



Introduction to satellite communications Advanced Technology in Radio Communications

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Lesson 3: Introduction to satellite communications

Contents

- Why are satellite communications so interesting?
- Which were the first satellites?
- What are the system elements?
- Types of orbits
- Types of satellite communications
- Services
- European Space situation: European Space Agency (ESA)
- Future directions

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Introduction

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Introduction

- Geostationary satellites start an authentic revolution
- Satellite communications have become an essential type of communications
 - in large distance telephone communications
 - in TV broadcasting
 - in data transmissions
- There are present in new technologies
 - Personal terminal, digital broadcasting, HDTV

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Introduction

- Satellites for communications: GEO
- Government institutions
- Commercial systems explosion
- Broadcasting with digital technology: Astra, interactivity
- Integration in PCN: GSM compatible, DECT or UMTS ("handy" terminal)
- Global, quick, ubiquitous, low cost



Ares I-X space rocket prototype, future propulsion of manned missions in Earth orbit (October 2009).

First satellites

- 1923 Hermann Oberth proposed to use satellite communications
- 1945 Arthur C. Clarke suggested to use geostationary orbits
 - “Extra-Terrestrial Relays: Can Rocket Stations Give World-Wide Radio Coverage?” (Wireless World)
 - Circular equatorial orbit at a height of 35786 Km



Part of Amazonas 3, last launched satellite of HISPASAT/HISPAMAR Constellation (February 2013)

First satellites

- 1957 Sputnik-1, First artificial satellite
- 1958 Explorer-1, First USA satellite
- 1958 Score, First communication satellite
- 1960 Echo-1, NASA passive balloon
- 1960 Courier-1, from USA army
- 1961 Oscar-1, amateur radio
- 1962 Telstar-1, First active in R/T simultaneously
- 1963 Telstar-2, First transatlantic TV transmission
- 1966 Molniya-1
- 1965 Early Bird/INTELSAT-1, GEO commercial

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System elements

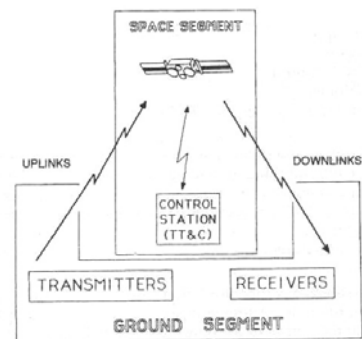
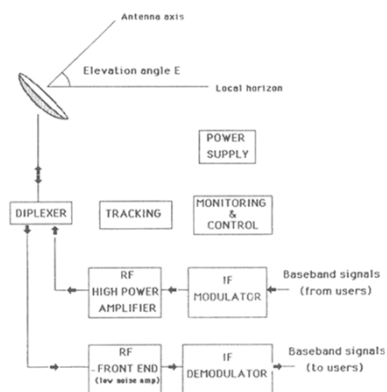
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System elements

- Main classification covers the distinction of:
 - Spatial segment
 - Terrestrial segment
 - At the same time spatial segment are made of platform or bus and useful load.

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Segments



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Bus

- Structural subsystem
- Thermal control subsystem
- Power generation subsystem
- Orbit control and stabilization subsystem
- Propulsion subsystem
- Tracking , telemetry and commanding (TT&C)

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Payload

- Radio equipment that operate like a repeater also known as transponder.
- It amplifies the signal.
- It makes frequency transfer.

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Types of orbits

- GEO
- HEO
- LEO
- ICO (MEO)

