



INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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COURSE ON BASIC TELECOMMUNICATIONS SCIENCE
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COMMUNICATIONS AND BROADCASTING BY SATELLITE

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INTERNATIONAL CENTRE
FOR THEORETICAL PHYSICS

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COURSE ON COMMUNICATIONS AND BROADCASTING
BY SATELLITE

Pierre Bartholomé
European Space Agency



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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

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

Disadvantages



REGULATORY BODIES

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



RADIO REGULATIONS

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

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COMMUNICATIONS SATELLITE SERVICES

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

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FREQUENCY BANDS

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- * 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)

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THE CCIR

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

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INTERNATIONAL NETWORKS

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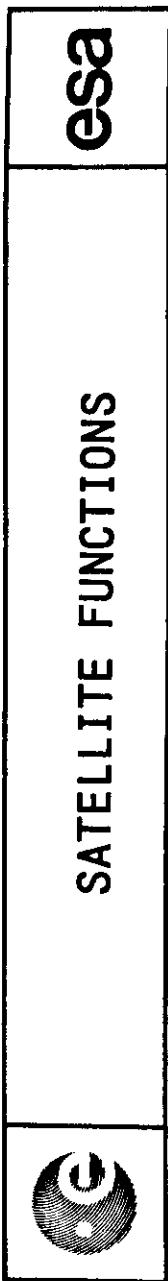
- * Worldwide
 - INTELSAT
 - INMARSAT
- * Regional
 - Intersputnik
 - EUTELSAT
 - ARABSAT
 - Pan Am Sat



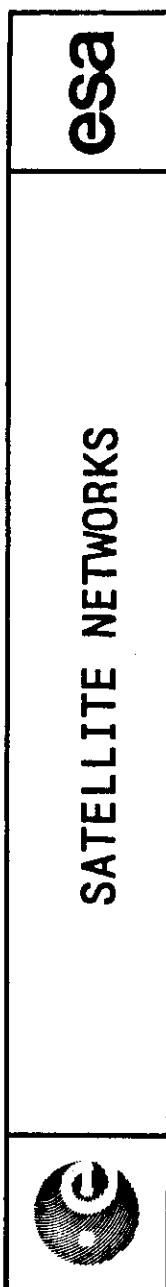
NATIONAL NETWORKS

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



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



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

	SATELLITE OPERATIONAL STRUCTURE	esa
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- * Satellite Operator
- * Payload Operator
- * Carriers
- * Service Operators
- * Service Commercialisers

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



TYPES OF APPLICATION

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



FIXED-SATELLITE SERVICE APPLICATIONS

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

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

	BROADCASTING-SATELLITE SERVICE	esa
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- * Television Low Power
- * Television Medium Power
- * Television High Power (DBS)
- * HiFi Radio
- * High Definition Television
- * Data Broadcasting



COMMUNICATIONS TECHNIQUES 1

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



COMMUNICATIONS TECHNIQUES 2

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



COMMUNICATIONS TECHNIQUES 3

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

?



ANTENNAS

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- * Effective Aperture Omni = $\frac{\pi * D^2}{4}$
- * 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

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- * Spreading Loss (Omni to 1 m²)

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

- * Over 36,000 km: $S = 162 \text{ dB [m}^2\text{]}$

- * Propagation Loss (Omni to Omni)

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

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

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NOISE

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

- * K is Boltzmann's Constant

$$K = -228 \text{ dB [W } \times \text{ Hz} * \text{ K]}$$

- * Noise Figure: $NF = 1 + T - 290$

- * Noise Temperature of a Lossy Medium:
 $T = T (1 - 1/\text{Loss})$

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RECEIVED POWER

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- * Received Carrier Power [dBW]:

$$C = P + G - S - \text{Att} + n + A$$

$$C = P + G - L - \text{Att} + G$$

- * Received Carrier-to-Noise ratio:

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

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

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LINK PERFORMANCE

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

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EARTH STATION TECHNOLOGY

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

