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和平利用外层空间委员会

区域空间科学和技术教育中心（附属于联合国）

卫星通信课程

目录

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一. 导言

1. 近年来卫星通信系统发生了根本性变革，从由政府和对地静止卫星所主导的技术过渡到包括由公营公司经营的低地轨道和中地轨道卫星系统在内的技术。这些新系统利用多天线波束——类似于地面蜂窝电话系统所使用的那种——在地球表面形成网络，能够进行包括语音通信和因特网通信在内的各类通信。

2. 通信卫星是设在空间的无线电中继站。它们起的作用与人们在公路上看到的微波塔的作用很相似。卫星接收从地面发出的无线电信号，将信号放大后发回到地面。由于卫星处在很高的高度，它们能“看见”地球的很大区域。这使它们具有主要的通信优势：能够覆盖广大的地域。

3. 卫星通信系统由若干不同的部分组成，包括一个空间段、一个地面控制段和地面基础设施设备。空间段包含卫星，卫星起着空间节点的作用，将来自地球终端的通信信号发送到地球表面的一个最后或中间目的地。地面控制段负责监测每个卫星的技术良好状态和状况并将卫星保持在空间的适当位置。基础设施设备控制整个通信系统的网络方面，为收费目的记录通话时间以及向各用户分配通信信道。

二. 卫星通信工作组的审议情况

4. 外层空间事务厅同欧洲空间局合作于 2001 年 9 月 3 日至 7 日在意大利弗拉斯卡蒂举办了联合国区域空间科学和技术教育中心：现状和未来发展专家会议。会议的主要目标之一是审查和更新各区域中心在以下四领域的教育课程：遥感、卫星气象学、卫星通信、空间科学。

5. 本报告载有卫星通信工作组的审议情况。工作组审查了在亚洲和太平洋空间科学和技术教育中心举办的几次培训班的课程（附件一），并制订了应成为卫星通信课程组成部分的专题的广泛大纲。

6. 工作组认为，各专题的详细内容及其覆盖范围需由各区域中心确定。通过专业教育和研究，各区域中心应帮助其参与成员国提高发展和传输卫星通信方面知识的能力。这样做的目的是加强当地国家和区域利用卫星通信技术促进可持续发展的能力。

A. 审查现有课程

7. 工作组审查了分别于 1997 年 1 月 1 日至 1998 年 9 月 30 日、1999 年 7 月 1 日至 2000 年 3 月 31 日和 2001 年 8 月 1 日至 2002 年 4 月 30 日在亚洲和太平洋空间科学和技术教育中心举办的第一、第二和第三期卫星通信研究生在培训班所使用的课程。这三期培训班总共为期 39 周，其中上课 35 周（包括为试点项目做准备 10 周）和参观各个卫星通信设施 4 周。培训班结束之后，学员们各自在本国进行了为期一年的试点项目。

8. 上述三期培训班的单元见表 1。

表 1

卫星通信课程单元

单元	专题	时间（周）
0	熟悉情况课程	1
1	通信系统和数字信号处理	5
2	卫星通信系统	6
3	地面站技术	3
4	利用通信卫星广播	3
5	卫星通信应用和趋势	3
6	实用通信卫星系统	1
7	卫星通信系统的网络规划、管理和操作问题	1
8	卫星通信促进发展、教育和培训	2
9	试点项目	10
	共计	35

9. 这些培训班每周上课五天，每天八堂课，每课 45 分钟。按培训的单元和类型分列的细项见表 2。

表 2

按培训的单元和类型分列的细项

	单元								
培训的类型	0	1	2	3	4	5	6	7	8
讲课	40	138	120	46	42	62	30	20	32
实践练习		54	48	28	48	28			20
参观			24	24	12	16			24
图书馆			24	12	8	4	10	20	4
课堂测验和考试		8	24	10	10	10			
共计	40	200	240	120	120	120	40	40	80