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Types of orbit

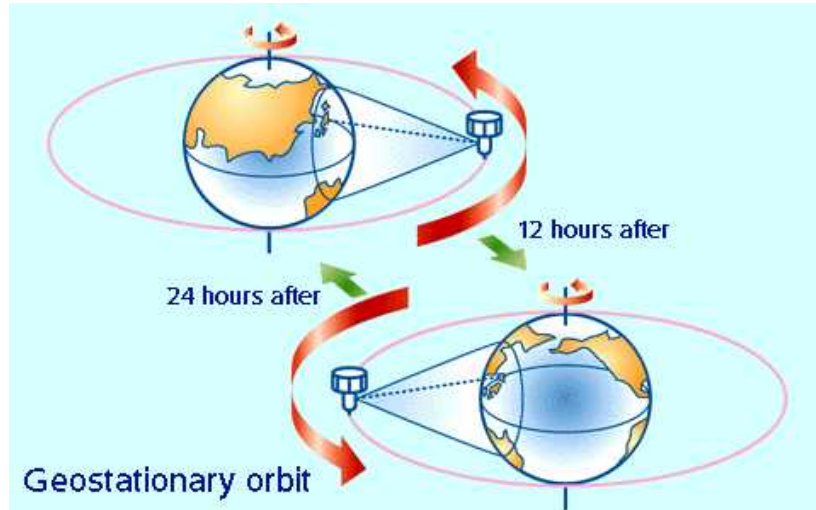
- GEO Geostationary

$$\frac{1}{2}v^2 - \frac{GM}{\rho+h} = -\frac{1}{2} \frac{GM}{\rho+h}$$

- HEO inclined and highly elliptical
- LEO low orbit
- ICO (MEO) medium orbit

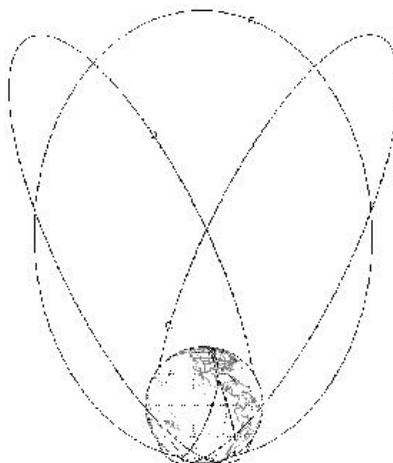
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GEO



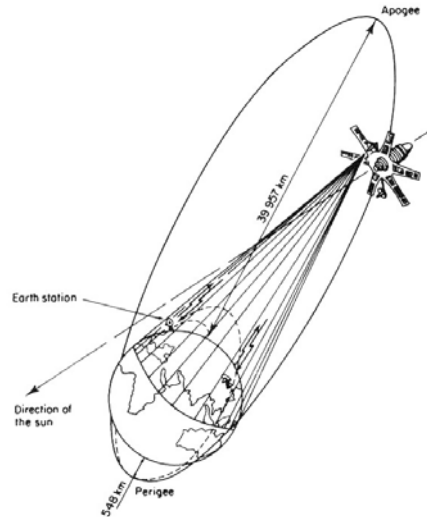
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HEO



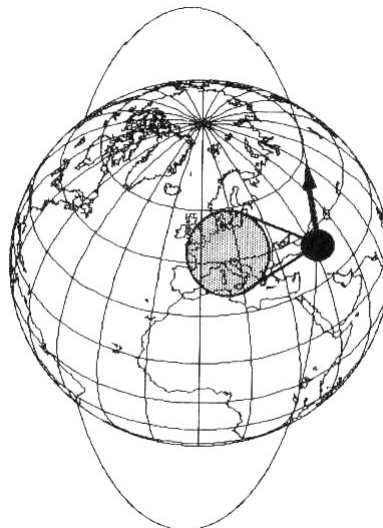
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HEO example: Molniya



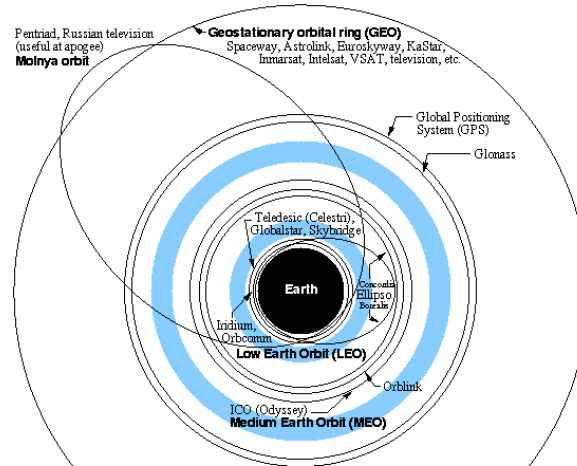
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LEO



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Orbits of mobile communication



Orbital altitudes for satellite constellations

■ peak radiation bands of the Van Allen belts (high-energy protons)
 orbits are not shown at actual inclination: this is a guide to altitude only
 from Lloyd's satellite constellations: <http://www.ee.surrey.ac.uk/Personnel/L.Wood/constellations/>

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Communication satellites

- Type of service
- Type of instrumentation
- ESA

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Communication satellites

- Type of service
 - Fixed. (Fixed point to point)
 - Mobile (Mobile point to point)
 - Broadcast (Broadcast, or P-T-MP)
 - Data Relay (exo-atmospheric, inter-satellite link)
- Type of instrumentation (payload)
 - Analogical and digital.
 - “Bent-pipe” and regenerative.
 - Simple conversion or double in frequency.
 - With/without processing/commutation on board.

