilities of satellite communications.

The overall programme, proposed by ESA for the rest of the decade and beyond, contains, on the one hand, a number of specific initiatives directly related to missions seen as keys to the promotion of future systems and, on the other, more general development activities in support of a strong expansion of the present market share that European industry should capture.

Thus, in line with the general world-wide evolution of networks, five areas are being proposed for European industrial initiatives:

- A preparatory programme directed towards the next generation of Universal Integrated Mobile Systems.
- A contribution, within the Global Information Infrastructure, to a regional satellite system based on advanced digital on-board processing techniques.
- A long-term involvement in Traffic Control Systems, starting with the GNSS 1 navigation project.
- Promotion of an Advanced Audio Broadcast and Associated Services for the northern hemisphere.
- Consolidation of the first generation of the European Data Relay network.

In addition to the mission-specific projects, a general set of market-driven developments must be foreseen in parallel to support industry in maintaining a state-of-the-art position in all critical areas of space communications, with the view to capturing a higher share of today s, and tomorrow s, World market.

13.1.2.2 Programme elements

13.1.2.2.1 Personal mobile systems

The future Universal Mobile Telecommunication Systems (UMTS) will expand the range of services offered by the first-generation mobile system, which are limited to voice telephony and low-speed data services. UMTS will offer new services, such as interactive video-phones and remote database querying, with data rates of up to 2 Mbit/s, and will provide seamless integration of both terrestrial and satellite (S-UMTS) components of the network, the latter allowing a wide roaming capability into areas beyond the reach of terrestrial systems.

Both the terrestrial and satellite components of UMTS will operate in the 2 GHz band.

In order to implement S-UMTS, significant new developments are necessary, particularly in the areas of transmission, networking, satellite active antennas, on-board digital processing, and compact lightweight user equipment.

13.1.2.2.2 Global Information Infrastructure (GII)

Space communication will play an integral role in the development of a global information infrastructure, allowing video, audio and data to travel without borders and restrictions. Satellites are a key element for the intercontinental traffic, as well as direct connection to users, bypassing terrestrial means. Already today, satellites offer wide-area coverage and instantaneous availability. In the future, they will also need to provide significantly higher capacity at lower cost. For these purposes, the key innovation is On-Board Processing (OBP), which the Agency has been developing for several years.

In 1994, a first end-to-end laboratory model was successfully tested and Step 1 of the OBP Programme was subsequently initiated. This project is aimed at the development of the core elements of a high-capacity processing system for on-demand communications between small 20/30 GHz user terminals.

An obvious follow-up to these developments should be an operational European OBP system that would be introduced by industry and potential operators, covering Greater Europe and adjacent regions and operationally compatible with similar systems deployed over other continents. ESA supports the launch of such an operational service as a partnership programme, under which the Agency would fund some of the development costs and assist in setting up the initial phase. Operators would exploit the system and thereafter guarantee the continuing availability of the overall infrastructure.

From http://www.estec.esa.nl, /artes3, and http://esapub.esrin.esa.it/br/br114/br114tel.htm.

13.1.2.3 OLYMPUS

ESA's Olympus satellite, launched in 1989, has redefined the leading edge of advanced telecommunications services. The satellite carried four payloads providing:

- direct-to-home TV broadcasting at 12/18GHz (reception with 0,3 to 1 m antenna dishes);
- specialized business services with a steerable cluster beam at 12/14 GHz (VSAT stations with 1 to 2,5 m antennas);
- new services with steerable spot beams at 20/30 GHz (VSAT stations with 0,8 2,5 m antennas);
- beacons for propagation studies in the 12/20/30 GHz.

Under ESA contracts some 100 terminals ranging from 35cm antennas to 4,0 m were made.

During the Olympus programme the Olympus Propagation Experiments Group (OPEX) has done extensive propagation measurements campaign, which is documented in 24 papers in the below mentioned Olympus conference. Unlike the ACTS results, the Olympus results are relevant for the European satellite coverage zones. The point of contact for propagation issues is Mr Arbesser-Rastburg at ESTEC.