注：上述数字系指每 45 分钟为一堂课。

B. 卫星通信培训班订正课程

1. 目标

10. 课程具体目标如下：

(a) 培训大学教育工作者、研究人员、电信专业人员、政府官员和其他人员在卫星通信领域及其在广播、电信、卫生保健、教育、灾害管理等方面的应用技能；

(b) 帮助制订卫星通信项目、确定政策和建立通信系统；

(c) 发展运用操作系统方面的专门知识并将先进的通信技术用于日常活动；

(d) 帮助促进区域内和区域间在利用通信技术和扩大其应用范围方面的合作；及

(e) 促进形成和加强公众对卫星通信技术可带来提高生活质量方面益处的认识。

2. 课程结构

11. 卫星通信是与外界进行联系和缩小各国距离，使它们共同进入被称为“地球村”的最有效的媒介。在这一背景下，该课程必须向发展中国家的学员提供使该技术发挥最大潜力的技能。

12. 该课程将由 11 个单元组成（包括一个熟悉情况单元），每个单元涉及卫星通信的特定领域（理论、技术和应用）。该课程为期九个月，包括 35 周课和 4 周参观卫星通信设施。然后在学员本国开展为期一年的试点项目工作。各单元所涉专题以及期限见表 3。

表 3

课程单元

单元号	专题	周数
0	熟悉情况课程	1
1	通信系统和数字信号处理	5
2	卫星通信系统	5
3	地面站技术	3
4	传输、多路传输和多路存取	2
5	利用通信卫星广播	2
6	卫星通信应用和趋势	3
7	实用通信卫星系统	1
8	卫星通信系统的网络规划、管理和操作问题	1
9	卫星通信促进发展、教育和培训	2
10	试点项目	10
	共计	35

