SATELLITE COMMUNICATIONS SURVEY

Systems and Applications

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EUROPEAN COMMISSION
JOINT RESEARCH CENTRE

Space Applications Institute

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SATELLITE COMMUNICATIONS SURVEY

Systems and Applications

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PREFACE

- Only ten years ago the future of satellite communications systems for applications other than TV broadcasting was considered very uncertain.
- Intercontinental trunk communications via satellite were seriously challenged by high capacity submarine optical cables, while V-Sat applications had difficulty in taking-off, mainly because of the high cost of user terminals.
- The satellite industry was in fact seriously endangered, given the parallel crisis of military applications and the shrinkage of government budgets for scientific and earth-observation missions all over the Western world.
- Today's space industry is living a very exciting and promising phase of its history, triggered on one side by the enormous success of wireless cellular telephony and on the other side by the worldwide diffusion of Internet and its related services.
- The space industry is increasingly becoming part of our everyday lives, both in business and at home. A synergistic element of the global communications infrastructure, space is providing diverse capabilities ranging from paging, mobile, and remote communications, to television broadcast services, to credit card and ATM bank transaction processing. It is being used to monitor our planet and provide data products used by businesses involved with oil and gas exploration, civil planning, disaster management, and the tracking of trucks and cargo.
  The space industry is no longer limited to the manufacture and launch of spacecraft.
- Despite the shy start and uncertain success of Second Generation Satellite Personal Communication Systems, S-UMTS systems are likely to benefit from the parallel exponential growth of terrestrial UMTS networks.
- Third generation mobile communications systems (S-UMTS) will extend capabilities of present mobile technologies, providing a single integrated network in which the user can access a wide range of telecommunications services, in an easy to use and uniform way, in all environments, "any where and at any time".
- The European Commission projects, under the 5th Framework Programme (1999-2002), are complementing the satellite technology developments carried out by Space Agencies bringing together the satellite and terrestrial communities with a view to developing solutions for inter-operable systems and services, with a global satellite/terrestrial perspective.

INTRODUCTION

- This report is an updated release of the annual JRC report on Satellite Communications (Satellite Communications Survey, EUR 18146 EN, September 1998).
- **The report's** objectives are:
  - To update information on new and future satellite technologies, systems and services;
  - To highlight the role of satcom systems in the global marketplace and to indicate the changes being enforced by advanced technologies, convergence and competition;
  - To provide some basic conclusions for the present and the future of the satellite communication system and associated standards, including the third-generation system under the project name Universal Mobile Telecommunication Systems (UMTS);
- Market studies show that there is room for different major system; this is an important perspective for the development of the telecommunications infrastructure worldwide.
- Several Communications satellite systems (Messaging-SMS, Personal-PCS, Broadband/Multimedia-BB/MM) are planned and announced worldwide and acquisitions of companies and new mergers are in progress.
- In the changing telecommunication environment new technologies and applications systems are exploited and some others started to be in commercial operation this year (i.e. global S-PCS Systems such as Iridium and Globalstar).
- All potential applications need extensive study with regard to:
  - Commercial viability
  - Detailed definition of requirements
  - Budgetary constraints

  for the selection of cost effective communications solutions.

INTRODUCTION

- This report summarizes the most important of the current and future satellite communications systems. The list is not intended to be exhaustive. Some systems that were cancelled or subsumed in other projects are also included.

- For a comprehensive list of all space related projects that the EC funded in the 4th Framework Programme (1994-1998), also look at Compendium of Space-Technology Applications Projects EUR 18971 EN (URL: http://www.sai.jrc.it/astron/space-compendium/).

- This report was correct, as for as could be ascertained, at the time of publicity.
  The satellite communications world is, however, a rapidly changing area: developments and changes are occuring constantly.
  Readers of this document are asked to keep this mind when consulting the information contained herein.

CONTENTS

CONTENTS

TECHNOLOGY AND SERVICES

Present Generation

→ PUBLIC SYSTEMS

- Trunk systems providing links between countries for the transfer of bulk international traffic (INTELSAT/EUTELSAT systems mainly)
- Internet Broadcasting Systems/Short Message Service open networks (INTELSAT/EUTELSAT standards)

Traditionally, satellite systems have been used to provide intercontinental trunk routes for telephony and an increasing volume of data traffic. New system concepts aimed at this market are inspiring a period of rapid change. A number of systems have been proposed at V-band (EHF) to service the forecast shortfall in trunk capacity. The traditional GEO trunk systems, such as INTELSAT, are now being challenged by a number of LEO and MEO constellations.
The variety in constellation design is clear from the range of orbital parameters and the number of satellites. One common element, however, is the use of very high bandwidth inter-satellite links (ISLs) to route the traffic around the constellation rather than routing it via an earth station and the terrestrial network. The ability to route traffic around the constellation using ISLs gives the operators a very high bandwidth space-based trunk network which can by-pass terrestrial bottlenecks and capacity shortfall.

→ END USER SYSTEMS

Small earth-station technology introduced in the early 1980's

- VSAT (Very Small Aperture Terminal) networks including **Fast Internet via satellite** systems (high volume information distribution to end users)
- Integrated systems **(DTH-TV + Interactive Multimedia Broadcasting)**
- Existing Mobile Communications Systems (for Mobile, Portable and Fixed Voice and Data Communications)

TECHNOLOGY AND SERVICES

New Generation

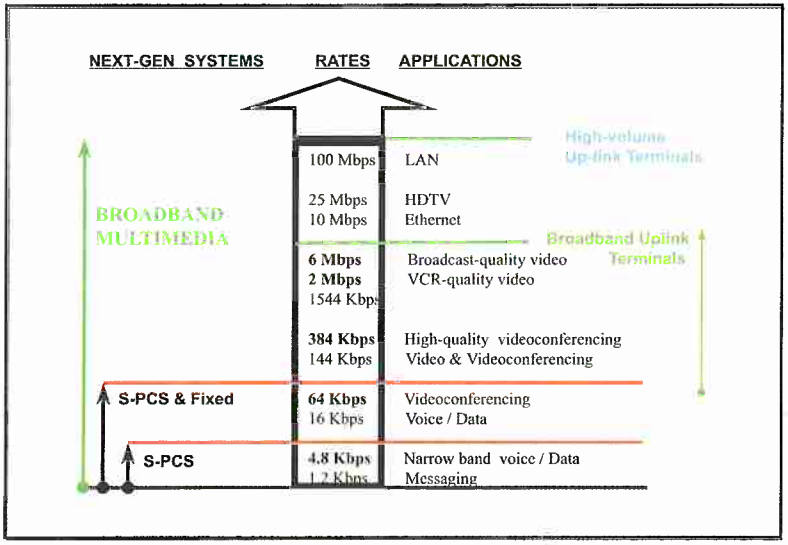
Two main groups of advanced satcom technologies

- Satellite Personal Communications Systems (S-PCS)
  - ✓ Satellite Handheld user Terminals
- Broadband Multimedia Systems
  - ✓ Convergence of Technologies (Communications/Computers/Media)
  - ✓ Small and Compact Multimedia End-user Terminals

More than 70 systems have been proposed

IMPORTANT POINTS / TRENDS

- Globalisation of networking (worldwide communications infrastructure)
- Low-cost mass-market services and high volume business services
- Manufacturers enter in the arena of commercial satcom services
- More than 80Billion US$ investments planned
- Regulatory implications



VSAT NETWORKS

Basics

→ Characteristics

- Space Segment : GEO satellites (C or Ku band)
- Architectures : Star, Mesh, Hybrid, Point-to-point links
- Bandwidth : range between 64Kbps-8Mbps
- Applications :
  - Closed user group business applications (Intranet)
  - Public communications in remote areas
  - **Fast Internet**
  - **Interactive Multimedia** applications with satellite/terrestrial return link (Tele-medicine, Tele-education, Tele-working, etc.)
- Services : data transmission, videoconference, archive access
- User Terminals : compact, 0.6 - 2.4m antennas (Ku-band)

- 17 years in the market / more than 240,000 VSAT terminals worldwide / US manufacturers dominate the market (HNS share>60%)
- Many operators in Europe (PTTs, private companies) the majority of which operate to Eutelsat satellites

→ Advantages of VSAT Network

- Small size earth stations easy and quick to install
- Cost insensitive to distance
- Connect central office to remote locations with no existing terrestrial lines
- Centralised network control and management
- High quality end-to-end video/voice/fax/data capability

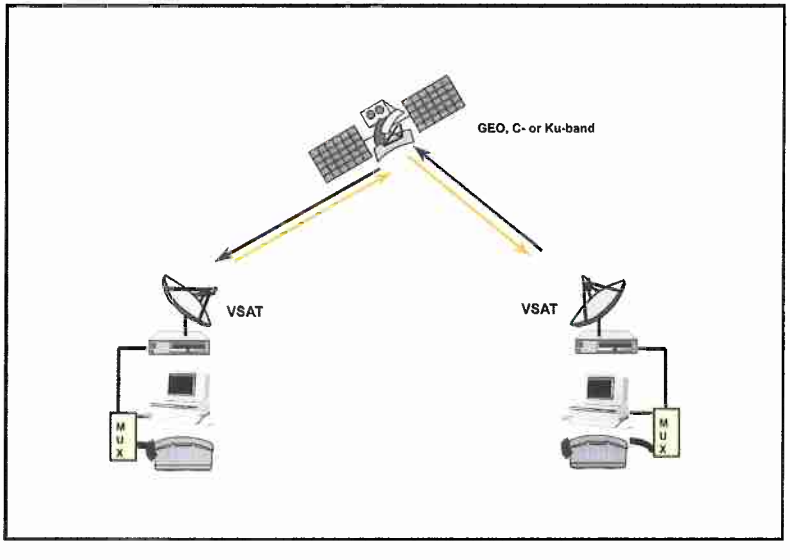
VSAT NETWORKS

Basics

→ Architectures

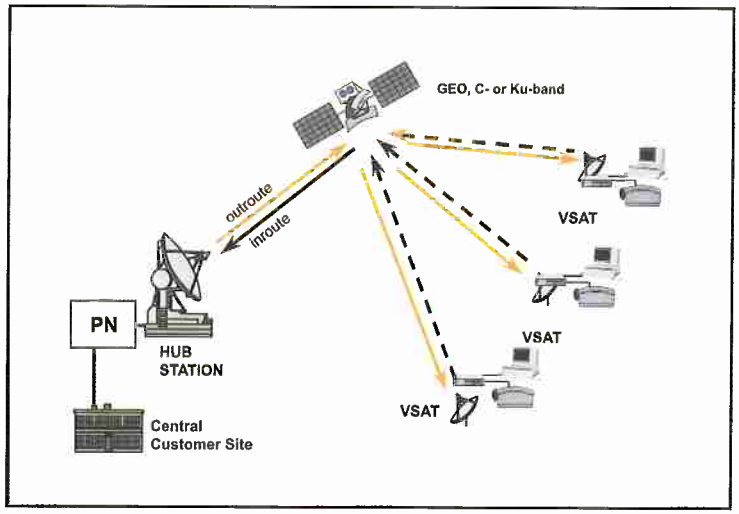
- Point-to-Point : VSAT to VSAT link, the simplest connection. Direct connection between two corporate distant sites (alternative to the leased line connection).
- Star : each VSAT communicates with other VSATs through a big earth station called Hub Station (central communications and management node).
  Used for closed-user group applications connecting a central processing site with a large number of remote sites.
- Mesh : Hub-less networks, all sites equipped with VSAT stations, each VSAT of the network is connected directly with other VSATs.
- HYBRID : Combination of the Star and Mesh configurations.

POINT-TO-POINT Link



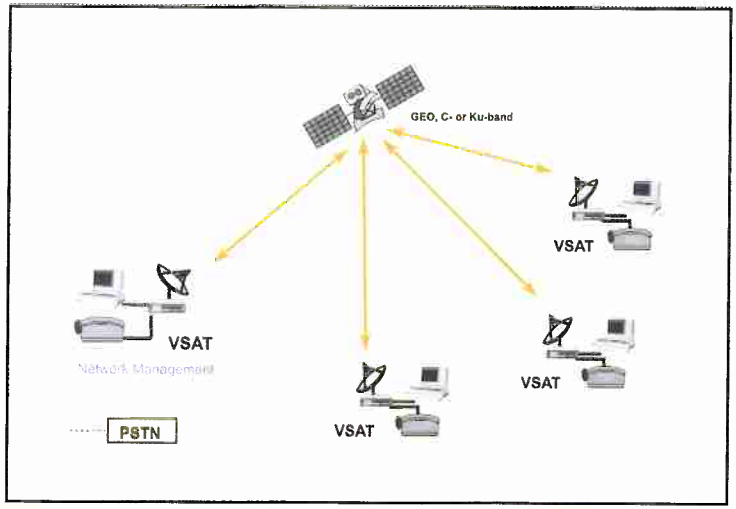
VSAT NETWORKS

Basics



STAR VSAT Network

MESH VSAT Network



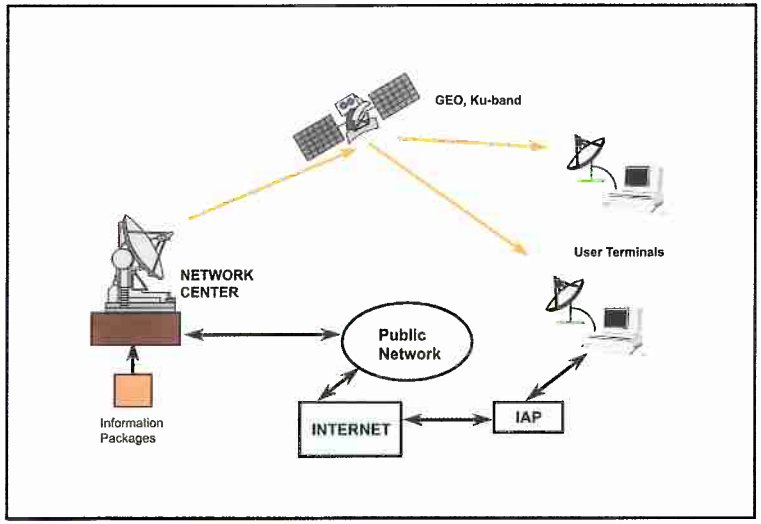
VSAT NETWORKS

Basics

→ Fast Internet

- Architecture based on VSAT technology (star, one-way or two-way)
- Combination of satellite, information and internet technologies
- Hub Station : Central transmission node supporting very high data rates to the end-users (up to a few tens of Mb/s)
- User equipment : Light-weight compact Rx-only terminals (small antenna, RF unit and PC adaptor card or Integrated Receiver Decoder / IRD equipment)
- Return link : User requests are sent via normal PSTN connections (asymmetrical networks). Ku-band low-data-rate return links are offered in special cases, while Ka-band return links will become a future alternative.
- Services : Broadcasting real-time news, financial information, live video, download computer software, delivery of large-volume internet files at high data speeds (point-to-(multi)point transmissions)

Fast Internet Topology



VSAT NETWORKS

Basics

→ Fast Internet (examples)

Satellites provide an efficient platform for high-data-rate Internet distribution

- DirecPC service of Hughes offered in USA, Japan, as well as in Europe.
  The service was launched in Europe by Hughes Olivetti Telecom (HOT) in September 1996, with hub in Frankfurt/Germany. It currently operates via a Eutelsat Hot Bird satellite (non DVB-compliant).
  Direc-Duo : a Hughes product, combines DirecPC and DirecTV service reception.