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Communication satellites

VLF(Very Low Freq.)	3-30 KHz
LF (Low Freq.)	30-300 KHz
MF (Medium freq.)	300-3000KHz
VHF(Very High Freq.)	30-300 MHz
UHF(Ultra High Freq.)	300-3000 MHz
SHF(Super High Freq)	3-30 GHz
EHF(Extremely High Freq.)	30-300 GHz

L	Mobile comm.	1-2 GHz
S	TT&TC, Mobile comm.	2-4 GHz
C	Conventional comm., Broadcasting	4-8 GHz
X	Military	8-12 GHz
Ku	TV, conventional comm.	12-18 GHz
Ka	TV, conventional comm, Data Relay	18-40 GHz

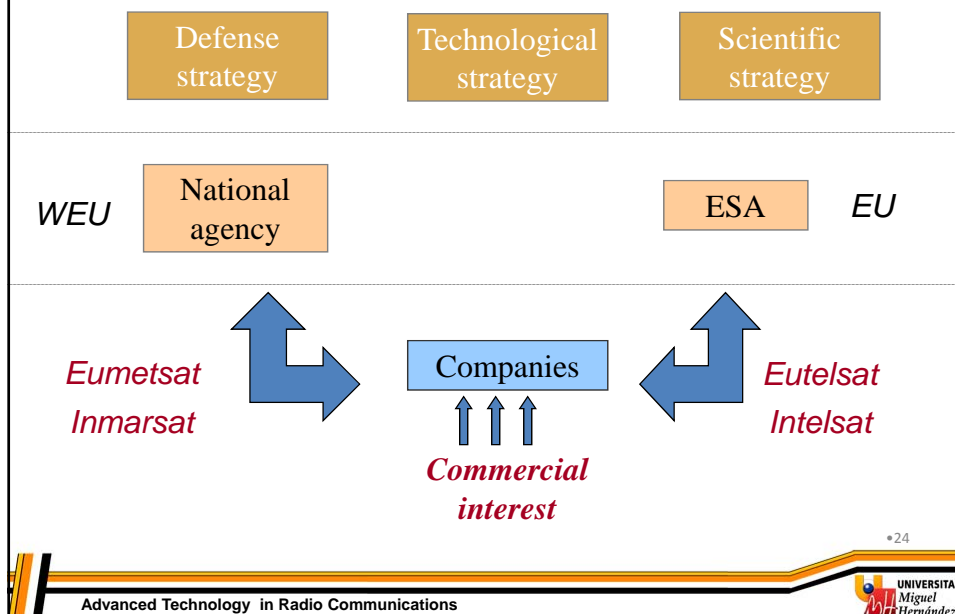
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Services

- Advantages:
 - Broadcasting capacity.
 - Huge bandwidth.
 - Quick deployment.
- Services:
 - Voice channels traffic or operators data (“trunking”).
 - Multiservices for remote places.
 - VSAT data networks.
 - Mobile communications.
 - Multimedia services and wideband.

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Space in Europe



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European Spatial Agency

- Netherland
- Belgium
- United Kingdom
- France
- Germany
- Italy
- Denmark
- Spain
- Sweden
- Switzerland
- Ireland
- Austria
- Norway
- Finland

ESA was born in 1975 as a group of ESRO and ELDO institutions, grouping civil spatial activities from this countries

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European Spatial Agency

- Objective: to promote between European countries the collaboration for peaceful purposes in:
 - Technologies and Space Investigation
 - Space applications
- To scientific purposes and operative applications implementing and making:
 - a new european spatial policy in long term
 - new activities and spatial programs
 - an industrial policy