讲课将占 40%，实践练习占 60%。

3. 设备和设施

13. 最低限度设备和设施要求如下：

高性能多媒体个人计算机

MATLAB 软件程序

频谱分析仪

信号发生器

网络分析仪

功率计

频率计数器

微波传输线系统

光具座

应答器或卫星模拟器

具有发射和接收功能的地面站（例如最低限度要求是甚小孔径终端）

测试循环转发器

误码率测试装置

电视单收系统

4. **订正课程**

单元 0： 熟悉情况课程

0.1 课程介绍

0.2 区域中心的活动和详情介绍

0.3 通信技能（口头、书面、演示、小组讨论）

0.4 当地环境介绍（语言、地理环境、社会制度等）

单元 1： 通信系统

1.1 通信和联网原理

1.1.1 讲课

电信概述

信息理论原理

调制和编码原理

微波理论和技术

光通信

网络和协议原理

1.1.2 实验课

MATLAB 模拟和硬件实验

1.2 数字信号处理

1.2.1 讲课

离散时间信号和系统

连续时间信号抽样

Z-变换

离散傅里叶变换

离散傅里叶变换计算

离散时间系统结构

过渡设计技术

卫星通信数字信号处理分系统实例

1.2.2 实验练习/辅导

MATLAB 练习

单元 2： 卫星通信系统

2.1 讲课

卫星通信入门

卫星轨道

卫星构型

运载火箭和卫星发射

空间环境

可靠性

卫星总线分系统

通信有效载荷（透明和机上处理）

卫星通信链路

卫星通信频带

电磁干扰、电磁兼容性、射频干扰

对卫星通信链路的传播影响

2.2 实验和示范

链路参数计算，包括真实传播模型

用卫星模拟器进行示范

轨道和足迹模拟

单元 3： 地面站技术

3.1 讲课

卫星通信地面站—概述

地面站分系统技术

地面站设计和构造方面的考虑事项

地面站标准

地面站测试

地面站可靠性

操作和维护

3.2 实验和示范

利用发射/接收卫星终端

单元 4： 传输、多路传输和多路存取

4.1 讲课

模拟和数字调制技术

前向纠错编码

多路传输/多路解编

扩谱技术

多路存取技术

4.2 实验室实验

MATLAB 模拟

硬件实验

单元 5： 利用通信卫星广播

5.1 讲课

模拟和数字广播系统标准

数字电视

卫星电视和存取系统

因特网协议广播

有关应用，例如：

用于无线电和电视的卫星新闻搜集

无线电联网

数字音频广播

室外广播工程拖车

电视工作室及其运作

体育节目的电视覆盖范围

多信道传播

卫星电视会议

多媒体（视频显示）

随选录象

5.2 实验室实验和示范

利用电视和因特网协议终端进行实践练习

单元 6： 卫星通信应用和趋势

6.1 讲课

卫星通信服务

卫星通信应用精选，例如：

甚小孔径终端网络

气象数据接收系统

新闻和气象数据传播系统

数据收集系统

利用卫星通信进行灾害管理

搜索和救援系统：

国际

区域

警报传播系统

远程医疗

时间和频率传输系统

移动通信和个人通信服务

战略卫星通信系统

卫星导航系统

卫星因特网系统

多媒体宽带卫星系统

6.2 实验室实验和示范

利用现有设施和终端用户的设备进行有关硬件的实验及系统示范

单元 7： 实用通信卫星系统

7.1 讲课

实用通信卫星系统概述

固定卫星服务

移动卫星服务

广播卫星服务

多媒体广播服务

实用通信卫星系统精选

国际电信联盟（国际电联）和其他标准化组织（国际标准化组织（标准化组织）、亚洲太平洋电信共同体（亚太电信共同体）、欧洲电信标准研究所）

国际规章

单元 8： 卫星通信系统的网络规划/管理/操作问题

8.1 讲课

网络规划方面应考虑的技术问题

空间段规划

地面段规划

网络操作和控制

通信卫星运行管理

系统内/系统间干扰协调

空间法

卫星通信的财务问题

单元 9： 卫星通信促进发展、教育和培训

9.1 讲课

卫星通信促进发展、教育和培训概述

以下方面的区域经验：

硬件

软件

社会调研

地方广播（电视、电台、电缆网络）

卫星通信促进发展规划

促进发展、教育和培训的卫星技术

促进发展的跨国境信道的运作、技术和法律问题

用户利用卫星电话会议促进农村发展的经验

灾害管理

9.2 利用现有系统进行示范

单元 10： 试点项目

项目定义

学员国家的需要

学员感兴趣的课题

能促成一年期项目的工作

建议的项目课题

地面站分系统

通信卫星系统分析

航天器设计

天线覆盖区设计

通信系统设计

网络规划和相关软件开发

促进通信发展的电视和无线电应用

卫星通信经济学

国内系统定义

政策研究

Annex I

Curriculum for the first three courses

Table

Curriculum of the course in satellite communications

Module/ submodule	*Topic*	*Number of 45-minute sessions*
0	Orientation course (1 week)	
0.1	Introduction to the regional centre	2
0.2	Introduction to activities of the local host institution	2
0.3	Communication skills (oral, written, presentation, group discussion etc.)	24
0.4	Introduction to the host country	6
	Geographic perspectives of the host country	
	Social systems and customs	
	Festivals of the host country	
0.5	Local language—common phrases in the local language	6
	Total	40
1	Communication systems and digital signal processing	
1.1	Classroom lectures—communication systems (3 weeks)	
	Telecommunications overview	
	Distribution, traffic, signalling, switching	6
	Analog and digital communications systems	2
	Long-distance communications	1
	Fibre optics technology and applications	4
	Data networking	10
	Signalling and modulation	
	Local area network (LAN)	
	Wiring plans	
	Data services in public networks	
	Introduction to transmission control protocol/Internet protocol (TCP/IP)	
	Internet	
	Asychronous transfer mode (ATM)	
	Personal communication services	4
	Integrated services digital network (ISDN)	3
	Packet switching fundamentals	3
	Broadband—an overview	3
	Protocols	3
	Microwave theory and techniques	6
	Transmission line parameters (Z, Y, ABCD, S)	
	Waveguide and coaxial components	
	Applications of microwave technology	
	Introduction to computers	6
	Computer architecture	
	Complex instruction set computer (CISC)	
	Reduced instruction set computer (RISC)	
	Parallel processor	
	Input/output (I/O) devices	
	I/O programming	