PLANNED Project

Other operators and service providers plan to offer services in the near future e.g. **News Corporation** Internet and data broadcasting service

→ Interactive Multimedia Systems (examples)

- European Satellite Multimedia / ESM (SES Astra, Intel, DT, HNS, Luxembourg PTT) :
  AstraNET DVB-compliant point-to-multipoint data distribution platform in Europe (38Mb/s)
- EUTELSAT Multimedia Platform : Based on DVB and MPEG-2 technology
  Launch of commercial services :
  - **Com.Net** (subsidiary of N. Telespazio with Telecom Italia)
  - **Polycom** (subsidiary of AFP, FT, SFB Bourse de Paris)
  - and others
- MCNSat (Matra) : Turbo PC Internet, DVB-compatible (up to 40Mb/s)

INTEGRATED SYSTEMS
(DTH-TV + Interactive MM Broadcasting)

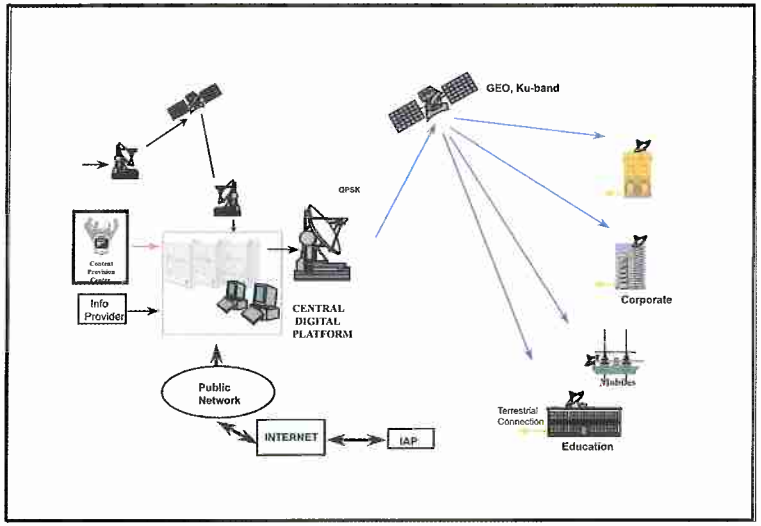
Basics

Convergence of Technologies (Communications, Computer, Media)

Digital platforms supporting multi-channel TV broadcasting (MPEG-2 / DVB standards) an interactive MultiMedia (MM) services*

Customer equipment : Dish antenna + RF and Integrated Receiver Decoder (IRD) [or Set-Top-Box (STB)] with return path capability

* DTH has been the 1st market segment to launch services targeted to the mass consumer market



Digital Satellite TV & Data Broadcasting Network Topology

EUTELSAT

- Partners : EUTELSAT was founded as an intergovernmental organisation and has grown to incorporate nearly 50 member countries in Europe. EUTELSAT currently operates according to a three-tier structure: the Assembly of Parties, a Board of Signatories and the Executive Organ
- Technical Aspects : The Eutelsat Fleet consists currently of **15 GEO** satellites. They are divided in **Hot Bird** (5), **Eutelsat I** (2), **Eutelsat II** (4), **W Series** (2), the **DFS-Kopernicus** satellite at 28.5 degrees East and **Telecom 2A** at 8 degrees West

✓ **Hot Bird**

With **five** satellites at **13 degrees East**, EUTELSAT's HOT BIRD™ family delivers over **320** analogue and digital television channels, as well as radio and multimedia services. The expected satellites **lifetime** range from **11** to **14** years. The downlink frequencies varies from **10.70** to **12.75 GHz**. The HOT BIRD™ satellites provide full coverage of Europe and also take in parts of Africa and Asia, including the entire Middle East.

HOT BIRDs™ 3 and 4 are equipped with a Steerable Beam which can be oriented anywhere visible from 13 degrees East, either northern or southern hemisphere.

HOT BIRDs™ 4 and 5 are the first in the world to be equipped with **SKYPLEX** for **on-board multiplexing** of digital signals into a single DVB stream which can be received on the downlink by standard IRDs.

✓ **Eutelsat I**

EUTELSAT I series was developed by **ESA**. **Four** EUTELSAT I satellites were successfully launched between **1983-88**. EUTELSAT F4 and F5 are still operating at **25.5 degrees East** and **12.5 degrees West** respectively. Downlink frequencies are **10.95-11.2** GHz, **11.45-11.7** GHz, **12.5-12.75** GHz.

✓ **Eutelsat II**

Five of the six EUTELSAT II satellites were successfully put into orbit and all five are still fully operational. The satellite are basically identical except for Eutelsat II-F6 which was modified for colocation at 13 ° East and renamed HOT BIRD™. Expected **satellite lifetime is 9 years**.

EUTELSAT

Orbital location is 48° East for Eutelsat II-F1, 12.5° West for Eutelsat II-F2, 36° East for Eutelsat II-F3 and 10° East for Eutelsat II-F4. Downlink frequencies are **10.95-11.2** GHz, **11.45-11.7** GHz, **12.5-12.75** GHz.

- **W Series**

  One W satellite is positioned at **16°East** and went into operation in **November 1998**. A second at **7° East** entered into service in **May 1999**, whilst the two remaining satellites will be launched in the **late 1999** and **2000**.

- Coverage : Positioned in geostationary orbit, the satellites span the orbital arc from 12.5° West to 48° East, enabling visibility of the earth from the east coast of North America to Asia
- Services :
  - **Consumer television and radio**

    By third quarter 1999 EUTELSAT was broadcasting over 550 (502 digital, 59 analogue) television channels directly into cable and satellite homes. The majority of channels (480) are delivered by the HOT BIRD™ satellites from 13° East.

  - **Multimedia Services**

    Since 1995 Eutelsat has been developing multimedia digital platforms to provide PC-based Internet and data broadcasting services via satellite. Eutelsat has developed solutions using **DVB** technology. The equipment needed to **receive** the service consists of a DVB/MPEG-2 card for PC (less than 300$) and an antenna (60 cm diameter). To **transmit** is needed an ordinary modem connected to a telephone line (**return link**). Satellite transmission is by nature a point-to-multipoint communication channel. By using **cryptographic** techniques, the number of potential users that can receive the broadcast data can be restricted to one user (**unicast**), or a group of users (**multicast**).

    Data speed can be up to **2 Mbps** per user or up to **40 Mbps** for broadcasting.

    Coverage is Western Europe, Eastern Europe, North Africa and Middle East.

  - **Business Services**

    Almost 20 transponders are used for one and two-way VSAT networks for applications such as videoconferencing, inventory tracking, telemedicine, distance-learning, newswire distribution etc.

EUTELSAT

- Services :
  - **Mobile Services**

    EUTELTRACS, the two-way message-exchange and position-reporting service for trucks and fishing vessels operates via EUTELSAT capacity in Europe, North Africa and the Middle East.

    EUTELSAT has also launched **emsat**, a mobile telephony service which can provide voice, data, fax, messaging and positioning services connected to the switched network. emsat is provided within the framework of an agreement with Telespazio to commercialize the EMS payload embarked on Italsat F2.
- Status: **Six new satellites** are currently under construction and will be launched by the late 2000:

W Series

Eutelsat is currently investing in powerful new telecommunications and television satellites to serve:

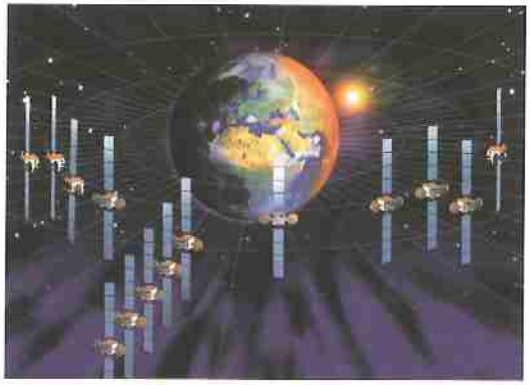
- The growing communications needs between Europe, the Mediterranean basin and central Asia
- Russia and Africa

Sesat

The Sesat satellite will be an addition to the EUTELSAT fleet, providing capacity for a wide range of telecommunications and multimedia services over an enhanced wide beam coverage spanning from the Atlantic islands to eastern Russia and including North Africa and Saudi Arabia.

SESAT will be positioned at 36° East. With the arrival of the W series of satellites at the orbital positions until now used by EUTELSAT II-F1, F2, F3 and F4, these satellites are gradually being relocated to new positions where they can continue to be used for a full range of telecommunications and television services.

EUTELSAT's **revenues** for 1998 were 455 million Euros with profits of 133 million Euros.



Eutelsat Fleet

ASTRA

ASTRA

- **Partners :**

  Societè Europèenne des Satellites (SES). The SES group comprises SES S.A., the ASTRA Marketing affiliates in Germany, the British Isles, France, Spain and Poland, SES Multimedia S.A. and SES Americas operation based in Ottawa, Canada

- **Technical Aspects :**

  The Astra fleet consists of **10 GEO** satellites.

  Eight spacecraft (1A, 1B, 1C, 1D, 1E, 1F, 1G and 1H) are co-located at the orbital position of **19.2 degrees East**, and two (2A and 2B) are located at **28.2 degrees East**

  - ✓ **Astra 1**

    The **64 transponders** of the Low Band **10.70 to 11.70 GHz** (ASTRA 1A, 1B, 1C and 1D) are transmittingfor the time being analogue services, but may technically be used for digital transmissions upon demand of broadcasters.

    The **56 transponders** of the High Band **11.70 to 12.75 GHz** (ASTRA 1E, 1F, 1G and 1H) are dedicated for the transmission of digital services

  - ✓ **Astra 2**

    A second orbital position at 28.2° East has been activated where ASTRA 2A and ASTRA 2B will provide **56 transponders** dedicated to new digital markets, operating in the frequency range **11.70 to 12.75 GHz**

- **Coverage :**

  The combined footprints of ASTRA and AsiaSat provide **74%** of Europe, Asia and Australia.

Astra Satellite

INTEGRATED SYSTEMS

ASTRA-NET

- Partners :

  ASTRA-NET, the **multimedia** service platform operated by the 100% SES-owned **SES Multimedia S.A.**, provide bandwidth and value-added services for broadcasting and multicasting customers.

- Technical Aspects :

  ASTRA-NET provides three different data delivery methods:

  - ✓ **IP Multicast Package Delivery** (a UDP/IP Multicast file transfer mechanism)
    Facilitates the simultaneous transmission of data and multimedia files, independently of their volume, to all addressed PCs within a closed user group. With a single and scheduled point-to-multipoint transmission throughout the footprint of the ASTRA Satellite System, providers can boradcast information which can be confirmed via the addressed PC's return channel
  - ✓ **IP Multicast Streaming Delivery** (a UDP/IP Multicast streaming mechanism)
    Enables Service Providers to reserve the required satellite bandwidth (between **64 kbit/s** and **6.5 Mbit/s**) flexibly and on demand. This delivery method is especially suited to allow content- and service providers to distribute services such as PC-TV, audio- or data ticker services
  - ✓ **High Speed Internet Services** (a TCP/IP data transfer mechanism)
    Enables e.g. Internet-Service-Providers (ISPs), to IP multicast content to subscribers at speeds of up to **6.5 Mbit/s**

- Coverage :

  ¾ of the world population

- Services :

  - ✓ ASTRA-NET offers **DVB** compliant and **IP-based** broadband multimedia and data distribution service in Europe.
  - ✓ Two-way broadband communications system via the **ASTRA Satellite System** by enhancing ASTRA-NET with satellite return channel technology.

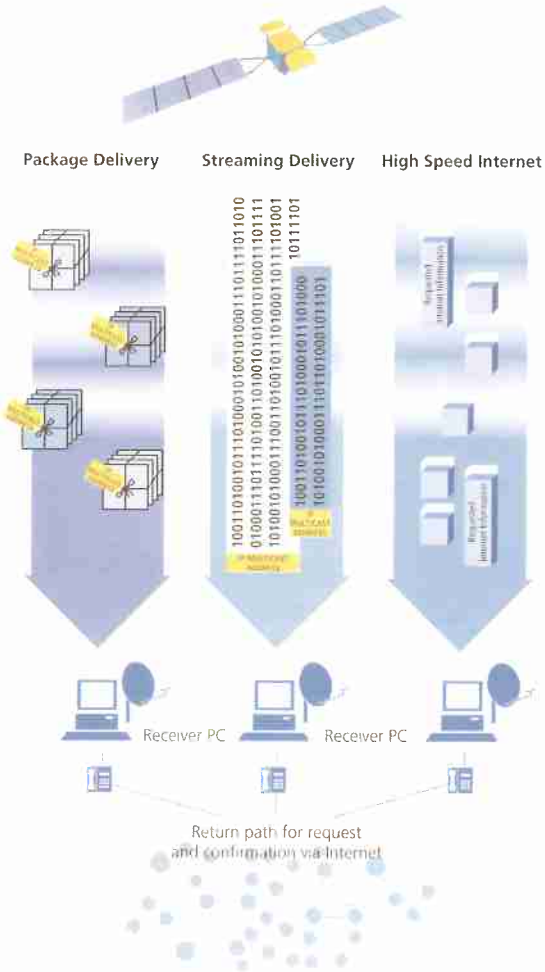
ASTRA-NET

- **Reported Cost :**

  To receive ASTRA-NET, a PC or server equipped with an ASTRA-NET compliant **DVB/MPEG-2** receiver card and a **50 cm** single feed dish with a Universal LNB are required.
  ASTRA-NET uses Ku-band broadband satellite transponders to provide up to **38 Mbit/s** from a single uplink earth station, the ASTRA-NET Network Operations Center.
  The cost to equip a reception site is approximately **770 Euro**

- **Status :**

  The enhancement of the existing ASTRA-NET platform with the new broadband return channel via satellite is planned for the year 2000.