A major event during Olympus's lifetime was the test campaign of inter-orbit communication between it and the Eureca platform, conducted between August 1992 and April 1993. This experimentation constituted a European "première" in terms of data-relay links between two satellites, one in low earth orbit (Eureca) and one in geostationary orbit (Olympus).

Olympus's experimental mission was concluded in 1993 when the satellite ran out of fuel.

The achievements of the Olympus Utilization Programme can be found in the proceedings of an International Conference concerning Programme results in Sevilla, SPAIN 20 to 22 April 1993.

13.1.2.4 ARTES-3

Another major ESA event of recent years was the start of a new programme called "ARTES" (Advanced Research in Telecommunications Systems), which has taken over from the previous PSDE and ASTP programmes. Several elements of the programme have already been started and are now running at full speed. They include:

- Element 1: Preliminary Studies and Investigations;
- Element 2: On-Board Processing;
- Element 4: ESA/Industry Telecommunications Partnership Programme;

- Element 5: Advanced Systems and Telecommunications Equipments;
- Element 7: Experiment and Service Demonstration; and
- Element 12: Little LEO Messaging System.

Artes 3 is an ESA programme designed to stimulate the satellite multimedia market to develop and to render competitive the European and Canadian industry in this field. Artes 3 is an approved ESA programme which is now in phase 1, the total financial envelope of the programme is approximately 350 Million ECU.

13.1.2.4.1 The ARTES 3 mission

- To put Member States' industry in a position to acquire as large a share as possible of the world market in satellite based communications services.
- To promote advanced applications and thereby assist with the development of new markets.

13.1.2.4.2 Why ARTES 3?

An independent business analysis of the ARTES 3 programme undertaken during May 1997 provided the following conclusions:

- the growth of the Internet subscriber base has created an awareness of the benefits to be derived from state of the art communication facilities and provided a tremendous stimulus to the multimedia market area;
- the scale of the addressable market for bandwidth provision in the superhighway era will be in excess of 120 billion US$ per year towards the end of the next decade;
- co-operation between companies in the applications area, service provision and the satellite manufacturing companies is the key to success.

ARTES 3 will support the development of applications to promote early market start up in:

- tele-medicine;
- tele-education;
- public administration;
- intranets;
- high speed Internet;
- promotion of open standards for interactive satellite terminals.

13.1.3 Italsat

Italsat is an advanced telecommunications programme of the Italian Space Agency (ASI) operating in high frequencies (20/30 GHz) using digital technology. The system is integrated with the national telephony network to improve its flexibility. The satellite's switching capabilities make it possible to assign channels according to demand. Spot beams with a total capacity of about 12 000 voice channels carry domestic telephone traffic. The beams use a form of TDMA, linear polarization and QPSK modulation allowing 147 Mbits/sec in a 100 MHz Ka-band bandwidth. On-board regeneration is used with the beams interconnected by a switching matrix. The system is made up of the two satellites, F1, launched in 1991 and still operating, F2, launched in 1996, and the related ground stations.

The major part of the Italsat programme was realized in Italy, with Alenia Aerospazio as prime contractor being responsible for the design, development, construction and testing of the satellites, the three telecommunications payloads and the ground communication and control stations. The ground segment consists of 20/30 GHz traffic stations, 20/40/50 GHz propagation stations and a dedicated station for the management and control of the communications system.

The satellite covers issues like:

- 20/40/50 GHz European Propagation Experiments necessary to future operational telecommunications systems at the Ka-band. The Propagation Payload (on ITALSAT F1 only) consists of two transmitters and of two antennas for European coverage.
- 20/20 GHz national, multi-beam telecommunications for digital telephony, videoconferencing, data transmission and analog television.

The realization of the payload and the terminal stations using 20/30 GHz, together with the switching matrix permit experimentation of new multimedia services and applications.

