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COURSE ON BASIC TELECOMMUNICATIONS SCIENCE

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COMMUNICATIONS AND BROADCASTING BY SATELLITE

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COURSE ON COMMUNICATIONS AND BROADCASTING BY SATELLITE

Pierre Bartholomé
European Space Agency

TYPES OF ORBIT

* Circular – Elliptical
* Equatorial – Polar – Inclined
* Low – Medium – High altitude
* Geosynchronous – Sun–synchronous
* Geostationary – Molniya – Tundra

THE GEOSTATIONARY ORBIT

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Advantages	Disadvantages
* Fixed satellite	* Poles not covered
* Covers 42 % of Earth	* Spreading loss
	* Transmission delay
	* Costly launch

REGULATORY BODIES

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* International Telecom. Union
* Intern. Frequency Registration Board
* World Administrative Radio Conferences
* Consultative Committees: CCIR – CCITT

RADIO REGULATIONS

* Frequency Plans
* Orbit Allocations
* Allocations – Assignments – Allotments
* Regulations
* Procedures

COMMUNICATIONS SATELLITE SERVICES

* Fixed
* Mobile
* Broadcasting
* Space Research
* Inter-Satellite Links
* Space Operations
* Radiodetermination
* Earth Exploration
* Amateur

FREQUENCY BANDS

* 1.6 – 1.5 GHz	Mobile (L Band)
* 6 – 4 GHz	Fixed (C Band)
* 8 – 7 GHz	Military (X Band)
* 14 – 11 GHz	Fixed (Ku Band)
* 18 – 12 GHz	Broadcasting
* 30 – 20 GHz	Fixed (Ka Band)

THE CCIR

* Recommendations
* Reports
* Resolutions
* Opinions
* Decisions
* Questions
* Study Programmes

INTERNATIONAL NETWORKS

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* Worldwide
  - INTELSAT
  - INMARSAT
* Regional
  - Intersputnik
  - EUTELSAT
  - ARABSAT
  - Pan Am Sat

NATIONAL NETWORKS

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* Anik (Canada)
* Brasilsat
* DFS-Kopern. (FRG)
* Morelos (Mexico)
* Telecom 1
* USSR
* AUSSAT (Australia)
* CS-2-3 (Japan)
* INSAT (India)
* Palapa (Indonesia)
* USA (6)

SATELLITE FUNCTIONS

* Transparent Communications Relay
  - Unidirectional
  - Bidirectional symmetrical
  - Bidirectional asymmetrical
* Regenerative Repeater
* Network Switching Node

SATELLITE NETWORKS

* Space Segment
  - Satellites in Orbit
  - Control Centre and Stations
* Earth Segment
  - User Earth Stations
  - Network Control Centre and Monitoring Stations

SATELLITE OPERATIONAL STRUCTURE

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* Satellite Operator
* Payload Operator
* Carriers
* Service Operators
* Service Commercialisers

SYSTEM ARCHITECTURE

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* Network-Oriented System
* User-Oriented System
* Mesh or Star Configuration
* Centralised or Distributed Control

TYPES OF APPLICATION

* Links Between Network Nodes
* Links End User to Network Node
* Links End User to End User
  (Closed Private Network)

FIXED-SATELLITE SERVICE APPLICATIONS

* Trunk Communications
* MESH International
* Distribution
* Private Business Services
* VSAT networks

MOBILE-SATELLITE SERVICE

* Maritime Telephone – Telex
* Maritime Low-Rate Data Transmission
* Aeronautical Data – Voice
* Land-Mobile Data – Voice
* Personal Communications

BROADCASTING-SATELLITE SERVICE

* Television Low Power
* Television Medium Power
* Television High Power (DBS)
* HiFi Radio
* High Definition Television
* Data Broadcasting

COMMUNICATIONS TECHNIQUES 1

* Source: Audio – Video – Data
  Voice–Sound Live–Still
* Processing: Analog – Digital
  Pre–emphasis
  Companding
  Analog–Digital Conv.
  PCM – Delta – Vocoding

COMMUNICATIONS TECHNIQUES 2

* Multiplexing: FDM – TDM – SCPC
* Mx Processing: Statist. Methods – DSI
* Encoding: FEC – ARQ
* Modulation: FM – PSK – QAM – ACSSB

COMMUNICATIONS TECHNIQUES 3

* Access Techniques: FDMA – TDMA – CDMA
* Assignment: – Preassigned
  – On Demand
  – Random
* Onboard Processing: – Transparent
  – SS–TDMA
  – Regenerative
  – Switching
  – Memory

ANTENNAS

* Effective Aperture: $A = \eta * \frac{\pi * D^2}{4}$
* Effective Aperture Omni $= \frac{\lambda^2}{4\pi}$
* Directivity Gain: $G = \eta * [\pi * D / \lambda]^2$
* 3–dB Beamwidth [deg]: $\theta = 70 / [D / \lambda]$
* Directivity Gain: $G = 30{,}000 / \theta_1 * \theta_2$

PROPAGATION

* Spreading Loss (Omni to 1 m^2)

$$S = 4 * \pi * D^2$$

* Over 36,000 km: S = 162 dB [m^2]

* Propagation Loss (Omni to Omni)

$$L = [\ 4 * \pi * D / \lambda\ ]^2$$

* Power Flux Density: PFD = P * G / S

NOISE

* Noise Power [W]: N = K * T * B

* K is Boltzmann's Constant

  K = − 228 dB [W / Hz*K]

* Noise Figure: NF = 1 + T−290

* Noise Temperature of a Lossy Medium:

  T = T (1 − 1/Loss)

RECEIVED POWER

* Received Carrier Power [dBW]:

$$C = P + G - S - Att + n + A$$

$$C = P + G - L - Att + G$$

* Received Carrier-to-Noise Ratio:

$$[C/N] = P + G - L + [G/T] - K - B$$

$$[C/N_0] = P + G - L + [G/T] - K$$

LINK PERFORMANCE

* Analog Signals: S/N
* Digital Signals: Bit Error Ratio [BER]
* Noise - Intermodulation
* Atmospheric Disturbances
* Sun Transit Outages
* Terrestrial Tails

EARTH STATION TECHNOLOGY

* Block Diagramme
* Antenna Configurations
* Tracking
* Low-Noise Receivers
* High-Power Amplifiers