Module/ submodule	*Topic*	*Number of 45-minute sessions*
	I/O controlling	
	Interrupt	
	Direct memory access (DMA)	
	Operating systems	
	Standard operating systems	
	Disc operating system (DOS)	
	UNIX and Linux	
	Windows 95 NT	
	Communication theory and mathematical tools	
	Probability theory and basic statistics	10
	Information theory	6
	Spherical geometry	1
	Linear algebra	4
	MATLAB mathematical tools	8
	Subtotal	80
1.2	Laboratory sessions	
	Computer	4
	MATLAB	8
	Microwave measurements	8
	Analog and digital modems	4
	Fibre optics	8
	Subtotal	32
1.3	Classroom lectures—digital signal processing (2 weeks)	
	Discrete time signals and systems	4
	Discrete time signals: sequences	
	Discrete time systems	
	Linear time-in variant systems	
	Frequency domain representation of sampling	
	Discrete time signals and systems	
	Representation of sequences by Fourier transform	
	Fourier transform theorems	
	Discrete time random signals	
	Sampling of continuous time signals	6
	Periodic sampling	
	Frequency domain representation of sampling	
	Reconstruction of a band limited signal from its samples	
	Discrete time processing of continuous time signals	
	Continuous time processing of discrete time signals	
	Changing the sampling rate using discrete time processing	
	Practical considerations	
	Z-transform	10
	Properties of region of convergence for Z-transform	
	Inverse Z-transform	
	Z-transform properties	
	Inverse Z-transform using contour integration	
	Complex convolution theorem	
	Parseval's relation	
	Unilateral Z-transform	

Module/ submodule	*Topic*	*Number of 45-minute sessions*
	Discrete Fourier transform (DFT)	6
	Representation of periodic sequences	
	Discrete Fourier series	
	Properties of discrete Fourier series	
	Fourier transform of periodic signals	
	Sampling of Fourier transform	
	Fourier representation of finite duration sequences	
	Discrete Fourier transform	
	Linear convolution using discrete Fourier transform	
	Computation of discrete Fourier transform	8
	Efficient computation of discrete Fourier transforms	
	Goertzel algorithm	
	Decimation-in-time fast Fourier transform (FFT) algorithms	
	Decimation-in-frequency FFT algorithms	
	Implementation of FFT algorithms	
	FFT algorithms for composite N	
	Implementation of DFT using convolution	
	Effects of finite register length in DFT computations	
	Structure for discrete time systems	6
	Block diagram representation of linear constant coefficient differential equation	
	Basic structure for infinite impulses response (IIR) systems	
	Basic network structures for finite impulse response (FIR) systems	
	Overview of finite precision numerical effects	
	Effects of coefficient quantization	
	Effects of round-off noise in digital filters	
	Zero input cycles in fixed-point realizations of IIR digital filters	
	Filter design techniques	12
	Basic issues in digital filter design	
	IIR filter design	
	Frequency transformation of low-pass IIR filters	
	Design of filters by windowing	
	Optimum approximation of FIR filters	
	FIR equi-ripple approximation	
	Wavelet transform	2
	Examples of DSP-based subsystems for satellite communications	4
	Subtotal	58
1.4	Laboratory exercises/tutorial	
	MATLAB-based exercises	10
	Design of FIR and IIR filters	
	Implementation of DFT/FFT	
	Examples of DSP-based communication subsystems	
	Familiarization with and implementation of evaluation board	12
	FIR and IIR filters	
	Demodulator algorithm	
	Viterbi coding	
	FFT and discrete cosine transform (DCT)	