Since 1995, through projects co-financed by the European Commission under its Fourth Framework Programme for research and development, Italsat has been used by Alenia Aerospazio and its European partners to develop multimedia services and applications as part of the following programs:

- ISIS (Interactive multimedia Satellite Information System);
- SECOMS (Satellite EHF Communications for Mobile and aeronautical Multimedia Services);
- ABATE (Advanced Broadband Aeronautical Terminal and Experiments);
- ACCORD (ACTS Broadband Communication Joint Trials and Demonstrator);
- ASSET (ACTS Satellite Switching and End-to-End Trial).

13.2 Australia / ASIA

13.2.1 NASDA - National Space Development Agency (Japan)

NASDA conducts research on the spacecraft systems required for the space operations. It also continues research on the leading-edge technology and common technologies used in such spacecraft. Finally, it conducts activities related to spacecraft tests. OICETS - Optical Inter-orbit Communications Engineering Test Satellite.

The goal of this experiments is orbital testing of elementary technology, particularly light beam acquisition, tracking and directional control for optical intersatellite communications, an important element of future space technology.

There are plans to conduct experiments together with the ARTEMIS geostationary satellite of the European Space Agency (ESA). Light beams travelling for a distance of several ten-thousands of kilometres will be accurately tracked. Finely intertwined light beams are expected to be transmitted with high directional accuracy.

Launch Date: In the summer of 1998.

Mission Duration: Approx. one year

The overall system for optical inter-orbit link experiments will consist of NASDA'S OICETS, Communications and broadcasting Engineering Test Satellite (COMETS), Tracking and Control Center (TACC) and domestic Tracking and Control Stations (TACSs), and ESA's ARTEMIS and ground stations. The experiments between OICETS and ARTEMIS will be conducted with supports from the ESA ground stations. OICETS will be controlled by TACC via a main S-band inter-orbit link with COMETS or S-band direct links with TACSs using ordinary radio frequency signals to transmit and receive telemetry, command, and mission data. Also studied is the feasibility of optical link and precize laser ranging experiments between OICETS and the optical ground station of the Communications Research Laboratory (CRL) of the Ministry of Posts and Telecommunications.

Mission equipment carried by COMETS includes inter-orbit communications equipment developed by NASDA, advanced mobile satellite communications equipment developed by the Communications Research Laboratory (CRL) of the Ministry of Posts and Telecommunications, and advanced satellite broadcasting equipment jointly developed by both of them. A further upgraded version of the 2 ton class large three-axis stabilized geostationary satellite bus developed for ETS-VI is used. Technology will be developed for electric power subsystem employing nickel-hydrogen batteries and flexible panels with highly effective solar cells, integrated propulsion subsystem with a bipropellant pressurized apogee engine and gas blow down jets, and high-accuracy attitude control subsystem to control the pointing angles of large antennas.

The Advanced Mobile Satellite Communications Mission developed by CRL will develop technology for relaying communications between mobile earth stations. Transponders to perform regenerative repeating and beam inter-connecting functions will be developed to constitute a system in combination with a multibeam antenna. Multibeam antenna to cover Kanto and Tokai in Ka-band and Kanto in millimetre wave will be installed.

Two older, Ka-band satellites were the CS-3 (a and b).