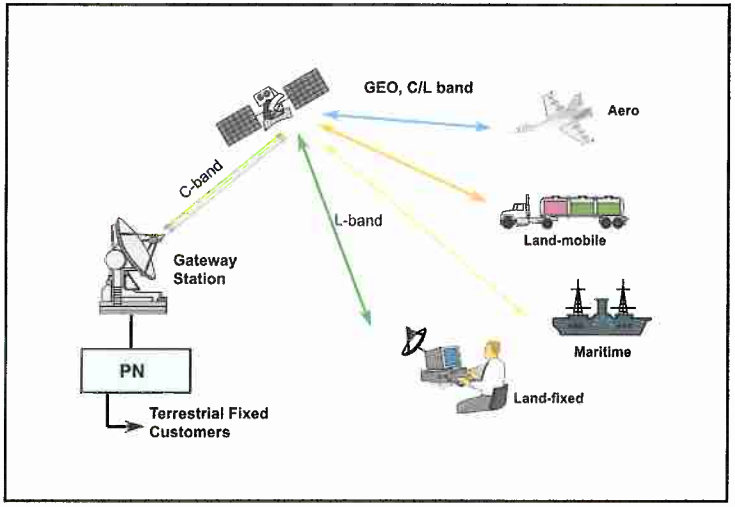
MOBILE COMMUNICATIONS SYSTEM

Basics

- Architecture : Mobile networks have a star topology and interface to the International Public Network via large Gateway stations
- Coverage : Global and regional systems
- Space Segment : GEO satellites, C/L bands mainly
- Applications : Maritime, Land Mobile, Aeronautical, Land-fixed, Portable
- Services : Two-way voice/fax, telex, data and low-rate video
- User Terminals : Variety of terminal standards and types available in the market that can satisfy different user needs

Example Systems

- → INMARSAT System (Global Mobile Network)
- → Euteltracs (Regional / European Coverage / Based on the Qualcomm Omnitracs system / Alcatel is the distributor of terminals)
- → AMSC Regional land mobile system (USA)
- → Omnitracs (USA, Japan, Korea, Malaysia)



Mobile Satellite System

MOBILE COMMUNICATIONS SYSTEM

INMARSAT SYSTEM

The world's first global satellite communications operator providing satellite services, founded in the 1970s for mobile users in remote locations

- Partners : Inmarsat has about 80 signatories, including Comsat (USA), BT, Stratos Global, KPN, Telenor, OTE (Greece), Singapore Telecom, Telestra. Inmarsat was privatised in early 1999.
- Coverage : Global, 4 GEO satellites (4 Ocean Regions : IOR, AOR-East/West, POR)
- Frequency bands of operation : C/L-band
- Ground Segment :
  - **Land Earth Stations (LESs) :** Central communications nodes (Gateways) interconnected to the PN for commercial services
  - **Mobile Earth Stations (MESs) :** User terminals
  - **Network Coordination Stations (NCSs) :** Network management nodes
- Communications Standards : Inmarsat-A, -B, -C, -M, Aero, Mini-M, Paging
- European involvement : Many European countries are shareholders in the Inmarsat Organization, operators of Inmarsat LESs and mobile satellite service providers

→ Mini-M Phone

- Technical Aspects :
  - **5 GEO** satellite (including one backup) using spot-beam technology
  - Expected satellite **lifetime 13 years**
  - **Voice :** 2.4 Kbit/s, **Data :** up to 64Kbit/s
- Global coverage
- Services :
  - Mobile voice, data, fax, positioning, **2.5 /min**
  - Terminal cost **3000** €
- Reported Cost : approximately **690 million** €
- Status : **Five** satellites have been **launched**, providing global coverage.

Inmarsat Satellite

Inmarsat (Mini-M) Portable Satellite Phone

INMARSAT SYSTEM

PROPOSED Project

→ **Horizons**

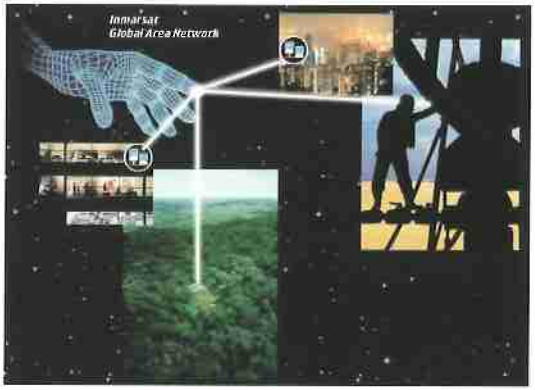
Mobile Multimedia satellite services (data rate up to 144Kb/s), (2B €).
This fourth-generation system of 3 or 4 satellites was expected for 2001, with full operation by the end of 2002. Inmarsat had been weighing this system since 1997 but **dropped the idea** when its governing council could not agree that the market was worth the investment

→ **Inmarsat Global Area Network**

Inmarsat's latest service, the Global Area Network, supports 64 kbps ISDN-compatible communications using new portable units the size of a notebook computer and weighing around 4kg.

→ **Inmarsat 4**

A € 1.4 billion system that will provide satellite-delivered Internet links by 2004.
The two satellites (54° West and 64° East longitude) + 1 ground spare, called Inmarsat 4, will permit users of laptop computers in many areas of the world to link to the Internet at speeds of up to 432 Kbit/s via 1 kilogram, 1.5 - centimeters - thick antenna (antenna cost less than € 1.000)

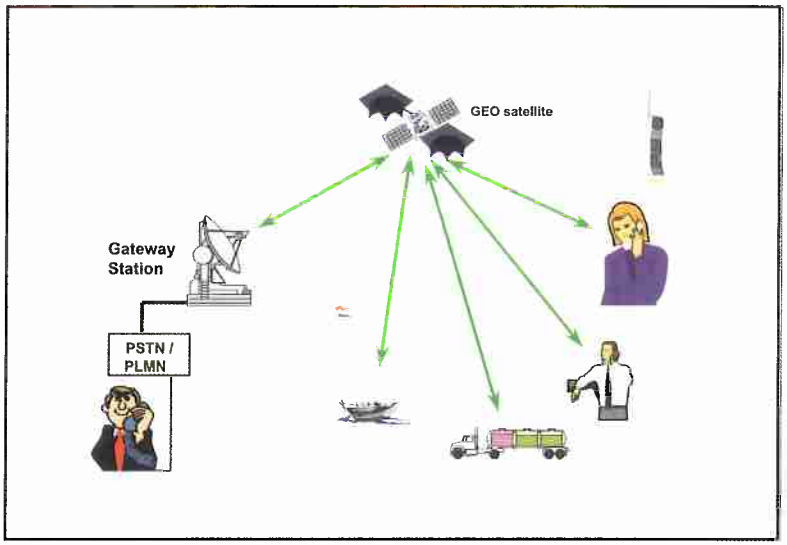


Inmarsat Satellite System

SATELLITE - PCS

Basics

- Space Segment : **LEO** or **MEO** or **GEO** satellite constellations
- Coverage : Global or Regional
- Interworking with terrestrial PSTN and PLMN
  (S-PCS operate as complementary to terrestrial infrastructure)
- User Terminals : Hand-held, Mobile, Fixed
  Dual-mode operation (e.g. satellite/GSM or DCS1800)
- Services : Voice, fax, low-rate data, paging, location determination
- Start of Operation : **1998-2000** (depending on the system)



GEO S-PCS Network Architecture

SATELLITE - PCS

Introduction

Business Considerations

- Half of the world population lives more than two hours from the closest telephone
- Four billion people around the world are without a telephone
- 50 million people worldwide are on waiting lists for telephones, the average wait being 1,5 years

- Several competing Satellite Personal Communication Networks are currently being developed
- Systems offering a global service are based on either Low Earth Orbit (LEO) satellite constellations, such as **Iridium** and **Globalstar**, or on a Medium Earth Orbit (MEO) constellation, like that of **ICO**
- The comparative costs of a GEO-based mobile satellite system, whose coverage is tailored to meet the specific needs of the region being serviced, are very attractive

Recent Developments

- The two closest contenders, Iridium and Globalstar, have both suffered from unexpected problems and delays:
  - ✓ **Iridium** has been hit by a variety of in-orbit satellite problems, with a total of 12 spacecraft that are unserviceable for a number of unconnected reasons. Commercial service was available on November 17th, despite several failures. The subscriber growth stalled because of shortage of handsets, terrestrial mobile competition and high prices: the company filed for bankruptcy protection in August '99.
  - ✓ **Globalstar** suffered by an Ukrainian Zenith 2 rocket launch failure : 12 spacecraft lost in one shot. Globalstar should become fully operational and start offering commercial services early 2000
  - ✓ **ICO** filed for bankruptcy protection in August '99, because of lack of investment.

SATELLITE - PCS

Introduction

Several Mobile and Personal Satellite Systems Proposed

- Iridium
- Globalstar
- ICO
- Orbcomm
- TMI / M-Sat
- ACeS (Asian Cellular Satellite System)
- Thuraya
- ECCO / CCI
- Ellipso
- Leo One
- FaiSat
- Leosat Courier
- Solidaridad / Satmex
- E-Sat, Gemnet, C&W Optus, VITAsat
- Cyprus GEM, ACTEL, Satphone
- Odissey, ASC/Agrani, APMT
- and others

Summary of the leading Satellite-Personal Communications Systems

SYSTEM	Iridium	Globalstar	ICO	Regionals
Orbit	LEO	LEO	MEO	GEO
Orbit Altitude (Km)	780	1414	10,355	36,000
Nº.of Satellites + Spares	66 + 6	48 + 8	10 + 2	1 +
Service Life	5 years	7.5 years	12 years	12 years
Spot Beams per Satellite	48	16	163	variable
User Link Frequency (Up/Down), GHz	1.621–1.626	1.610–1.621 / 2.483–2.495	1.980–2.010 / 2.170-2.200	1.525-1.559 / 1.626-1.660
Feeder LinkFrequency (Up/Down), GHz	30/20	5.1/6.9	5.2/6.9	14/12
Multiple Access	TDMA/FDMA	CDMA/FDMA	TDMA/FDMA	TDMA/FDMA
Nominal Capacity per Satellite (voice ckts)	1,100	2,400	4,500	16,000 (typ.)
No. of Gateways	12	38	12	variable
Reported Cost ($Billion)	4.7	3.5	4.8	1-1.5 (typ.)

SATELLITE - PCS

IRIDIUM

- Partners : **Motorola**, LM, Sprint, Raytheon, Nippon Iridium Corp., BCD Mobile Communications Inc., DDI, UCOM, SK Telekom Corp., PT Bakrie Communications Corp., Bouygues
  European Participation : STET, Vebacom
- Technical Aspects :
  - ✓ **66 LEOs** (**11** sats x **6** planes, 780 Km altitude) using **ISLs**.
    6 spare satellite are provided. Orbital period of 100 min. and 28 sec.
  - ✓ **48** Radio beams per satellite
  - ✓ Expected satellite **lifetime 5-8 years**
  - ✓ **User Frequency :** 1.616 GHz to 1.6265 GHz
  - ✓ **Feeder Uplink / Downlink Frequency :** 29.1 to 29.3 GHz / 19.4 to 19.6 GHz
  - ✓ **Intersatellite Crosslinks Frequency :** 23.18 GHz to 23.38 Ghz
  - ✓ **Voice, Fax & Data :** 2.4 Kbit/s
- Global coverage : Including mid-ocean and remote areas
- Services :
  - ✓ High-end markets / voice, fax, data, paging **2.5 € /min**
  - ✓ Terminal cost from **1500** € , prices should fall.
- Reported Cost :
  4.4 B € . Iridium need a debt-refinancing between 1 and 1.7 B € .
- Status : **Operational.** Seven out of 72 launched satellites malfunctioned. Replacement satellites were launched and now the constellation is complete and operational. At the end of first quarter 1999 it had 10294 subscribers for revenues of just over 1 million $ in first five months of service. Last year backers expected it to get over half a million subscribers by the end of 1999.
  The company filed for Chapter 11 bankruptcy protection on Aug -13, 1999.

Iridium Network

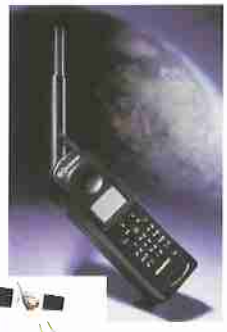
Handset

SATELLITE - PCS

GLOBALSTAR

- Shareholders and Strategic Partners : **Space Systems/Loral**, Qualcomm, DASA, Alenia Aeropazio, Alcatel, Aerospatiale, Vodafone, Airtouch, France Telecom, China Telecom, Elsag Bailey, DACOM
  European Participation : **>25%**
- Technical Aspects :
  - ✓ **48 LEO** satellites (+ **8 spares**) in circular orbit, comprising **8** planes, at an altitude of 1414 Km and inclination of 52°
  - ✓ **16** spot beams per satellite
  - ✓ Expected satellite **lifetime 7.5 years**
  - ✓ **User Uplink/Downlink Frequency :** 2.4835 to 2.5 GHz / 1.61 to 1.6265 GHz
  - ✓ **Feeder Uplink/Downlink Frequency :** 5.025 to 5.225 GHz/ 6.875 to 7.075 GHz
  - ✓ Qualcomm's terrestrial **CDMA** technology for mobile link, and for the feeder link **FDM** uplink and **FDMA** downlink
  - ✓ **38 Gateways**
  - ✓ **Voice :** typically 2.4 Kbit/s, **Data :** 9.6 Kbit/s (maximum)
- Global coverage. All but highest latitude are completely covered
- Services :
  - ✓ Primarily mobile and fixed voice, with paging, messaging, fax and GPS services as secondary applications: price from **1** to **1.2 € /min**
  - ✓ Terminal expected cost 750 $
- Reported Cost : **€ 3.26 billion**
- Status : 12 Satellites were lost on Sep. '98 with the failure a Zenith 2 rocket.
  Operations began with only 32 satellites in orbit before the end of 1999. Globalstar expects to provide service covering 45% of the world, with 16 gateways by the end of 1999 and full service by **March 2000** with 38 gateways

Handset



Globalstar Network

SATELLITE -PCS

ICO

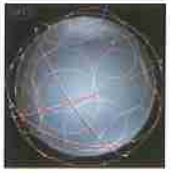
- Partners : **Hughes**, TRW, 57 investors including BT, Deutsche Telecom, Telekom South Africa, Inmarsat and India's VSNL
  European participation : **20%**
- Technical Aspects :
  - **10 MEOs** (**5** sats x **2** planes, 10390 Km altitude) with an orbital inclination of 45 degrees. **2 spare** satellites are provided (one per plane)
  - Expected satellite **lifetime 12 years**
  - **163** Radio beams per satellite. Each satellite is designed to support at least **4500** telephone channels through the use of TDMA and has **separated** service-link (satellite-to-user) transmit and receive antennas
  - **12 Gateways** (Satellite Access Nodes) cover the earth forming the **ICONET** and integrating mobile satellite communications capability with terrestrial networks
  - **User Uplink / Downlink Frequency :** 1.98 to 2.02 GHz / 2.065 to 2.1 GHz
  - **Feeder Uplink / Downlink Frequency :** 5 GHz / 7 GHz
  - **Voice :** 4.8 Kbit/s, **Data :** up to 38.4 Kbit/s
- Global coverage
- Services :
  - Voice, data, fax, messaging, base tariff of calls will be **1.95 € /min** with range from **0.5 to 3 € /min** depending on the service used
  - Terminal cost around **700 €**
- Reported Cost : **4.5 billion €** (including ground infrastructure). ICO has raised in excess of 2 billion € in equity
- Status : Service due to commence in **third quarter of 2000**. ICO Global Communications filed for Chapter 11 bankruptcy protection on August 27, 1999 following a failure to reach agreement between strategic investors, suppliers and bondholders.