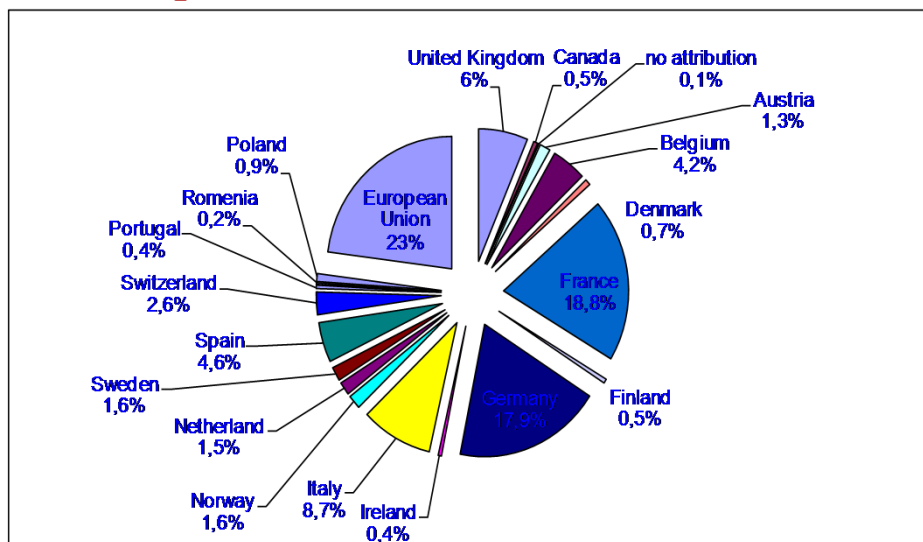
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International Cooperation

- Europe cooperates with another countries:
 - Japan, Russia, USA, Brazil, Canada
- Programs who include cooperation:
 - Spacelab, Ulysses, Hubble, Cassini/Huygens
- International Space Station
- It cooperates with developing countries too:
 - Meteorological data networks in African countries

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Budget in countries



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ESA: facilities



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ESA: activities

- Compulsory
 - Basic activities: technological investigations, future projects.
 - Scientific satellites and space scientific activities
- Optional
 - Telecommunication
 - Earth sight-seeing
 - Space shuttles
 - Space flight and microgravity

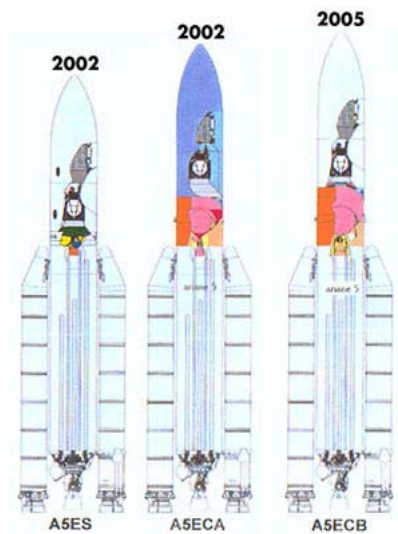
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Space shuttle: Ariane



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Space shuttle: Ariane



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Ariane 502: First success



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Telecommunication activities

- Project
- Future trends

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Telecommunication activities

- A new generation of mobile communication global systems
- Broadcasting in traffic control systems
- Consolidation of first support network of European data generation.
- Spanish contribution: SMOS satellite (Soil Moisture and Ocean Salinity). SMOS uses 69 antennas for electromagnetic ocean and ground surface emission measures.



SMOS locates Spain in Space (November 2009).

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Telecommunication activities

- Collaboration with Galileo European satellite navigation system.
 - Global Navigation Satellite System (GNSS) developed by EU.
 - It is hoped that the systems starts in 2014.
 - 30 satellites in three 56° inclined planes, at a height of 23.616 km.



Galileo satellites from IOV (In Orbit Validation) series with Soyuz space shuttle from Kourou (21 October 2011).



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Giove-A satellite, first stage of Galileo constellation, it was launched from Baikonur (December 2005).

Telecommunication: Projects

- DRTM Data Relay & Technology Missions
- ARTEMIS Advanced Relay and Technology Mission
 - It includes mobile telephone services.
 - It introduces new technologies (laser)
 - ISL communication
- Collaboration with ISS (International Space Station)



Jules Verne European ship docked to ISS - April 2008

Artemis transmits first images from Envisat taken to the north of Russia - March 2003



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Telecommunication: Projects

- DRS Data Relay Satellite
 - Spatial segment and several activities
 - Cooperation: TDRSS (US) and DRTS (Japan) satellites
 - It includes 2 satellites: Artemis and DRS-1
- Cryosat
 - It studies ice layers from Earth

- Smart-1



- To get more knowledges about Moon
- Solar propulsion

Detection of ice layers thickness with centimeter precision (November 2010).

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Future trends

- Distinction between broadcasting, mobile and fixed communication
- Smaller user terminals
- Ubiquity: we have always the possibility of global communication
- At least three mobile telephone operators including Iridium and Globalstar
- DAB and DVB: new broadcasting standards

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