Module/ submodule	*Topic*	*Number of 45-minute sessions*
	Subtotal	22
	Total[a]	192
2	Satellite communication systems (6 weeks)	
2.1	Classroom lectures	
	Introduction to satellite communications	4
	Evolution of satellite communications	
	Elements of satellite communications	
	Types of satellite orbits	
	Geosynchronous satellite communications	
	Satellite communications services	
	Satellite orbits	4
	Launch vehicles and launching of satellites	4
	Satellite communications links	4
	Frequency bands for satellite communications	2
	Propagation effects on satellite communication links	2
	Satellite communication techniques	28
	Multiplexing techniques	4
	Modulation techniques	6
	Multiple access techniques	6
	Code division multiple access (CDMA)	2
	Coding theory and error correction techniques	4
	IP over satellite	4
	Satellite configurations	2
	Space environment	2
	Satellite bus subsystems	12
	Mechanical structure	2
	Attitude and orbit control system (AOCS)	2
	Propulsion subsystem	2
	Electrical power subsystem	2
	Telemetry, tracking and command (TT and C)	2
	Thermal subsystem	2
	Communication transponder	2
	Communication transponder subsystems	6
	Antenna and feed	2
	Receiver and transmitter	2
	I/O multiplexer	2
	Advanced communication transponder on-board processing	4
	Integration and testing of communication transponders	2
	Integration and testing of satellites	2
	In-orbit check out of communication payloads	2
	Reliability and space qualifications	2
	Reliability of satellite communication payloads	2
	EMI, EMC and RFI	2
	Electrostatic discharge hazards in satellite communications electronics	2
	Life of a satellite	2
	Satellite communications (video computer-based teaching (CBT) and tutorials)	28
	Subtotal	120

Module/ submodule	*Topic*	*Number of 45-minute sessions*
2.2	Experiments/demonstrations	
	Familiarization with measuring instruments	4
	Determination of satellite look angles and optimization of Earth station antennas	4
	Azimuth and elevation angles	
	X-Y angles	
	Optimization of sense of polarization	
	Measurement of satellite link parameters	8
	Total C/kT and down-link C/kT	
	Antenna gain to system noise temperature ratio (G/T) and effective isotropic radiated power (EIRP)	
	Bit error rate (BER) versus C/kT	
	Familiarization with and measurement of satellite transponder characteristics (communication simulator)	4
	Familiarization with and operation of single channel per carrier (SCPC), spread spectrum multiple access (SSMA) and time division multiple access (TDMA) equipment	12
	Testing of communication transponder subsystems	16
	Multiplexer	
	Receiver	
	Power amplifier	
	Antenna and feed	
	Subtotal	48
2.3	Visits to laboratories and other facilities of the host institution	24
	Communication payload research and development laboratories	
	Communications techniques laboratories	
	Payload fabrication facility	
	Environmental test facility	
	Communication system laboratories	
	Remote sensing laboratories	
	Subtotal	24
	Total[a]	192
3	Earth station technology (3 weeks)	
3.1	Classroom lectures	
	Satellite communications Earth station—an overview	2
	Technology of Earth station subsystems	22
	Antenna reflector and mount for large, medium and small Earth stations	
	Feed system for large, medium and small Earth stations	
	Antenna tracking system	
	Low-noise amplifier (LNA)	
	Solid-state power amplifier	
	High-power amplifier (HPA)	
	Frequency converter	
	Modulator and demodulator	
	Encoder and decoder	
	Test-loop translator	
	Electrical power supply system	
	Foresight and rearward link	
	Earth station design considerations	5