Handset


ICO Satellite

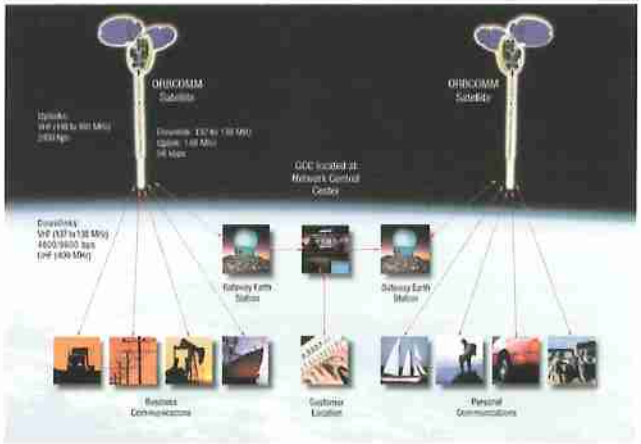
SATELLITE - PCS

ORBCOMM



- Partners : Orbital Sciences Corporation, Teleglobe Inc.
- Technical Aspects :
  - **48 LEO** satellite manufactured by Orbital Sciences, orbiting at **825 Km**. 8 additional satellites will be kept as spares on the ground and may be added if there is sufficient demand
  - Expected satellite **lifetime 4 years**
  - **Transmit / Receive Frequency :** 137 to 138 MHz and 400.05 to 400.15 MHz / 148 to 149.9 MHz
  - **Data :** up to 2.4 Kbit/s (typically 0.3 Kbit/s)
- Global coverage
- Services :
  - Messaging, email, fax, GPS
  - Terminal cost : **1000 €**
- Reported Cost : **500 million €**
- Status : Commercial service began on **30 November 1998**, with 28 satellites in orbit.
  The last 8 satellites were successfully launched in September 1999.

Orbcomm Network



SATELLITE -PCS

MSAT

- Partners :

  TMI Communications, Telesat Canada, GTIS, Glentel, Infosat, Mobility Canada Satellite
- Technical Aspects :
  - **1 GEO** satellite (HS601)
  - Expected satellite **lifetime 12 years**
  - **Feeder Uplink / Downlink Frequency :** 13 to 13.15 GHz and 13.2 to 13.25 GHz / 10.75 to 10.95 GHz
  - **User Uplink / Downlink Frequency :** 1.6315 to 1.6605 GHz / 1.53 to 1.559 GHz
  - **Transponders:** Two Ku-band to L-band forward link repeaters and one L-band to Ku-band return link repeater
  - **Data :** 4.8 Kbit/s
- Coverage :

  North and Central America (including coastal waters to 400 kms), Mexico, Hawaii, and the Caribbean
- Services :
  - Mobile and fixed voice (from **1 €** to **2 €** per minute), fax, data
  - Terminal cost approximately **6000 €**
- Reported Cost : Not known
- Status : **Operational.**

MSAT Terminal

MSAT Satellite

SATELLITE - PCS

ACeS

- **Partners :**
  Lockheed Martin, Pasifik Satelit Nusantara (PSN)/Indonesia, Philippine Long Distance Company, Jasmine International PLC of Thailand
- **Technical Aspects :**
  2 GEO satellites (A2100) manufactured by Lockheed Martin
- **Regional Coverage :**
  South East Asia, India, China, Australia
- **Services :**
  - ✓ Mobile and fixed voice, fax, data, paging, **1 € /min**
  - ✓ ACeS aims to provide cost-effective, fill-in service for cellular operators and user.
  - ✓ The main market will be Indonesia and the Philippines.
  - ✓ Ericsson will supply 10000 dual-mode GSM / satellite handsets retailing at **1000 €** .
  - ✓ Satellite operators **ACeS** and **EAST** have joined forces with Ericsson, Lockheed Martin and Matra Marconi Space to create a satellite air interface standard named **GMSS** (Geostationary Mobile Satellite Standard). The GMSS will be developed from GSM, the world-wide cellular standard.
- **Reported Cost :**
  800 million € (fully financed)
- **Status :**
  Launch was originally expected to be in September 1998, with operational service starting in 1999. However, the launch of ACeS's Garuda 1 satellite has been postponed **late 1999**, with service beginning a few months thereafter

ACeS Network

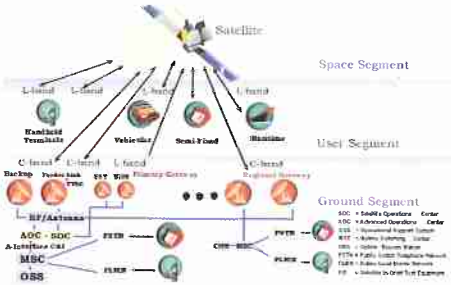
SATELLITE - PCS

THURAYA

- Partners : Etilsalat, Abu Dabi Invest. Co, Arabsat, BATELCO (Bahrain), ADIC, Al Murjan Trading & Industrial (Saudi Arabia), General Post & Telecom (Lybia), Q-Tel (Qatar), MTC, GIC (Kuwait), PTC (Yemen), Telecom Egypt, Nat. Telecom (Morocco), Tunis Telecom, DETECON (Germany)
- Technical Aspects :
  - ✓ **2 GEO** satellites (**1** operational **+ 1** spare ready for deployment) with 6 degrees inclination. Hughes is providing satellites. **250-300** spot beams per satellite Expected satellite **lifetime 12 years**
  - ✓ **250-300** spot beams per satellite. On-board Digital Signal Processing (**DSP**).
  - ✓ **Frequencies Mobile Links :** Earth-to-Space / Space-to-Earth 1.6265 – 1.6605 GHz / 1.525 – 1.559 GHz
  - ✓ **Frequencies Feeder Links :** Earth-to-Space / Space-to-Earth 6.425 – 6.725 GHz / 3.4 – 3.625 GHz
  - ✓ **Primary Gateway** to be situated in Sharjah will be responsible for entire network. Individual **Regional Gateways** located later in other countries to meet specific requirements of local markets
  - ✓ **Voice** comparable to GSM, **Fax / Data** of 2.4, 4.8 and 9.6 Kbit/s
- Regional Coverage : Indian Subcontinent, Central Asia, The Middle East, Europe, North and Central Africa
- Services :
  - ✓ Voice telephony, fax, data, short messaging. Average price **0.5 € /min**
  - ✓ Location determination within 100 m accuracy upon request
- Reported Cost : **1 billion €**
- Status : Thuraya plans to launch the first satellite in May 2000, with commercial operation beginning in **September 2000**. It expects to launch the second satellite two to three years later, subject to demand.

Handset

Thuraya Network



SATELLITE - PCS

AMSC

- Partners : Hughes Communications Corporation, Motorola, Roland Baron, Singapore Telecom, AT&T
- Technical Aspects :
  - ✓ **2 GEO** Hughes HS601 satellite. AMSC and MSAT operate two identical Hughes HS601 GEO satellites.
  - ✓ **Transmit / Receive Frequency :** 1.6265 to 1.6605 GHz / 1.525 to 1.559 GHz
  - ✓ **Data :** up to 4.8 Kbit/s
  - ✓ Providing Secure Telephone Unit (**STU-III**) services, the national security standard for encrypting voice and data
- Coverage : USA, Mexico, Hawaii, US Virgin Islands and regions of US coastal services
- Services : Originally AMSC offered mobile and fixed voice, messaging and GPS.
  However, AMSC moved into the mobile data market, using a dual-mode terrestrial-satellite system.
- Reported Cost :
  System cost not Known. Airtime charges range from **0.85 € to 1.99 € per minute**, depending on usage
- Status :
  The first-generation AMSC satellite (known as **MSAT-2**) **is operational**.
  A second generation is expected to be launched in 2000.
  AMSC is targeting businesses that require remote communications and is now focusing particularly on narrowband mobile data.
  A future second-generation satellite may provide handheld mobile services.

Satellite Coverage

AMSC User Terminals

SATELLITE - PCS

EAST - Euro African Satellite Telecommunications

- Partners : **Matra Marconi Space and Digimed** (subsidiary of Cyprus Telecommunication Authority), Nera, Ericsson, Matra Hautes Technologies, Aon Space (space insurance division of Aon Corp)
- Technical Aspects:
  - ✓ A Matra Marconi Eurostar 3000 **GEO** satellite, with L-and Ku-band payload
- Regional Coverage : Saudi Arabia, Eastern Europe, North Africa, South and West Africa
- Services :
  - ✓ **Main focus is on voice :** Handheld mobile and rural / fixed telephony
  - ✓ **Also data services :** Internet access is at 57.6, 115.2 and 384 Kbit/s
    Low-cost services that complement and extend the coverage of terrestrial fixed and mobile services.
  - ✓ **For Mobile :** domestic charges will be about 0.6 € /min, falling to .4 € /min.
    International surcharges will be 0.3 to 0.35 € inside the EAST coverage area and 0.4 to 0.45 € outside.
  - ✓ **For Fixed :** domestic charges will be about 0.15 € /min, falling to 0.10 € /min.
    International surcharges will be 0.15 € inside the EAST coverage area and 0.25 € outside
- Reported Cost :
  - ✓ **800 million** for satellites
  - ✓ **350 million** for gateways
  - ✓ **250 million** in financing
- Status : The EAST satellite will be launched in third quarter 2001, and commercial service is expected for the **end of 2001** or early **2002**.
  250 million € of capital investment is already in place (from MMS, Nera and Cyprus Telecommunications Authority), and a further 150 million € is needed to begin implementation.

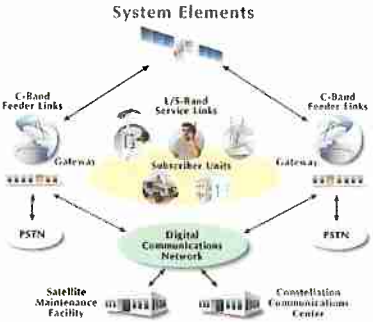
Handset

East Satellite

ECCO

- Partners : **Constellation Communication Inc.**, Orbital Sciences (Prime Contractor), Telebras, Bell Atlantic, Raytheon, Space Vest, Matra Marconi Space, E-Systems Inc., CTA Launch Services Inc
- Technical Aspects :
  - ✓ **The first phase** will have **11 LEO** satellite (+ **1 spare**) in orbit around the equator at an altitude of 2000 Km. Once the equatorial system is in place CCI will **expand** the system to provide the same affordable, high-quality services globally
  - ✓ First generation equatorial system will have **24** Spot beams per satellite. The satellites used to expand globally will have **32** antenna beams
  - ✓ **User Uplink / Downlink Frequency :** 1.61 - 1.6265 GHz / 2.4835 - 2.5 GHz
  - ✓ **Gateway Uplink / Downlink Freq. :** 5.091 - 5.25 GHz / 6.924 - 7.075 GHz
  - ✓ The system will use **CDMA** transmission techniques
- Coverage : Initially in equatorial belt between Tropics of Cancer and Capricorn, then, with the expansion, worldwide.
- Services :
  - ✓ Fixed and mobile telephony **0.9 € /min**, datacomms, fax, paging
  - ✓ Radio location
  - ✓ With the expanded **system** also high-speed digital transmission services at rates up to 28.8 Kbit/s, Group 3 facsimile, internet access, and other multimedia services
- Reported Cost : The original budget was **450 million €** but with the extension of the constellation the total cost of the project is now **1.1 billion €**
- Status : Commercial service is expected to **begin in 2001**, with equatorial constellation. ECCO has been granted a US licence to operate a global system of 46 satellite.
  The **expansion** of the system will come **in 2003.**

ECCO Satellite



SATELLITE - PCS

ELLIPSO

- Partners : **Boeing**, Mobile Communications Holdings, Vula Communications, Spectrum Network Systems, Harris Corp., IAI, Spectrum Astro Inc., L-3 Com, Lockheed Martin, Boeing, Aon Space
- Technical Aspects :
  - ✓ **17** satellites (with **1** in-orbit spare) divided in two constellations :
    Borealis - 10 satellites in elliptical orbits in two planes. They have apogees of 7846 Km, perigees of 520 Km and provide coverage of the northern temperate latitudes
    Concordia - 6 MEO satellites to be deployed in a quasi circular equatorial orbit at an altitude of 8040 Km. They provide coverage to the tropical and southern latitudes
  - ✓ **61** Radio beams per satellite
  - ✓ **User Terminal Uplink / Receive Frequency :** 1.61 to 1.6215 GHz / 2.4835 to 2.5 GHz
  - ✓ Use of **CDMA** for maximum spectrum efficiency
  - ✓ **Voice** 2.4 Kbit/s, **Data** up to 9.6 Kbit/s
- Regional Coverage :
  Primarily the northern hemisphere but also as far south as 55 degrees latitude in the southern hemisphere
- Services :
  - ✓ Mobile and fixed voice, data, fax, paging, **0.35-0.5 € /min**
  - ✓ Terminal cost around **1000 €**
- Reported Cost : **1.5 billion €** (from 910 million € previously). This include all the space and ground segments
- Status : Ellipso has been granted a US licence and is expected to start operational service in **late 2001** or 2002.