Table 35: Main Characteristics of CS-3a, 3b

Launch:	CS-3a: February 19, 1988, CS-3b: September 16, 1988
Attitude control:	S pin-stabilized
Design Life:	7 years. CS-3a finished its programmed operation on November 30,1995. CS-3b finished its programmed operation on May 31, 1996.
Launch Vehicle:	H-I
Launch site:	Tanegashima Space Center
Orbit:	Geostationary
CS-3a:	132deg. E. longitude
CS-3b:	136deg. E. longitude
Weight:	Approx. 1 099kg (at launch) ,Approx. 550kg (beginning of life)
Dimensions:	Cylindrical D:220cm
Role	The CS-3 utilizes Ka band (30/20 GHz) and C band (6/4 GHz) and is used in the domestic public and private communications services and to provide temporary communications. By improving communication performance, cost and reliability over the CS-2 and by employing more domestic technologies, the CS-3 has improved performance, such as increased number of transponders installed (from 8 to 12 transponders) and longer life (from three years to seven).
Utilization	The CS-3 provides 12 channels: 10 channels in Ka band and 2 channels in C band, permitting full mission operation through a solar eclipse period. The service area of Ka band covers the major Japanese island including Okinawa island, while C band extends to the remote island.
Related Organizations	The CS-3 was developed by NASDA. The communications antenna and transponders are based on the design developed by the Nippon Telegraph & Telephone Corporation (NTT). During early phase after launch, NASDA conducted the operation and control of the satellite in order to check all the satellite functions and performances. After that, the satellite was handed over from NASDA to the Telecommunications Satellite Corporation of Japan (TSCJ) and is provided for operational use.

NASDA: National Space Development Agency of Japan: http://www.nasda.go.jp/welcome_e.html.

13.2.2 Telstra (Australia)

Telstra's R&D spend in the next three years is expected to focus on: Broadband Services. Mobility. Customer Access. Network Management. Service Activation and Assurance. Billing.

Telstra launches a high speed international Internet satellite delivery service option for Big Pond Direct, Telstra's permanent Internet access service for ISPs, corporate and government organizations. Telstra already has in operation 45 Megabits per second of backbone satellite capacity between the United States and Sydney. The use by Telstra of its own international satellite capacity to deliver Internet access services has the potential to significantly reduce costs for Internet Service Providers (ISPs) connected to Telstra.

The Asymmetric Satellite Access Port (ASAP) option will be available on application to all new and existing customers of Big Pond Direct.

Over one year, Telstra has more than doubled their domestic and international Internet transmission capacity, and see satellite delivery as a viable technology option to both increase capacity and reduce prices.

Telstra handles the routing of traffic for the customer through a single access port. Traffic delivered through the access port into Australia comes via satellite, while traffic going back to the US or other countries travels along the conventional optical fibre submarine cables. Telstra claims ASAP customers will be able to reap the cost benefits of satellite without the need for their own satellite earth stations, contracts with satellite providers and Internet Access Providers or complex routing configurations. By using ASAP, they will not be exposed to exchange rate risks in the same way as with direct contracts with international satellite service providers."

Reference: http://www.telstra.com.au/

13.2.3 ROCSAT (China)

With the scheduled 1998 launch of ROCSAT-1, the Republic of China (ROC) will join the space community. Developed by TRW for the ROC National Space Program Office (NSPO), the satellite will fly in low-earth orbit and host ROC-built space physics, oceanography and communications experiments. As the first spacecraft in its civil space program, ROCSAT-1 will allow NSPO to meet two goals: develop a science satellite and establish ROC satellite design and development capabilities.

The payload contains an Experimental Communication Payload (ECP) to relay Ka-band telecommunications. The design life is 4 years, and launch date April 1998. The orbit is 600 km circular orbit, 35 degree inclination.

Reference: http://www.trw.com/seg/sats/ROCSAT.html

13.2.4 KOMPSAT (Korea)

KOMPSAT (Korea Multi-Purpose Satellite) is the first joint spacecraft development project for the South Korean aerospace agency KARI (Korea Aerospace Research Institute). Its payload will contain several scientific instruments as well as a Ka-band communications device. TRW and Korean engineers will work together to develop the spacecraft, launch planned for 1998 or 1999, and orbit at 685 km

Reference: http://msl.jpl.nasa.gov/QuickLooks/kompsatQL.html

13.3 America / NASA ACTS

ACTS experimental satellite was launched aboard the Space Shuttle Discovery as part of the STS-51 mission on September 12th, 1993.

The ACTS High Data Rate terminal is capable of transmitting data at 622 Mbps using a 3,5 m antenna. Alternatively, up to 4 stations operating at the 155 Mbps can be supported simultaneously in a satellite switched time division multiple access (SS/TDMA) mode. NASA's ACTS satellite performed extremely well; the project was very well managed and involved testing a variety of new ground stations and services. ACTS experiments form a basis for several of the new Ka-band systems.