Module/ submodule	*Topic*	*Number of 45-minute sessions*
	Earth station standards	
	EIRP and G/T	
	Antenna size and gain	
	Radiation pattern and antenna coverage	
	Redundancy and reliability	
	Environmental specifications	
	VSAT/mobile/briefcase/hand-held terminals	
	Check out of Earth stations	8
	Antenna measurements (farfield, nearfield, anechoic chamber)	
	LNA and G/T	
	HPA and EIRP	
	Frequency converter	
	Test-loop translator	
	Reliability of Earth stations	1
	Operations and maintenance of fixed and transportable Earth stations	2
	Fabrication techniques	6
	Mechanical fabrication techniques	
	Electronics fabrication techniques	
	Microwave integrated circuits (MIC)	
	Subtotal	46
3.2	Local visits	24
	Department of Telecommunications (DOT) Earth station	
	Department of Electronics (DOE) Software Technology Park	
	Antenna test facility (host institution)	
	MIC facility (host institution)	
	Electronics fabrication facility (host institution)	
	Mechanical fabrication facility (host institution)	
	Subtotal	24
3.3	Experiments/demonstrations	
	Familiarization with Earth station subsystems	4
	Testing of Earth station subsystems	24
	Testing of feed system	
	Testing of HPA	
	Testing of LNA	
	Testing of frequency converter	
	Testing of antenna tracking system (manual and auto mode)	
	Subtotal	28
	Total[a]	98
4	Broadcasting using communication satellites (3 weeks)	
4.1	Classroom lectures	
	Broadcasting system standards	6
	Frequency modulation television (FMTV)	
	High-definition television (HDTV)	
	Digital video broadcasting (DVB)	
	Moving Picture Experts Group (MPEG)	
	Digital television (video presentation)	6
	Satellite links for TV broadcasting (analog and digital)	2
	Frequency bands for satellite broadcasting and national/international	2

Module/ submodule	*Topic*	*Number of 45-minute sessions*
	regulations	
	Satellite TV and access systems	6
	Cable TV	
	Direct broadcasting satellite/direct-to-home (DBS/DTH)	
	Conditional access	
	Network management	
	Satellite news gathering (SNG) for radio and TV	2
	Radio networking	2
	Digital audio broadcasting	2
	Outdoor broadcasting van	2
	TV studio and its operations	2
	TV coverage of sports	2
	Multicasting	2
	Videoconferencing via satellite	2
	Multimedia (video presentation)	2
	Video on demand	2
	Subtotal	42
4.2	Laboratory experiments/demonstrations	48
	Familiarization with video baseband systems	
	Measurement of video signal-to-noise (S/N) ratio versus carrier-to-noise (C/N) radio and video threshold	
	Measurement of TV audio S/N	
	Measurement of S/N versus FM deviation	
	Measurement of TV signal parameters using waveform monitor, vectorscope and automated test equipment	
	SCPC/multiple channels per carrier (MCPC) digital TV	
	Determination of transponder operating points for:	
	Single carrier per transponder	
	Multicarrier per transponder	
	Familiarization with radio networking terminals	
	Demonstration of operations of SNG terminals	
	Setting up a TV direct reception system	
	Digital sound and data broadcasting (DSDB) system	
	Multimedia broadcasting/multicasting	
	Subtotal	48
4.3	Local visits	12
	TV broadcasting station of Doordarshan	
	Radio networking system of All India Radio (AIR)	
	TV studio of the Development and Educational Communication Unit (DECU)	
	Subtotal	12
	Total[a]	102
5	Applications and trends in satellite communications (3 weeks)	
5.1	Classroom lectures	
	Satellite communications services	26
	Rural/remote area communications	2
	VSAT network	8
	Time division multiplexing (TDM)-TDMA	

Module/ submodule	*Topic*	*Number of 45-minute sessions*
	SCPC-demand assignment multiple access (DAMA)	
	Remote terminals	
	Hub	
	Network management	
	Meteorological data reception systems (National Oceanic and Atmospheric Administration (NOAA), Indian National Satellite System (INSAT))	2
	News and meteorological data dissemination system	2
	Data collection system	2
	Disaster management using satellite communications	2
	Search and rescue system	2
	International	
	Regional (INSAT)	
	Cyclone warning dissemination system	2
	Telemedicine	2
	Time and frequency transmission system	2
	Mobile and personal communication services (IMT-2000, 4G etc.)	8
	Strategic satellite communication systems	4
	Satellite navigation system	6
	Satellite-based Internet system	2
	Multimedia broadband satellite system	2
	Video CBT and tutorials	14
	Subtotal	62
5.2	Laboratory experiments/demonstrations	
	NOAA very high resolution radiometer (VHRR) data reception	
	News and meteorological data dissemination system	
	Search-and-rescue beacon	
	Operations of Global Positioning System (GPS) receiver and INSAT reporting system	
	VSAT terminal and network	
	Data and sound broadcasting system	
	Subtotal	28
5.3	Local visit	
	Press Trust of India (PTI)	
	India Mobile Department (IMD)	
	Airport	
	National Informatics Centre Network (NICNET)	
	Subtotal	16
	Total[a]	106
6	Operational communications satellite systems (1 week)	
6.1	Classroom lectures	
	Overview of operational communications satellite systems	8
	FSS	
	MSS	
	BSS	
	Broadband multimedia system	
	Operational communications satellite systems	18
	International Telecommunication Union and other standardization organizations (ISO, APT, ETSI)	2