Handset

Ellipso Network

Leo One

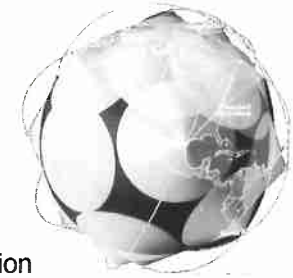
- Partners : **Leo One worldwide, Inc.** is an affiliate of dbX Corporation, Dornier Satellitensysteme GmbH, Eurockot Launch Services GmbH, Lockheed Martin Space Electronics & Communications
- Technical Aspects :
  - ✓ **48 LEO** satellite arranged in 8 orbital planes at an altitude of 950 Km with an orbital inclination of 50°
  - ✓ Expected satellite **lifetime 5 to 7 years**
  - ✓ **Uplink / Downlink Frequency :** 148 to 150.05 MHz / 137 to 138 MHz
  - ✓ **Gateway Uplink / Downlink Frequency :** 148 to 150.05 MHz/400.15 to 401 MHz
  - ✓ **Data rate Uplink / Downlink :** 2.4 Kbit/s to 9.6 Kbit/s / 24 Kbit/s
  - ✓ **Gateway Uplink / Downlink data rate :** 50 Kbit/s
- Coverage : Leo One will provide store and forward coverage of all points between the Artic and Antarctic Circles and near real-time service to the most populated regions of the Earth
- Services :
  - ✓ Vehicle tracking, status monitoring, emergency alerting, messaging, paging, positioning. Service cost will be competitive with terrestrial-based datacomms systems
  - ✓ Leo One will provide low-cost, real-time mobile and fixed service for industrial, business and personal data communications. Transceivers will cost **100 € to 500 €**
- Reported Cost : **250 million €**
- Status : The FCC awarded a licence in February 1998. Commercial service is expected to begin in **2000 or 2001**

Leo One Network

SATELLITE - PCS

FAISAT

- Partners : **Final Analysis Communication Inc. (FAI)**, AKO Polyot Enterprises
- Technical Aspects:
  - ✓ **38 LEO** satellites at **1000 Km** height.
    Two (**2**) of the satellites are launched to an **83-degree** inclined orbit.
    Thirty six (**36**) satellites are launched in **six orbit planes** with six satellites in each plane, including one in-orbit spare.
  - ✓ The orbits are inclined at **51 degrees**
- Global coverage
- Services :
  - ✓ Two-way messaging, asset tracking, monitoring and control, file transfer services offered in real time, near real time, and store and forward modes
  - ✓ Both TDMA and CDMA technique allowing a sharing of the spectrum with other users
- Reported Cost : **250 million €**
- Status : FAI received an **FCC licence** in the second round in early 1998, after receiving a licence to launch two experimental satellites.
  Service is expected to begin in **2001** with full operation expected no later than **2002**.
  Polyot launched test satellites in **1995** and **1997**. Construction of 3 Ground Stations in Maryland, Utah and Norway has been finished.



FAISAT Constellation

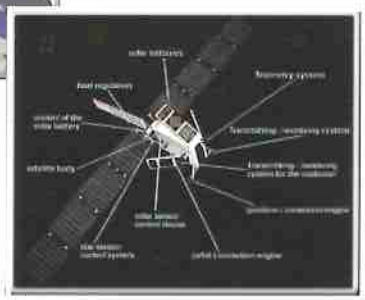
FAISAT Satellite

SATCON

LeoSat Courier

- Partners : **SATCON GmbH** is a European co-operation project developed from "off the shelf" components. It aims to combine the economic advantages and scientific technical know how of the Russian space industry with the technologies, and resouces of the Western European space industry.
- Technical Aspects :
  - ✓ **72 LEO** satellites (9 satellites x 8 planes) orbiting at **800 km**.
  - ✓ Use of satellite interlinks **(ISLs)**
  - ✓ Expected **satellite lifetime 5 years**
  - ✓ Voice channels per satellite : 2000
  - ✓ **Data rate :** 9.6 kbit/s, **Voice rate :** 2.4 / 4.8 / 9.6 kbit/s
  - ✓ **Two control centres** and of up to **19 gateways**, for the world-wide linking in public and private terrestrial network structures.
  - ✓ The architecture of LEO SAT COURIER is open for new developments of the Universal Mobile Telecommunication System-**UMTS**
- Global coverage
- Services : Voice, Data, Fax, Paging, Messaging, Position finding /Navigation. **0.3-2 € /min**
- Reported Cost : **1 billion €**
- Status :
  LEO SAT COURIER will be installed between 2000 and the year **2001**.

LEO SAT Network



LEO SAT Courier Satellite

SOLIDARIDAD / SATMEX

- Partners : **Loral Space & Communications'** joint venture with Telefonica Autrey was recently selected as the winner of the auction to acquire a 75 % stake in Satellites Mexicanos, S.A. de C.V. (SatMex). **Hughes Space and Communications** Company provides the satellites
- Technical Aspects : **3** satellites : **Solidaridad 1**, **Solidaridad 2** and **SatMex 5**

Solidaridad 1 & 2

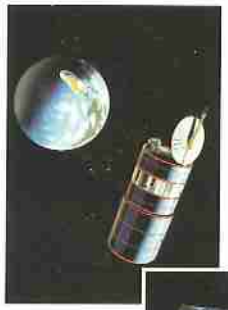
- ✓ are Hughes 601 HP satellites, each carrying twelve 36 MHz and six 72 MHz transponders in **C-band** and sixteen 54 MHz transponders in **Ku-band**. Expected satellite **lifetime 14 years.** These replace the two Hughes built **Morelos I** and **II** satellites, retired respectively in 1994 and 1998.
- ✓ Solidaridad 1 was launched in **November 93** and Solidaridad 2 in **October 94**

SatMex 5

- ✓ A Hughes 601 HP satellite that carries a payload of 24 **C-band** and 24 **Ku-band** transponders. It was launched in **December 98.** Expected satellite **lifetime 15 years**

- Coverage : Solidaridad 1 & 2 are covering from the southern United States into Central and South America. SatMex 5 has a footprint extending from Canada to Argentina
- Services :
  - ✓ Commercial broadcast, data, direct-to-home, telephony and radio applications
  - ✓ A new feature is nationwide mobile services
- Reported Cost : Not known
- Status : Loral has incorporated SatMex's operation under its LORAL SKYNET subsidiary.

SatMex 5 is the third generation of Hughes satellites to serve Mexico. Hughes launched Mexico's first satellites, Morelos I and II, which were HS 376 spacecraft, in 1985.
In 1993 and 1994 Solidaridad 1 and 2 were launched.
SatMex 5 will replace Morelos II.



Morelos Satellite

Solidaridad Satellite

Other Programs

→ E-SAT

- Partners : Echostar Communications, DBSI
- Technical Aspects :
  - ✓ **6 LEO** satellites orbiting at **1260 Km**
  - ✓ The system will operate in the 148-148.905 MHz uplink and 137.0725-137.9725 MHz downlink
  - ✓ Utilizes **CDMA**
- Coverage : Although its satellite system will offer global coverage of hard-to-access fixed assets, E-SAT will initially concentrate on the continental United States. Transmitting data from the ground in foreign countries requires permission from their regulatory agencies, obtained on a country-by-country basis
- Services :
  - ✓ Store and forward messaging
  - ✓ Low-cost, two way data messaging services for fixed users in rural areas in the USA and Europe
- Reported Cost : **110 million €**
- Status : Three micro-satellites are due for launch in first quarter **2001** with service commencing in the USA in the same quarter. DBSI is in discussions with Echostar to acquire a majority holding

→ GEMNET

- Partners : Orbital Sciencies, CTA Inc.
- Technical Aspects :
  - ✓ **38 LEO** satellites in **1000 km** orbits
  - ✓ Expected satellite **lifetime 5-7 years**
- Global Coverage
- Services : Tracking and monitoring, email, paging
- Reported Cost : **160 million €**
- Status : Operational service is expected to begin in **1999**

SATELLITE - PCS

Other Programs

→ C&W OPTUS (MobileSat)

- Partners : Cable and Wireless Optus Pty Ltd.
- Technical Aspects :
  - ✓ **2 GEO satellite** (B1 and B3) manufactured by Hughes
- Coverage : Mainly Australia with some parts of PNG, New Zealand and Indonesia
- Services :
  - ✓ Fixed and mobile voice, data, fax, paging
- Reported Cost :
  - ✓ **320 million €** for the entire project
  - ✓ Terminal cost about 3800 €
  - ✓ Current cost is from 0.5 to 2.0 € per minute for mobile voice services, with a 28 to 32 € monthly fee
- Status : Operational

→ VITAsat

- Partners : Volunteers in Technical Assistance, Final Analysis Inc., TOOL
- Technical Aspects :
  - ✓ **2 LEO** satellites orbiting at 1000 Km
- Coverage : Worldwide
- Services : Email and data transfer capabilitiy
- Reported Cost : **10 million €**
- Status : The first satellite was launched in September **1997**

→ CYPRUS GEM

→ ACTEL (African Continental Telecommunication)

→ and others....

On Hold / Discontinued

→ SATPHONE

- Partners : **Lockheed Martin Telecommunications**, Advanced Technology Fund Inc., M.O.Al Amoudi Corp.
- Technical Aspects :
  - ✓ **3 GEO** satellites system manufactured by Lockheed Martin
  - ✓ **150** Radio beams per satellite
- Regional Coverage : The Middle East, Northern Africa and the Mediterranean
- Services : Mobile and fixed voice. Looking to complement and extend terrestrial fixed and mobile services
- Reported Cost : **1.7 billion €**
- Status : The first satellite was scheduled for launch at the end of 1998 and was expected to be in service in September 1999. The **project** seems to have been put **on hold**.

→ ODYSSEY

- Partners : Proposed by **TRW Inc.**, with participation of Teleglobe Inc.
- Technical Aspects :
  - ✓ **12 MEO** satellites orbiting at altitude 10345 km with 7 ground stations
  - ✓ Expected lifetime of 15 years
  - ✓ **User uplink/downlink frequency:** 1.61 to 1621.35GHz / 2.4835 to 2.5GHz
  - ✓ **Feeder uplink/ downlink frequency:** 29.1 to 29.4GHz **/** 19.3 to 19.6GHz
  - ✓ **Voice:** 2.4 kbit/s, **Data:** 9.6 kbit/s
  - ✓ Use of CDMA access technique
- Global Coverage
- Services : Fixed and mobile voice telephony, fax, digital data, short messages
- Reported Cost : 3,2 Billion €
- Status : **System** now **cancelled**; US **licence** will be **returned to FCC**. US licence was granted in January 1995, and commercial service was expected to be operating by 2001. However, the system has now been cancelled and TRW has acquired a 7% share in **ICO Global Communications.**

SATELLITE - PCS

On Hold / Discontinued

→ ASC (AGRANI) – Afro-Asian Satellite Communications

- Partners : Essar Telecom, Essel Group, VSNL.
- Technical Aspects:
  - ✓ **2 GEO satellites**
- Coverage : Expected to cover 54 countries, stretching from Turkey to Singapore and from Russia to Sri Lanka
- Services :
  - ✓ Mainly voice, but also fax, data and messaging for fixed and mobile users, **2 € /min**
  - ✓ The handheld phones are expected to cost **700 to 1000 €**
- Reported Cost : **750 million € .**
- Status : The original launch date of 1999 is unlikely to be met, but ASC **is looking at leasing another satellite** until its own is in orbit

→ APTM – Asia Pacific Mobile Telecom

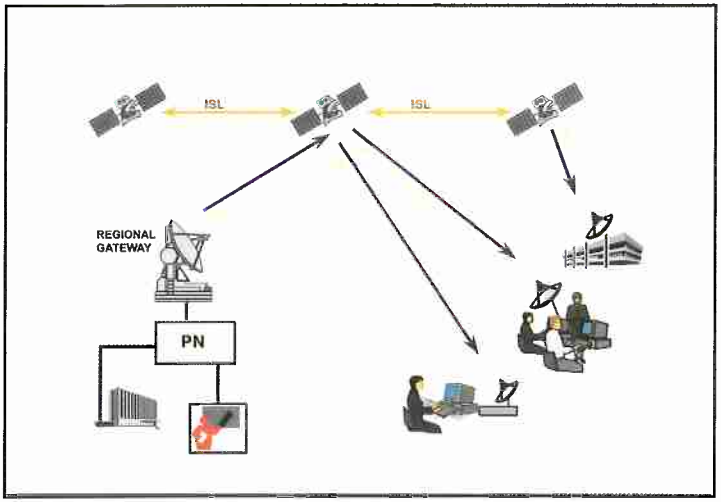
- Partners : China Satellite Launch & Tracking Control General, China United Telecommunications Satellite Co. Ltd., China Telecommunication Broadcast Satellite, China Overseas Space Development & Investment Co., Singapore Technologies (Singapore Telecom has withdrawn). China had confirmed investment in the project, although the amount has not been disclosed
- Technical Aspects :
  - ✓ **2** HS-702 **GEO** satellites (one spare). Expected satellite **lifetime 12 years**
- Coverage : East and South East Asia, particularly China, the Philippines, Vietnam and surrounding countries. The coverage is almost identical to that of ACeS Garuda
- Services : Mobile and fixed voice plus fax and data, **1 € /min**
- Reported Cost: **650 million €**
- Status: Satellite was scheduled for launch at the end of 1999, and service scheduled to begin in 2000. In February '99 the US government **withheld export licence** from Hughes for the sale of the APTM satellite

BROADBAND MULTIMEDIA SYSTEMS

Basics

- Space Segment : **High-power** satellites (**GEO**, **MEO**, **LEO**), Multiple spot beams, Inter Satellite Links (ISLs), On-Board Processing & Switching (OBP&S)
- Technology :
  - ✓ **Ka-**, **Ku-** and **V**-band (EHF)
  - ✓ Small, compact, lightweight multimedia end-user terminals (Ultra Small Aperture Terminals / **USATs,** and **VSATs** for very high Tx rates)
  - ✓ Advanced digital coding / modulation techniques
  - ✓ Gateway stations located in strategic positions
- Services :

  Two-way high-speed, high-capacity consumer and business services (video telephony, video conference, computer networking, digital libraries, interactive tele-learning, CAD/CAM transmission, high-speed internet, corporate intranets, DTH broadcasting, high capacity links up to 155 Mb/s)
- Start of Operation : **1999-2003** (depending on the system)



Simplified Broadband/ Multimedia Network Architecture

BROADBAND MULTIMEDIA SYSTEMS

Introduction

The Multimedia Market is today the main driver behind the Development of New Telecommunications Satellites

- DTH broadcast of new TV services, all based on the new Digital Video Broadcasting (DVB) standard: Pay TV (PTV), Pay Per View (PPV), Near Video On-Demand (NVOD)
- Fast Internet access and Media On-Demand applications
- Two-way interactive multimedia services (Tele-medicine, Tele-education and Tele-working)

→ All the above services have a fundamental need for interactivity, that can only be achieved by using large bandwidths and on-board connectivity

↓

Evolution of Ka-band (20/30GHz) and On-Board Processing technologies

→ In these two fields Europe arrived **first in the competition** with the USA, launching the first regenerative and on-board switching satellite at Ka-band, Italsat F1 (designed and built by Alenia Aerospazio), in 1991, followed by an F2 in 1996 (the NASA Advanced Communications Technology Satellite, ACTS, was launched in 1993).