The ACTS program has shown how satellites can inter-operate with, and in some cases even compete against, fiber-optic cables. The use of Ka-band frequencies and wide bandwidth transponders gives ACTS a capability that no previous satellite has had: an ability to carry digital communications signals at standard optical communications data rates (155 Mbps and higher). ACTS transmits high-speed traffic with the same quality of service as fiber-optic cables, and often with performance and economic advantages.

The goals of the ACTS program are to develop advanced communications technology, usable in multiple frequency bands and which would be applicable to a wide range of future communications systems for industry, NASA and other governmental agencies. The objective is to enable growth in the capacity and effective use of the frequency spectrum and, enable the U.S. industry to maintain its competitive position in the world communications satellite market. Specifically, ACTS is to develop the technology for 30/20 GHz, spot beam communications satellites with on-board baseband and microwave matrix switching.

The spot beams allow the use of very small aperture (VSAT), low cost terminals as well as provide a large degree of frequency reuse. The frequency reuse allows a much larger communications capacity per satellite. Since the capacity per unit on-orbit weight is also greatly increased, these systems will allow lower service costs. The ACTS system provides on-demand, integrated digital, satellite/terrestrial networks with service data rates from 64 Kbps to 622 Mbps.

Validation of the ACTS technologies has been and continues to be accomplished through the ACTS Experiments Program. The program has performed testing in the following areas:

- business related experiments;
- health Care related experiments;
- long distance education and training;
- improved National Defence and Emergency/Dizaster Communications;
- expanding Scientific Research Networks;
- advancing technologies and U.S. competitiveness.

ACTS provides an opportunity to study the characteristics of impairments to Earth-space communications at Ka-band (30/20 GHz) caused by propagation phenomena and to develop techniques to counter them. Rain is a major impediment to Ka-band communications because it causes fades in the satellite signal. It presents quite a challenge to system designers because it causes more severe fades at this frequency than in other, lower frequency bands. Other phenomena also affect the satellite signal. Clouds and atmospheric gases such as water vapour and oxygen can also cause signal fades. Tropospheric scintillation (twinkling in the atmosphere) is another important factor.

These experiments and demonstrations include extensive testing of ATM, T-1 VSAT , Frame Relay, ISDN, wide and local area network, educational, medical, land and aeronautical mobile services, terrestrial fiber-satellite hybrid services and other useful applications and technologies.

Significant on-orbit results include:

- ACTS communications system is highly reliable with no electronic failures in two years;
- good availability can be achieved by proper system design which adequately accounts for Ka band fades;
- voice quality over ACTS/BBP is considered very good. Satellite delay was not an issue for users;
- Service Quality (BER) requirements were met;
- users highly desire on-demand, integrated services;
- small aperture earth stations are highly desired from a stand point of installation and transportability where necessary. A 1,2 meter T1 VSAT can be located on ground, roof or pole mount;
- T1 VSAT is extremely versatile providing a digital telephony interface at rates from 64 Kbps to 1,544 Mbps (T1). Virtually any type of voice, video, data and multimedia user application hardware is compatible with the ACTS system;
- technology is low enough risk for commercial use.

ACTS operations have shown that Ka band, spot beam satellite systems with on-board, baseband and microwave switching can provide reliable and robust communications.

The following is a list of ACTS experimenters.