Module/ submodule	*Topic*	*Number of 45-minute sessions*
	International regulations	2
	Total[a]	30
7	Network planning/management/operational issues of satellite communications systems (1 week)	
7.1	Classroom lectures	
	Technical considerations for network planning	2
	Planning for space segment	2
	Traffic requirements	
	Options for satellite transponder (coverage, power, bandwidth, bent-pipe/regenerative)	
	Cross-pol isolation and collocated satellites	
	Choice of orbits (geosynchronous Earth orbit (GEO), MEO, LEO)	
	Planning for ground segment	2
	Trade-off between space segment and ground segment	
	HPA power and transmit antenna size	
	Off-axis radiation pattern	
	LNA noise temperature and receive	
	Antenna size	
	Cost	
	Network operations and control	2
	Management of communication satellite operations	4
	Normal operations	
	Operations of satellite control Earth station (tele-command, telemetry, tracking and ranging)	
	Orbit determinations, station keeping and fuel management	
	Sun outage and eclipse operations	
	Loss of lock	
	Intra-system/inter-system interference coordination	4
	Space law	2
	Financial aspects of satellite communications	2
	Total[a]	20
8	Satellite communications for development, education and training (2 weeks)	
8.1	Classroom lectures	
	Satellite communications for development education and training—an overview	4
	Indian experience with the Satellite Instructional Television Experiment (SITE), Kneda Communications Project (KCP), Training and Development Communications Channel (TDCC), Jhabua Development Communications Project (JDCP) and University Grant Commission (UGC)	6
	Hardware	
	Software	
	Social research	
	Local broadcasting (TV, radio, cable network)	2
	Planning for satellite communications for development	4
	Research and evaluation	
	Program production for development communications	
	Hardware	
	Cost	
	Satellite technology for development, education and training	8

Module/ submodule	*Topic*	*Number of 45-minute sessions*
	Receive system	
	Transmit system	
	Talk-back system	
	DAMA control	
	Value-added services	
	Return video	
	Data broadcasting	
	Internet broadcasting	
	Multimedia broadcasting	
	Two-way videoconferencing	
	Operational, technological and legal issues in transborder channels for development	2
	Teleconferencing experiences of users for rural development	4
	Disaster management	2
	Subtotal	32
8.2	Demonstrations	20
	Demonstration of talk-back systems (JDCP and TDCC)	
	Direct reception system (analog and digital)	
	Two-way video conference (Spacenet)	
8.3	Field visits	24
	Total[a]	76
9	Pilot project (10 weeks)	
	Project definition	
	Needs of the participant's country	
	Topic of interest of the participant	
	The work leading towards the one-year project	
	Suggested topics for the project	
	Earth station subsystems	
	Systems analysis for communications satellites	
	Spacecraft design	
	Antenna footprint design	
	Communication systems design	
	Network planning and relevant software development	
	Applications of TV and radio for development communications	
	Economics of satellite communications	
	Domestic system definition	
	Policy research	

[a]Totals do not include tests and examinations or library work (see also chap. II.A, table 2).

Annex II

Recommended teaching material

Elbert, B. Introduction to satellite communications, 2. ed. Boston, Artech House Publishers, 1999.

Feher, K. Wireless digital communications: modulation and spread spectrum applications. Upper Saddle River, New Jersey, Prentice Hall, 1995.