Italsat F1

Recent Developments

→ A number of multimedia space systems are being proposed based on different constellations of geostationary and/or non-geostationary satellites, it is worth mentioning:
Spaceway (Hughes), Astrolink (Lockheed-Martin), Cyberstar (Space Systems/Loral), West (Matra Marconi Space), Euroskyway (Alenia Aerospazio), Skybridge (Alcatel Space), Teledesic (backed by Bill Gates and merged with Motorola), Rostelesat (Russian Federation)

Introduction

Key Trends in Spacecraft Antenna Technology aiming at

- To raise Spacecraft Effective Radiated Powers (EIRP)
- To make Communications Payloads smarter and more flexible
- To make Earth Terminals smaller and cheaper

- The following table presents a good indication of the near-term state of the art, illustrating the antenna systems that a representative sample of commercial Ka-band operators plan to fly in the 2000-2005 timeframe

SYSTEM	Astrolink	Cyberstar	Euroskyway	West	Spaceway	Teledesic
Sat Orbit	GEO	GEO	GEO	GEO/MEO	GEO	LEO
Number	5	3	5	12/9	20	288
Coverage	Pop.Centers	North America Europe, Asia	Europe, Africa, Mid-Est	Europe, Africa, Mid-Est	Pop.Centers	Global
No.Beams	96	72	32	64	24	64
Satellite Antenna	Horn fed	Horn fed	Horn fed	Horn fed	Horn fed	Array
Market	Multimedia	Multimedia	Multimedia	Multimedia	Infrastructure	Infrastructure
On Board Proc.	Full	Baseband	Baseband		Baseband	Full
Through-put	7.7 Gb/s	4.9 Gb/s		6 Gb/s	4.4 Gb/s	13.3 Gb/s
ISL	V Band	Potentially V	V Band	Optical	V Band	V Band
Terminals	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed

Characteristics of Planned Commercial Ka-Band Communications System

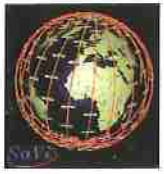
Introduction

Very High Bandwidth Inter-Satellite Links

- Many of the gigabit trunk systems are only now being considered due to a growing confidence in the technology required for their implementation. The proving of ISL technology and on-board switching on the US MILSATCOM programme and the advent of commercial systems such as Iridium using ISLs has given the satellite industry faith in the principles of these technologies.
- These systems rely on optical ISLs on-board the spacecraft to give them the capacity in their space-based network to carry the large amounts of data traffic that they are forecasting.
  ISLs therefore play a critical role in their system design and capacity planning.

SYSTEM	Expressway	V-Stream	GESN	Orblink
Coverage	Global	Global	Global	Not high latitudes
Orbit	GEO	GEO	GEO/MEO	MEO
N°.of Satellites	14	12	19	7
Operating Band	V	V	V	V
Data Rate	1.5 to 155 Mbps	1.5 to 155 Mbps	155 Mbps to 1.6 Gbps	1.5 Mbps to 7.0 Gbps
Start of Service	2003	2003	2003	2003
ISL	Yes	Yes	Yes	Yes

Example of proposed V-band (EHF) satellite services



TELEDESIC

- Partners : **Bill Gates** and **Craig McCaw** have private shareholdings and own the majority of the shares at present. In April 1998, His Royal Highness Prince Alwaleed Bin Talal Bin AbdulAziz Alsaud of Saudi Arabia invested USD200 million for a 13.7% stake in Teledesic. In May 1998, **Motorola** received a 26% stake in Teledesic for an investment of USD750 million. Design and development work from Celestri was re-directed to the new joint project. Motorola will be the prime contractor. Prior to the Motorola deal, **Boeing** had invested USD50 million for a 5% stake in the company, with an option on a further 5% for US 50 million $ (not yet exercised).
- Technical Aspects :
  - ✓ **288 LEO satellites** (rather than the 840 initially proposed) plus spares in a **1375 Km** circular orbit, divided into **12 planes**, **each with 24 satellites.** Expected satellite **lifetime 10 years**
  - ✓ Each satellite in the constellation is a node in the fast packet switch network, and has intersatellite communication links (**ISLs**) with eight adjacent satellites
  - ✓ **Uplink / Downlink Frequency :** 28.6 to 29.1 GHz / 18.8 to 19.3 GHz (**Ka-band**)
  - ✓ **Data :** from 16 Kbit/s to 2 Mbit/s uplink and 16 Kbit/s to 64 Mbit/s downlink
- Global coverage
- Services :
  - ✓ Broadband and data voice services
  - ✓ Internet / Intranet access are likely to be key markets
- Reported Cost :

  around **9 billion €** but may change following the Motorola deal
- Status :

  First launch expected in 2000 and operational service in **2003**.

  In January 1999 filed for licence with FCC for a proposed 30-satellite MEO system called "Ku-band Supplement" to augment the 288-satellite constellation to relieve congestion in high traffic areas.

  In May 1998 Motorola's Celestri project has been incorporated in the Teledesic system following the partnership announced on 21 May 1998 (Teledesic, Motorola, Boeing and Matra Marconi)

Teledesic Satellite

SPACEWAY

HUGHES SPACEWAY

- Partners : **Hughes Communications Inc.**
  Morgan & Stanley is currently looking for non-US partners
- Technical Aspects :
  - **Baseline system** consists of **8 GEO** HS702 satellites with an expected lifetime of **15 years** per satellite.
  - **A further 20 MEO** system (NGSO) could be developed later. The 20 satellites are divided in **four** orbit **planes**, orbiting at an altitude of **10352 Km** and inclination of 55 degrees. This system will use inter-satellite links **(ISLs)**
  - Both systems will operate in **Ka-band**
  - **Uplink / Downlink Frequency :** 27.5 to 30 GHz / 17.7 to 20.2 GHz
  - **Data rate :** 384 Kbit/s up to 6 Mbit/s
- Coverage :
  Most of the major continents will be covered except for parts of Asiatic Russia. The first regional system (North America), will consist of two GEO satellites, plus an orbit spare. The bulk of the inhabited world will be covered when the global system is completed
- Services :
  - Fixed voice, video, data and multimedia and VSAT applications. Terminals expected to cost **1000 €**
  - The GEO system is focused on the high data rate transport market and the NGSO system will provide advanced, interactive, broadband multimedia in high traffic markets globally
- Reported Cost :
  3.6 billion € for the GEO system, **2.4 billion €** for MEO's
- Status :
  First launch in 2002 with commercial service to begin in **2003**. Next three satellites to be launched at six month intervals after that, with further satellites in response to market demand.

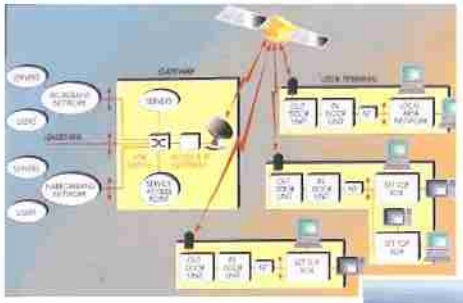
Spaceway Satellite

Spaceway Services

SKYBRIDGE

- Partners : **Alcatel Space**, Loral Space & Communications, Mitsubishi, Sharp, Spar Aerospace (Canada), Aerospatiale (France), SRIW (Belgium), Toshiba and Com Dev (Canada)
- Technical Aspects :
  - ✓ **80 LEO** satellites orbiting at an altitude of **1469 Km**, with an inclination of 53° (plus spares). **2** identical **sub-constellations** of 40 satellites each with **20 planes**, each containing 4 satellites
  - ✓ No inter-satellite links are required. Each satellite creates **18 spot-beams**
  - ✓ **Uplink/Downlink Frequency :** 12.75 to 14.5 GHz/ 10.7 to 12.75 GHz (**Ku-band**)
  - ✓ **Data rate :** 16 Kbit/s to 2 Mbit/s uplink and 16 Kbit/s to 20 Mbit/s downlink
- Global coverage
- Services
  - ✓ Interactive multimedia, high data rates and real-time applications
  - ✓ **Terminal cost** is expected to be **700 €** . Access to the service from **30** to **40 €** per month.
  - ✓ It is primarily aimed at providing broadband access in areas with low or moderate density populations
- Reported Cost : **4.2 billion €** for satellite costs and **1,9 billion €** for terrestrial cost (**200 gateways** costing approximately 10 million **€** each)
- Status :

  The program has been upgraded from 64 to 80 satellites.
  Skybridge was expected to enter service in **2001**, with half of its 80 satellites in operation.
  Full operation was expected in **2002**.
  Frequency approval has now been given by WARC-97 subject to non-interference with existing GEO systems.
  Will be marketed together with **Cyberstar**.



Skybridge System

Gateway

CYBERSTAR

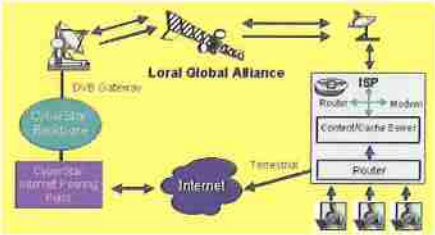
- Partners : **Loral Space & Communications**, Alcatel Espace
- Technical Aspects :
  - ✓ **3 GEO** satellites operating in **Ka-Band** with **on board processing** and **inter-satellite links**
  - ✓ Satellites offer speeds of 27 to 45 Mbit/s with Gateways
- Coverage : The initial service rollout covers the continental US. Additional coverage will be available for Europe, Middle East, and Asia
- Services :
  - ✓ Internet access, broadband interconnection, VOD (Video On Demand) and other data services
  - ✓ Targeting broadband applications such as Internet and Intranet access from low-cost fixed terminals. Supporting industry standards such as Internet Protocol (IP), MPEG, and HTML
  - ✓ **User Terminals** (Antenna diameter)**: 0.7 m** (up to 384 Kbps), **1.55 m** (up to 1.5 Mbps), **3 m** (up to 3 Mbps)
- Reported Cost :

  1.6 billion € for GEO satellites
- Status :

  The Cyberstar branded service is currently being offered in the USA on the existing **Telstar Ku-band** satellites.

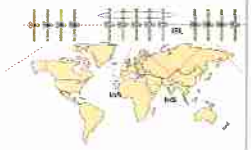
  A dedicated GEO constellation was intended to be ready in **2000** and full operational service was expected in **2001**, in conjunction with LEO constellation of **Skybridge**.

  In fact Loral has formed a strategic alliance with Alcatel to market the Cyberstar GEO and Skybridge LEO projects together



Cyberstar System

Gateway



EUROSKYWAY

- Partners : **Alenia Aerospazio**
- Technical Aspects :
  - ✓ **5 GEO** satellite (2 in phase 1 and 3 additional in phase 2) with average capacity of 45 Gbps, **On-Board Processing** and **Inter-Satellite Links** in V-Band
  - ✓ Expected satellite **lifetime 12 years**
  - ✓ Use of **Ka-Bands** (20/30 GHz) for earth/space connections and **V band** (56 GHz to 64 GHz) for short-medium range (100-24000 Km)
  - ✓ User Terminals **Uplink / Downlink data rate :** 160 Kbps to 2Mbps / 32 Mbps
- Coverage : Europe initially, with eventual global coverage through regional partnering
- Services :
  - ✓ Fixed data, voice and video with full compatibility with the ISDN, ATM, IP and DVB/MPEG standards. Also plans to offer broadband services to mobile users.
    Three types of user terminals are planned:
  - ✓ **Small** (lap-top size) with 160 kbps upstream speed
  - ✓ **Standard** (PC-sized) with 512 kbps upstream speed
  - ✓ **High-Capacity** (PC-sized) with 2 Mbps upstream speed
- Reported Cost : **795 million €**
- Status :
  First satellite due for launch in **2000** with second due one year after that.
  - ✓ First satellites (initial constellation) will cover Europe and the Mediterranean Basin.
  - ✓ The final three satellites (final constellation) will be launched afterwards to provide extended coverage to Africa, Eastern Europe and Asia

Euroskyway Satellite

Euroskyway Services

ASTROLINK

- Partners : **Lockheed Martin Telecommunications** (46%), TRW and Telespazio (27%).
  TRW was selected as payload contractor in Feb. 1998 and will build the communications payload with the option of being a service provider. Telespazio will supply ground systems and manage and operate network control systems during operation
- Technical Aspects :
  - **9** A2100 Lockheed Martin **GEO** satellites in **Five Orbital** positions
  - Expected satellite **lifetime 12-15 years,** from 24 to 88 Uplink/Down link beams/sat.
  - Satellites use **inter-satellite** links and frequency in the **Ka-Band**
  - **Uplink / Downlink Frequency :** 28.35 to 28.6 GHz and 29.25 to 30 GHz / 19.7 to 20.2 GHz
  - **30** to **50 Gateways Earth Stations**. The gateway will allow customers on terrestrial networks to connect with the Astrolink system at data rates up to 110 Mbps
  - Astrolink architecture is based on **ATM** protocol
  - **Data rates :** 384 Kbit/s, 2.3 Mbit/s, 9.2Mbit/s and 110 Mbit/s with Gateways
- Global coverage
- Services :
  - Primarily fixed data services : broadband and multimedia
  - User terminals are expected to sell at a **few hundred Euros** and will have **65-120 cm** antennas (16 K – 8M bps).
  - Lockheed plans to market the Astrolink service to businesses and common carrier providers worldwide, providing high-speed, two-way data services
- Reported Cost : **3.6 billion €**
- Status : The first satellite is scheduled for launch in **2002**, providing service to Europe and North and South America.
  Three further satellites will be launched at six-month intervals for worldwide service, and eventually there will be, in total, up to nine satellites in five orbital positions, depending on market demand.
  System construction initiated in **May '99**


Astrolink Satellite

ASIASAT

- Partners : **Asia Satellite Telecommunications Co. Ltd. (AsiaSat)**, Hughes Space and Communications International
- Technical Aspects :

3 GEO satellites : AsiaSat 1, AsiaSat 2, Asiasat 3S

AsiaSat 1

- Hughes HS376 satellite. Launched in **April 1990**
- **24** transponder with 36 MHz band each
- **Frequency Band** : 6/4 GHz (**C-band**)

AsiaSat 2

- Lockheed Martin Series 7000 satellite. Launched in **28 November 1995**
- Expected satellite **lifetime 13 years**
- 24 transponders in **C-band** (20 having a 36 MHz bandwidth the others a 72 MHz)
- 9 transponders in **Ku-band** (with a 54 MHz bandwidth)

AsiaSat 3S

- Hughes HS601 HP satellite. Launched in **March 1999**
- Expected satellite **lifetime 15 years**
- 28 transponders in **C-band** (with a 36 MHz bandwidth each)
- 16 transponder in **Ku-band** (with a 54 MHz bandwidth each)

- Coverage :
  - **AsiaSat 1** (China, Taiwan, Hong Kong, Japan, Korea, S.E. Asia, Pakistan, India, Iran, Iran, Afghanistan)
  - **AsiaSat 2** (Asia, Middle East, C.I.S. Australia, the Greater China Region, Korea, Japan)
  - **AsiaSat 3S** (Asia, Middle East, C.I.S. Australia, East Asia beam, South Asia beam, and one steerable beam)
- Services : TV, Radio Broadcasting and Telecommunications Services
- Reported Cost : Not Known
- Status : The 3 satellites are in orbit. **AsiaSat 3S** was launched to replace **AsiaSat 3** launch failure. **AsiaSat 3S** replaced, in terms of orbital position, **AsiaSat 1** at 105.5 degrees East.