Bellcore
Corporate Computer Systems
Florida Ctr for Commrcl. Dev. Space/ FL Atl. Univ.
Georgetown University
Hawaii PacSpace Consortium
Indiana State University
Jet Propulsion Laboratory
Mayo Clinic
Motorola Incorporated
NASA Goddard Space Flight Center
National Communications System
National Library of Medicine
New Mexico State University
Rockwell International
Stanford Telecommunications
U.S. Army Research Laboratory
U.S. Army Topographic Engineering Center
University of Florida
University of Oklahoma
University of Washington
BBN Systems and Technology
Citibank

Communications Research Centre
General Electric Electronics Laboratory
Georgia Tech Research Institute
Hughes Network Systems
International Business Machines
Javeriana University

Latin American Institute of Doctrinal & Social Studies
Ohio University
SUNGARD Recovery Services
Unisys Corporation
University of Colorado
U.S. Air Force Rome Laboratories

U.S. Army Future Battle Lab
U.S. Army Med Diagnostic Imaging Support
US West Communications
Weber State University

CBS Radio
Florida Atlantic University
George Washington University
Georgia Tech Research Institute
Huntington Bank
Institute for Telecommunications Sciences/NTIA
Martin Marietta Astro Space
MITRE Corporation
NASA Ames Research Center
NASA Lewis Research Center
National ISDN User's Forum
NBC, Network Distribution Engineering
Ohio Supercomputer Center
Southern California Edison
Teleglobe Canada
U.S. Army Space Command
University of British Columbia
University of Maryland CCDS
University of South Florida
Ascom Timeplex, Inc.
Boeing Defense & Space Group
Combined Arms Ctr. Dept. of the Army/Army Space Inst.
Cray Research
General Electric Medical Systems
Hewlett-Packard Medical Imaging
INTELSAT
Inter-American Development Bank
Laboratory Command/Army Space Technology Research Office
NASA Johnson Space Center

Sprint
Texas Instruments
University of California, Berkeley
University of Hawaii
U.S. Army Communications Electronics Command
U.S. Army Inf Systems Engineering Command
U.S. Army Signal Center
Wasatch Research

Reference: http://kronos.lerc.nasa.gov/acts/acts.html

14 Issues for Standardization and Further Work

14.1 Possible Issues for Standardization

The list contains issues that have been submitted to ETSI, identified by the responses to the ETSI questionnaire. The list also includes other issues that may be relevant for standardization, discussed among other places in the steering committee meetings. It does not consider whether ETSI is the right body or not to involve in these topics. The purpose of the list is to functions as a "brainstorming inspiration", with an open mind. Due to the nature of the way these issues were compiled, some may seem to overlap or be just another word for the same thing. We have, however, chosen to keep the exact wording of those proposals we have received.

Table 36: Table of possible standardization issues for broadband satellite multimedia

Category	Issue	Known Activities	Other Relevant Forums
Protocol	ATM over satellite	ATM Forum, TIA	
	DVB for interactive multimedia over satellite	DVB Forum	
	TCP/IP over satellites	NASA, IETF	
General Terminal	Type approval of user terminals		
	Terminal installation requirements		
	Standards for EMC certification		
	Landing rights		
	Blanket licensing		
	Host nation agreements		ITU
	Terminal classes (Bit rates)		
	Terminal classifications (home, business,…)		
	Control and Monitoring		
	Safety		
Mobility	Mobile Multimedia	UMTS	
	Portable terminals		
	Inter-system Roaming		
System	Availability		
	Error Rates (BER, Cell Error Rates)		
	Fading Margins		
	Antenna tracking (NGSO)		
	Satellite Handover (NGSO)		
	Beam Handover (NGSO)		
	Modulation (fixed and adaptive)		
	Coding (fixed and adaptive)		
	Power Control (adaptive)		
Interfaces	Radio interface	TIA	
	IF interfaces		
	Antenna interfaces		
	Application interface		
	User interface		
	Computer interface		
	Interconnection		
	Inter-working		
	Open interfaces		
	System Administration Interfaces & Management		
Coexistence	Frequency sharing and re-use	ITU, FCC	ERC, WRC, CEPT
	Avoiding harmful interference to users	ITU, FCC	ERC, WRC, CEPT
	RF spectrum emissions		ERC, WRC, CEPT
	RF Power emission		ERC, WRC, CEPT

14.2 Issues relevant for ETSI (to be elaborated during Phase 2)

14.3 Actions required by ETSI (to be elaborated during Phase 2)

14.4 Other suggested further work

Table 37: Other suggested future work

Issue	Action
Database of systems and their specification	TBD
Regular update of the broadband survey	TBD
V Band systems / Issues	TBD
Mobile multimedia	TBD

Bibliography

Table 38: A list of some useful URLs

URL	Description
http://web.fou.telenor.no/fou/frekvensplan/Online/	Telenor, Lists of satellites, positions and frequencies
http://www.itu.int/itudoc/itu-r/space/snl.html	ITU-R, Space Network Lists
http://www.fcc.gov/ib	FCC, International Bureau
http://www.itu.int	ITU
http://www.etsi.org	ETSI
http://www.visionconsult.com	Report on Ka-band satellites and Internet via Satellite
http://www.dvb.org	DVB Organization, Digital Video Broadcast MPEG-2
http://www.eutelsat.org	Eutelsat
http://www.ASTRA.lu	SES ASTRA
http://www.mot.com	Motorola
http://www.msua.org/mobile.htm	Lists numerouse pointers to satellite related web-sites.
http://www.ee.surrey.ac.uk/Personal/L.Wood/constellations/	Lloyd's Satellite constellations
http://kronos.lerc.nasa.gov/	NASA ACTS home page
http://www.telenor.no/international/	Telenor
http://www.itu.int/itudoc/itu-r/space/snl.html	The ITU space network list
http://www.etsi.org/	ETSI
http://www.itu.int/	ITU
http://www.ero.dk	European Radio Organization
http://www.umts-forum.org	UMTS Forum
http://www.fcc.gov/ib	FCC International Bureau
http://www.fcc.gov	FCC
http://www.echostar.com	EchoStar
http://www.kastarcom.com	KaStar
http://www.hcisat.com	Hughes Communications
http://www.ge.com/capital/spacenet	GE Amricom / GE Capital
http://www.morningstar.com	Morning Star
http://www.netsatx.com	NetSat
http://www.OrionNetworks.net	Orion Networks
http://www.loral.com	Loral
http://www.panamsat.com	PanAmSat
http://www.teledesic.com	Teledesic
http://www.astrolink.com	AstroLink
http://www.cyberstar.com	CyberStar
http://www.orbital.com/	Orbital Sciences
http://www.alespazio.it/frtlc.htm	Alenia Spazio/ EuroSkyWay
http://www.skybridgesatellite.com/	SkyBridge
http://www.trw.com/seg/sats/MILSTAR.html	TRW / Milstar
http://www.skystation.com	SkyStation
http://www.magnet.consortia.org.il/consolar/spsp.html	ConSolar
http://www.angeltechnologies.com	HALO / Angel Technologies
http://www.thk.fi/suomi/cept/ceptinfo.htm.	CEPT Info
http://www.LTA.com	Leslie Taylor Associates
http://www.estec.esa.nl	ESA / Estec
http://www.tiaonline.org	TIA
http://www.atmforum.com/	ATM Forum
http://www.ietf.org/	Internet Engineering Task Force
http://tcpsat.lerc.nasa.gov/tcpsat/	NASA page for TCP over satellite
http://www.isoc.org/isoc/	Internet Society
http://www.atmdigest.com/satellit.htm	ATM satellite Links
http://msl.jpl.nasa.gov/.	Jet Propulsion Laboratory
http://www.cordis.lu	CORDIS Info-server (EU)
http://www.uk.infowin.org/ACTS/	EU ACTS
http://www.estec.esa.nl/artes3	ESA Artes-3
http://www.nasda.go.jp	National Space Development Agency of Japan
http://www.telstra.com.au/	Telstra
http://www.itu.int/itudoc/itu-r/space/snl.html	ITU Space Network List
http://kronos.lerc.nasa.gov/acts/acts.html	NASA ACTS
http://www.nist.gov	US National Institute of Standards and Technology

History

Document history		
V1.2.1	October 1998	Publication

ISBN 2-7437-2595-8
Dépôt légal : Octobre 1998