Other Programs

→ KaSTAR

- Partners : **KaSTAR Satel. Communications Corp.**, Space Systems/Loral, Arianespace
- Technical Aspects :
  - ✓ **2 GEO** satellites manufactured by Lockheed Martin with ISL's, satellite **lifetime 15 years**
  - ✓ **Uplink / Downlink Frequency :** 19.2 to 20 GHz / 29 to 30 GHz
  - ✓ **Data rates** from **64 Kbit/s** to **155 Mbit/s**, but typically **1.5 Mbit/s** to **5 Mbit/s**
- Coverage : US, Central and South America and parts of Europe and Mexico
- Services : Broadband data services and internet by satellite.
- Reported Cost : **520 million €**
- Status : Earliest operational date is expected to be **2001.**

→ ORBLINK

- Partners : **Orbital Science Corporation**
- Technical Aspects :
  - ✓ **7 MEO** satellites in an equatorial orbit (**9000 km** altitude) with **ISL's**
  - ✓ Each satellite will have **100 spot beams** , expected satellite **lifetime 9 years**
  - ✓ By using frequencies in the **37.5 – 38.5 GHz** and **47.7 – 48.7 GHz** bands, Orblink will offer direct two-way digital connections between terrestrial users at speeds between **1.5 Mbps** and **1.25 Gbps**
  - ✓ Use of the **65.0 – 71.0 GHz** band for inter-satellites communications, providing a "space cable" wireless ring in orbit around the Earth with intercontinental capacity of up to about **15 Gbps**
- Coverage : 50 degrees North and South latitudes, encompassing about **95 %** of Earth's population
- Services : High-speed data communications services, video conferencing, computer networking, internet access, imagery transmission, and other BB applications
- Reported Cost : **900 million €**
- Status : Orbital plans to start launching its satellites in **2001** and begin service in **2002**

Other Programs

→ EXPRESSWAY

- Partners : **GM Hughes Electronics**
- Technical Aspects :
  - ✓ **14 GEO** satellites transmitting on **V** and **Ku-band** with **inter-satellite links** and **on board processing**
  - ✓ 10 orbital locations
- Global coverage
- Services : High-speed data services (up to 155 Mbit/s). The service is aimed at the businesses that send huge amounts of information around the world
- Reported Cost : **3.9 billion €**
- Status : GM Hughes has filed an application with the FCC (July 97).

  Interestingly, Hughes later filed for a scheme called Expressway with the FCC - 14 GEO satellites in ten locations, linked with optical ISLs, with an estimated cost of **€** 4billion. This does sound rather like Spaceway reinvented - but it's apparently Ku-band and the very high-frequency V-band rather than Ka-band, so this looks like a bid to gain more frequencies if more capacity is needed.

→ V-STREAM

- Partners : **PanAmSat**
- Technical Aspects :
  - ✓ **12 GEO** satellites with **inter-satellites links** and **on-board processing** that use 3 GHz of spectrum in the 50/40 GHz band of frequencies **(V-band)**
- Global coverage
- Services : Broadcast and telecommunications services
- Reported Cost : **3.5 billion €**
- Status :

  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. Services are expected to start after the **year 2000**

Other Programs

→ GESN – (Global EHF Satellite Network)

- Partners : **TRW**
- Technical Aspects :
  - ✓ **4 GEO** and **15 MEO** satellites working in **ka-Band,** frequencies between **37.5 GHz** and **50.2 GHz**
  - ✓ **Data rates :** form 1.5 Mbps to 3 Gbps
- Global coverage
- Services : High-rate trunks between regions and continents for broadband data transport, multimedia services and private networks. It will complement fiber-optic systems
- Reported Cost : **3.4 billion €**
- Status : Due to start in **2005**

→ ROSTELESAT

- Partners : **Russia** State initiative
- Technical Aspects : The ROSTELESAT system is based on **two** inter-coupled, non-geostationary systems

  ROSTELESAT-N (Ku-Band)
  - ✓ **91 LEO** satellites (7 orbital planes of 13 each) in circular orbit at 700 Km altitude and 82° inclination
  - ✓ **User Uplink / Downlink Frequency :** 12.75 to 13.25 GHz / 10.7 to 10.95 GHz
  - ✓ **Data rate :** 64 Kbit/s to 2048 kbit/s for end-user terminals, 75 Mbps for gateways

  ROSTELESAT-V (Ka-Band)
  - ✓ **24 MEO** satellites (4 orbital planes of 6 each)in circular orbit at 10360 km altitude and 82.5° inclination
  - ✓ **User Uplink / Downlink Frequency :** 29.5 to 29.9 GHz / 19.8 to 20.2 GHz
  - ✓ **Data rate :** 64 kbit/s to 2048 kbit/s for end-user terminals, 32 Mbps for gateways
- Global Coverage
- Services : Fixed voice and datacomms for fixed users, in the Ku- and Ka-bands
- Reported Cost : Not known
- Status : The ROSTELESAT system is currently **under development**. Service will initially be introduced on a national basis, then on a sub-regional and eventually global basis

Programs On Hold/Discontinued

→ CELESTRI (Millenium, Mstar)

- Partners : **MOTOROLA** started with applications for **Millenium** (GEO, Ka-band) and **MStar** (LEO, V-band), while in June 1997 applied for a new system, CELESTRI, regarded as an umbrella designation for all systems. Matra Marconi Space (MMS) signed an agreement to build the satellite bus.
- Technical Aspects :
  - ✓ **Hybrid** Global system: **9 GEO** satellites + **63 LEO** satellites (7 planes) at an altitude of 1400km
  - ✓ Expected lifetime was **eight** years, Spot beams / Optical ISLs
  - ✓ **Ka-band** (18.8 - 30 GHz) and V-band (40-50 GHz), **data rates** : 64 kb/s - 155 Mb/s
- Coverage : Up to 70° north and south latitude
- Services : Broadband data services, including interactive multimedia and point-to-point real-time user communications, also suitable for fixed voice services
- Reported Cost : **12,9 billion €**
- Status : As a result of the partnership of Motorola, Teledesic, Boeing and Matra Marconi Space, announced on 21 May 1998, Celestri has **now been incorporated into the Teledesic project**.

→ WEST

- Partners : **Matra Marconi Space**
- Technical Aspects :
  - ✓ Initially comprise **2 GEO** satellites, later to be extended to include **9 MEO**
  - ✓ The satellites are to be based on **Eurostar 3000** with a **lifetime of 15 years**
  - ✓ **Ka-Band** (20/30 GHz), **data rate :** 384 Kbit/s to 6 Mbit/s (return link)
- Coverage : Worldwide, once the MEO component is operational
- Services : High-quality broadband interactive services. Terminal prices are expected from **500** to **2000€**
- Reported Cost : **> 2.5 billion €**
- Status : Due to Matra Marconi Space's involvement in Teledesic (and previously the Celestri project), the future of WEST is unclear.

Other Programs

More than 35 Broadband / Multimedia projects in the Ku-, Ka-, V-bands

→ M2A

Proposed by **GE Americom** and **CLS NA**. Launch and operational service was expected to start in 1999. However, work was suspended in Jan 98. It is unlikely that the system will be operational before 2000 at the earliest.

→ GE*Star

Proposed by **GE Americom** and **CLS NA**. Filed with the FCC for five ka-band orbital slots; launch date is unclear. Officially put on hold in May '99 with all contract work stopped.

→ Aster

A Spectrum **Astro Porject**. Is a five-satellite GEO system with inter-satellite links.

→ Pentriad

Is a proposed by **Denali Telecom**, primarily V-band constellation using thirteen satellites in highly elliptical (HEO) Molnya orbits over the Northern Hemisphere.

→ Voicespan

An **AT&T** project. Has been **withdrawn**. AT&T said that its decision to cancel the ka-band project is based on its need to concentrate on "core communications services, including such growth areas as wireless, online and local service".

→ VIRGO

A **Virtual Geosatellite** project. The VIRGO system utilizes the innovative use of inclined, elliptical orbits similar to the Ellipso™ system. The company was incorporated in 1998, and is based in Washington, D.C.. VIRGO promises to reuse the frequency spectrum now assigned to geostationary satellites, without interfering with their signals.

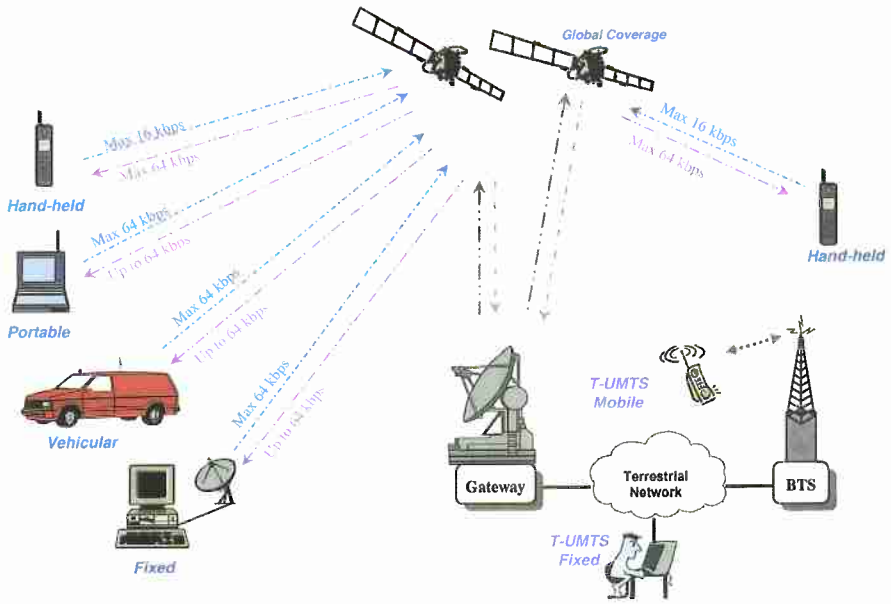
→ StarLynx & SpaceCast

Proposed by **Hughes**. Expected to cost 2.87 billion € and 1.68 billion € respectively.

→ and others ...

Services

- **Interactive Data Communications** (low, medium and high data transfer)
- **Fax/Telephony** (analog, digital compressed)
- **Telex** (mainly for maritime applications)
- **Video** and **Audio** transmission and broadcasting (analog, digital)
- **Broadcasting** of Data / Voice / Message
- **Multi-channel digital TV / Audio** broadcasting
- **Internet** over satellite
- **Multimedia** services
- **High volume trunk** interconnections
- **Mobile** communications (voice, fax, data, telex, video, internet)



Advantages

- **Wide geographical area coverage**
- Ability to provide **instant infrastructure** once satellites are launched
- Provide solutions in remote areas with no or poor terrestrial network infrastructure
- **Broadcasting** to unlimited number of users within satellite coverage
- Continuous technological advancements resulting in reduction of end- user terminal dimensions/cost, and service charges
- Wide range of communications services
- **Global** networks
- Satellite transmission costs do not vary with distance
- Low-cost alternative for point-to-(multi)point transmissions
- Coverage of rural and remote locations
- **Portability** (and/or **mobility**) of end-user terminals
- **Expandability** (flexible network expansion) / Easy network reconfiguration
- **Upgradability**
- **High reliability/availability**
- **High capacity** trunk connections
- **High speed transmission** & high throughput for several types of satcom networking
- Provide communications solutions in **emergency/disaster** cases (fly-away and mobile terminals)
- Private networking solutions, adapted to customer needs, independent of public organizations
- **Small-size, compact** end-user terminals (technology evolution)
- **Interworking** with public terrestrial networks

Applications

- **Data, audio, video distributions**
- **Broadcasting of information** (data, audio, video, text) to unlimited number of users within coverage or to closed user groups
- **Fast Internet delivery**
- **Tele-learning and Tele-education**
- **Tele-medicine**
- **Tele-working**
- **Video conferencing**
- **Remote monitoring and control**
- **News broadcasting**
- **LAN interconnection**
- **Data reporting / Position reporting**
- **Radio Determination**
- **Radio Navigation**
- **Fleet Management** (land mobile and maritime)
- **Supervisory Control And Data Acquisition** (SCADA)
- **Multichannel digital TV services**
- **Near Video-on-demand** (NVoD)
- **Multimedia applications**
- **Financial / Commercial applications** (e.g. credit card authorization, ATM transactions, credit/check verification, EDI, reservation systems, automized accounting systems)
- **Emergency communications** (portable/mobile/handheld satellite terminals)
- **Disasters recovery** (portable/mobile/handheld and fly-away satellites terminals)
- **Social communications**

Frequencies

- **VHF** : few hundred MHz; used for TT&C and Little LEOs
- **L-band : 1-2 GHz**, used by navigation and mobile services
- **S-band : 2-4 GHz**, used by navigation, mobile, and Big LEO services
- **C-band : 4-6 GHz**, used mostly for fixed services such as telecoms and broadcasting
- **X-band : 7-8 GHz**, used mostly for government and military services
- **Ku-Band : 10-18 GHz**, with 17.7-18.1 GHz used for the satellite-to-earth (downlink) portion. Mostly for fixed services such as telecoms, DBS
- **Ka-Band : 18-30 GHZ**, with 19.7-20.3 GHz for the downlink. Used mostly by MegaLEOs
- **V-Band : 40-60 GHz.** Not yet used; applied for by new broadband systems for many uses

There are no hard-and-fast definitions of Ku, Ka and V frequency bands.
The terms are used loosely, to give a general indication of the operating frequency of satellites.
But because spectrum allocation has changed several times, there is often confusion about the limits of each band.
For example, when frequency in the 17.7 GHz-18.4 GHz waveband was activated, engineers added it to Ku band for convenience. Many engineers still consider Ku-band to mean 10.7-14.5 GHz only.
Originally the Ka band was designated K and Ka bands, they are still sometimes called "lower Ka" and "upper Ka" band.
The International Telecommunication Union is trying to settle on 12-18 GHz for Ku and 27-40 GHz for Ka, although the latter contradicts general usage.
The V band is anything above 40 GHz, but new definitions are expected here too.
Many engineers say they would rather not use these terms at all, and prefer exact frequency references.

Cost Elements

Indicative cost elements subject to variations

→ Ground Segment

- Large Earth Station : Millions of Euro
  (for carrier or large business applications)
- Middle-range Earth Station : 35 - 120 KEuro
  (for direct corporate applications,
  e.g. point-to-point links)
- Hub stations : 400 - 1500 KEuro
- VSAT station (1.2-2.4m antenna) : 3 -12 KEuro (depending on configuration)
- Inmarsat end-user terminals : 2.5 - 25 KEuro
- "Fast Internet & Multimedia" terminals : 500 - 1000 Euro
  (0.6m antenna, RF and PC adapter card)
- IRD / STB : 400 - 700 Euro
- Future Ka-band USAT : 800 - 1000 Euro
- Future Ka-band VSAT : 1500 - 5000 Euro
- S-PCS user terminal : 400 - 2500 Euro (depending on terminal type)

Cost Elements

→ Space Segment *

- Ku-band transponder (33/36MHz) : 2.0 - 4.4 MEuro / year
- Unilateral 64 Kbps Ku-band channel (end-user applications) : 8 - 20 KEuro / year (depending on equipment dimensions, transmission parameters, modulation, type of network/satellite in use)
- 1.2 MHz BW channel for a star VSAT (outroute) : 140 - 190 KEuro / year

* Space segment tariffs vary in the different places of the world

→ Services

- **Star-VSAT Networks**
  Monthly tariff / Remote VSAT (equipment rental cost included) — 400-800 Euro (depending on facilities and satellite in use)

- **"Fast" Internet & Multimedia Networks**
  Different user charges apply to the different service packages available.
  Example : Package of 130 Mbytes/month — 30 Euro

- **INMARSAT Network**
  Inm-C data : 0.8 Euro / Kbit
  Inm-M data : 2-3 Euro / min

- **S-PCS Telephony** — 1-3 Euro / min

Space Segment Operators/Providers

- **INTELSAT**
  - ✓ Intergovernmental international organization
  - ✓ More than 140 member countries
  - ✓ Owner of the world's largest commercial geostationary satellite network
  - ✓ Fixed services, global coverage, C- & Ku-band
  - ✓ Filings for 10 global Ka-band orbital locations
- **INMARSAT**
  - ✓ Intergovernmental international organization
  - ✓ Mobile services, global coverage, C/L bands
- **EUTELSAT**
  - ✓ Intergovernmental European organization
  - ✓ Fixed services, TV broadcasting mainly, regional coverage, Ku-band
  - ✓ Eutelsat plans to operate Ka-band satellites

➔ **Intelsat, Inmarsat and Eutelsat** are engaged in a restructuring process to become commercial companies in order to adapt to competitive environment

- **INTERSPUTNIK**
  - ✓ Intergovernmental organization
  - ✓ Regional coverage
- **ASCO** (ARABSAT system)
  - ✓ Intergovernmental organization
  - ✓ Regional coverage, fixed services
- **ASIASAT**
  - ✓ Regional coverage, fixed services

Space Segment Operators/Providers

- **ORION**
  - ✓ International satcom provider / Private company
  - ✓ Fixed services, currently regional coverage
  - ✓ Filings for 8 Ka-band orbital locations
- **PANAMSAT**
  - ✓ International satellite services / Private company
  - ✓ Global coverage / Fixed services (telecoms and DTH)
- **ASTRA**
  - ✓ European private company,
  - ✓ regional coverage, TV broadcasting services)
- **COLUMBIA** (private US company, regional coverage)
- **GE Americom** (private US company, regional coverage)
- **Space Communications Corp.** (Japan)
- **Panamsat's** merger with **Hughes Galaxy** created world's largest private satellite operator with 16 operational satellites growing to 21 by end of 1998
- **Intersputnik** has signed a joint venture agreement with **Lockheed Martin** / Plans for new satellites to be built by the US company
- **AT&T** sold its Skynet Satellite Services to **Loral Space & Comm.**
- **Loral Space & Comm.** has acquired **ORION**
- **GE Capital Satellites** (Gibraltar) : Owns 16 transponders on Sirius2 (5°E, European coverage) / Plans for additional future satellites

The Changing Telecommunications Environment

→ The Major Shift in Satellite Industry

It is currently estimated that commercial communications satellites will account for about 67% of the total satellites to be launched worldwide from 1999 to 2008.
It is also forecast that approximately one thousand commercial communications satellites will be launched in this period, for a total value of just under 50 billion €.
A strongly competitive and commercially oriented satellite market is growing, causing a marked shift towards new technological and organizational paradigms, such as:

- Adoption of high frequency bands (e.g. Ka-band)
- Development of active multibeam antennas
- Design for cost, producibility and testability
- Modular approach to design
- Large scale production of spacecrafts and payloads
- Short time-to-market


Globalstar Integration

The realization of satellite constellations for mobile or multimedia communications asks for large number of spacecrafts to be produced in a very short time.
In Europe an example of new design and production approaches was applied in the Small Satellite Center, the production plant developed by Alenia Aerospazio in the frame of the Globalstar project, where a production rate of 1 satellite/week was achieved.
After the involvement in satellite constellation projects of Second Generation, satellite and telecommunications companies in Europe are now facing the challenging task of deploying a space system able to provide multimedia services to tens of millions of mobile users.


Globalstar Test

The Changing Telecommunications Environment

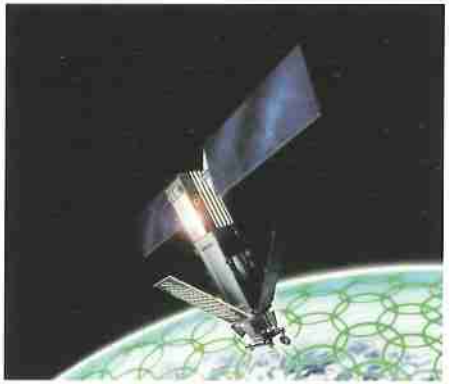
→ Addressing the Issues

- Is there enough capital to invest in all the proposed systems (and those not yet proposed)?
- Is there enough underwriting capacity in the insurance industry to cover the large number of satellites and launches?
- With telecommunications technology changing so rapidly and deployment times taking years, what are the risks of obsolescence?
- Wide differences among nations as to social / economic / political objectives
- Non-Geostationary systems must coordinate with each other to avoid collision
- The large number of launches adds greatly to the orbital debris problems, a risk to all systems
- A great problem may be the availability of launch pads, not launchers
- Can satellite manufacturers speed up production and still maintain quality?
- Is there enough traffic to support all of the proposed systems?
- What are the market differentiation between / among different systems?
- LEOs and MEOs must not interfere with GEO satellites

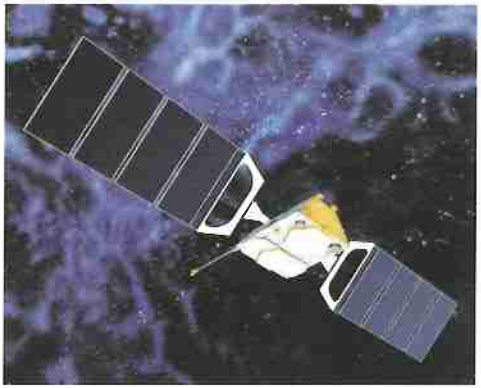
The Changing Telecommunications Environment

➔ Prospects for the Future

There is a very significant role in the future for Mobile Satellite Services: there will be **260 million** mobile service **users in Europe by 2010** of which **1.6 million** will require Mobile Satellite Systems (UMTS Forum, 1999). In the field of cellular telephony via satellite, two systems (Iridium and Globalstar) will be both operational by the **end of 1999.**



Iridium Satellite



Globalstar Satellite

Constantly cited as a major force behind the growth of the communications market is the need for multimedia, though it is not always clear what it is, who needs it and what for. More precisely, the less glamorous term of broadband systems should be used to describe the trend.
Constellations of geostationary and non-geostationary satellites are being developed by several companies around the world for the provision of mutimedia services; all programmes envision budgets of several billion dollars for their systems to become operational.

The Changing Telecommunications Environment

→ Prospects for the Future

That notwithstanding, the variability of the communications market, its extreme competitivity and the high rate of technological development would suggest a thought of caution, especially concerning the relationship between satellite systems and terrestrial networks, where integration rather than competition should be sought after.

Wasting time in today's mobile communications market is dangerous, however, every passing day sees an increase in the territory covered by cellular Networks.

Iridium is hardly the first mobile system to have started with a few difficult months because of kinks in the distribution network or in the supply of handsets. Inmarsat and satellite television ventures have had similar experiences. Market forecasts can hardly predict such problems and are thus especially unreliable in the first few months.

For the time being, as far as broadband applications are discussed, the satellite "killer application" is and will remain that of TV and data broadcasting, with the introduction of some degree of interactivity and the adoption of modern digital standards.

The Internet booming will also keep pushing the satellite industry, first of all with a request of copious bent-pipe capacity for linking Internet Services Providers (ISP's) with the terrestrial backbone infrastructure.

Today, pratically no satellite broadcaster is profitable, and three of the long-awaited broadband constellations, Spaceway, Astrolink and Teledesic, placed satellite or launch contracts in 1999 with enough equity on the table to convince even cynical observers of the Ka-band scene that it, at last, is moving forward.

Introduction

Utilised in over 110 countries world wide, the unprecedented rise of GSM has spurred the telecomm industry to the next significant development in wireless communications, both terrestrial and via satellite, related to the provision of true multimedia services at high bit rates.

The Universal Mobile Telecommunications System represents a new generation of mobile technology, aiming at providing communications services, to any one, anywhere, at any time, in a Multimedia environment.

Standardizationis ongoing for these third-generation systems in the European Telecommunication Standardization Institute (ETSI), under the project name Universal Mobile Telecommunication Systems (UMTS) and in the International Telecommunications Union (ITU), where it is called IMT2000.

UMTS will provide wireless wide band multimedia capabilities over mobile communications network and so enable a new range of innovative services to be deployed, including interactive video, Internet and other high-speed applications.

→ Objectives

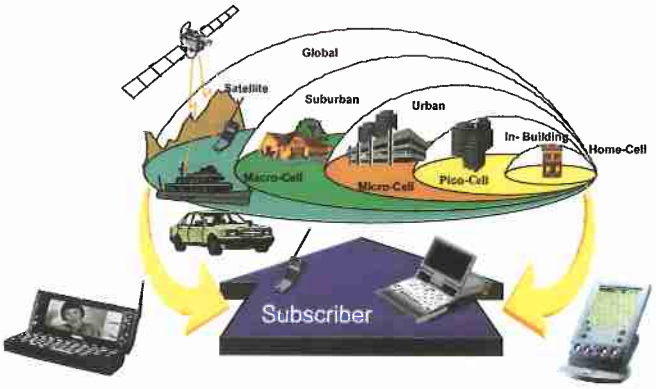
- to extend capabilities of today mobile technologies;
- to provide a single integrated system in which the user can access services in an easy to use and uniform way, in all environments;
- to provide communication services to any person, any where, at any time;
- to provide a wide range of telecommunications services, including those provided by fixed Networks, supporting the following user bit rates:
  - ✓ up to 144 Kbps in vehicular environment;
  - ✓ up to 384 Kbps outdoor;
  - ✓ up to 2 Mbps indoor.
- to enable a pedestrian user, within the residential environment, to access all services normally provided by fixed Networks;
- to provide global Roaming.

The System

As shown in Figure, the global UMTS network, including its satellite component, will provide different services to different user terminals and in different coverage areas.

Services can be classified depending on the coverage areas:

- Pico cells: medium to high traffic density, for low speed mobile stations and wide band services. Predominantly situated indoors and are characterised by cell radius of less than 50 m.
- Micro cells: medium-to-high traffic density, low speed mobile station and narrow band services. Predominantly situated in urban areas, with a typical cell radius of up to 1 Km.



UMTS System

- Macro cells: low-to-medium traffic density, for moderate speed mobile stations and narrow band services. Generally situated in a rural or sub-urban environment, with moderate building blockage and possible foliage blockage.
- Satellite cells provide coverage to large areas and in different environments, from remote to urban. Employed in remote areas or areas with low traffic density, such as in developing countries, in the polar regions and over the oceans.

The System

The composite texture of the UMTS network, in terms of cells dimensions, environment and data rates is summarised below.

Cell Type	Radius	Environment	Max Available Bit Rate
Pico Cell	Less than 50 m	Indoor	2 Mbps
Micro Cell	Up to 1 Km	Outdoor	384 Kbps 2 Mbps (low mobility)
Macro Cell	Several tens of km	Rural or sub-urban	384 Kbps
Satellite Cell	Large areas	From remote to urban	144 Kbps (goal)

UMTS Cells Description

The goal of the UMTS is to achieve personal communications, employing user terminals able to roam between different local, regional or global networks. In other words, UMTS subscribers will be able to roam seamlessly from a pico-cellular private network into a micro-cellular public network, then into a wide area macro-cellular network and eventually into a mobile satellite network.

Several studies have been carried out towards the definition of potential markets for multimedia mobile services based on terrestrial networks.
The scenario outlined by all these studies confirms the convergence of personal communications and multimedia services into the third generation of mobile systems. Such convergence will merge the personal communications market into the "Information Society", by delivering voice, graphics, video and other broadband information directly to the users, regardless of their location, network or terminal.

The System

Mobile Users (Millions)	2000	2005	2010
Europe, EU 15	113	200	260
North America	127	190	220
Asia Pacific	149	400	850
Rest of the world	37	150	400
Total	426	940	1730

Worldwide mobile market forecast (UMTS Forum)

In parallel to the widespread diffusion of terrestrial cellular networks in the next decade, satellite systems are likely to play an important role in complementing terrestrial UMTS/IMT2000 by providing a more complete geographical coverage, and by targetting "niches" of the mobile market, e.g. maritime and aeronautical users. Air interfaces for the satellite component of these networks are currently being developed under the coordination of international organizations.

In numerical terms, the satellite share of UMTS will never probably account for more than a 5 or 10 per cent of the total market.

Even so, tens of millions of potential users constitute a good basis for a new business case and well justify the starting of entrepreneurial ventures.

This is only the start of the story: a number of organisations (satellite operators) are already making plans for new space infrastructure and the satellite technology will play an important part in the UMTS.

Much work still has to be done in order to develop an effective, complementary, integrated UMTS that brings together the best of space and terrestrial technologies.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

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