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Hodge, W. W., Interactive television. New York, McGraw Hill, 1995.

Killen, H. B. Digital communications with fiber optics and satellite applications. Englewood Cliffs, New Jersey, Prentice Hall, 1988.

Lewis, G. E. Communication service via satellite. Oxford, Oxford BSP Professional Books, 1988.

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Manolakis, P. Digital signal processing. 2. ed. New Delhi, Prentice Hall, 1996.

Martin, J. Communication satellite system. Englewood Cliffs, New Jersey, Prentice Hall, 1978.

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Nejat Ince, A. Digital satellite communications systems and technologies: military and civil applications. Boston, Kluwer Academic Publishing, 1992.

Pattan, B. Satellite systems: principles and technologies. New York, Van Nostrand Reinhold, 1993.

Pocha, J. J. An introduction to mission design for GEO satellites. Dordrecht, D. Reidel Publishing, 1987.

Pratt, T. and C. W. Bostian. Satellite communications. New York, John Wiley and Sons, 1986.

Richharia, M. Satellite communications systems: design principles. New York, MacMillan Publishers, 1995.

Roddy, D. Satellite communications. 2. ed. New Delhi, McGraw Hill International, 1996.

Schramm, W. and D. F. Roberts, eds. The process and effects of mass communication. Urbana, University of Illinois Press, 1971.

Senior, J. M. Optical fiber communications. 2. ed. New Delhi, Prentice Hall, 1992.

Annex III

Explanatory notes for the curriculum

AIR	All India Radio
AOCS	attitude and orbit control system
APT	Asia Pacific Telecommunity
ATM	asynchronous transfer mode
BER	bit error rate
BSS	broadcast satellite service
CBT	computer-based teaching
CDMA	code division multiple access
CISC	complex instruction set computer
C/kT	carrier-to-receiver noise density
C/N	carrier-to-noise (ratio)
DAMA	demand assignment multiple access
DBS	direct broadcasting satellite
DCT	discrete cosine transform
DECU	Development and Educational Communication Unit
DFT	discrete Fourier transform
DMA	direct memory access
DOE	Department of Electronics
DOS	disk operating system
DOT	Department of Telecommunications
DSDB	digital sound and data broadcasting
DSP	digital signal processing
DTH	direct-to-home
DVB	digital video broadcasting
EIRP	effective isotropic radiated power
EMC	electromagnetic compatibility
EMI	electromagnetic interference
ETSI	European Telecommunications Standards Institute
FFT	fast Fourier transform
FIR	finite impulse response
FM	frequency modulation
FMTV	frequency modulation television
FSS	fixed satellite service

GEO	geosynchronous Earth orbit
GPS	Global Positioning System
G/T	antenna gain to system noise temperature ratio
HDTV	high-definition television
HPA	high-power amplifier
IIR	infinite impulse response
IMD	India Meteorological Department
IMT	International Mobile Telecommunication
INSAT	Indian National Satellite System
I/O	input/output
IP	Internet protocol
ISDN	integrated services digital network
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JDCP	Jhabua Development Communications Project
KCP	Kheda Communications Project
LAN	local area network
LEO	low-Earth orbit
LNA	low-noise amplifier
MBS	multimedia broadcast service
MCPC	multiple channels per carrier
MEO	medium-Earth orbit
MIC	microwave integrated circuit
MPEG	Moving Picture Experts Group
MSS	mobile satellite service
NICNET	National Informatics Centre Network
NOAA	National Oceanic and Atmospheric Administration
OBP	on-board processing
PTI	Press Trust of India
RFI	radio frequency interference
RISC	reduced instruction set computer
SCPC	single channel per carrier
SITE	Satellite Instructional Television Experiment
S/N	signal-to-noise (ratio)
SNG	satellite news gathering
SSMA	spread spectrum multiple access

TCP/IP	transmission control protocol/Internet protocol
TDCC	Training and Development Communication Channel
TDM	time division multiplexing
TDMA	time division multiple access
TT and C	Telemetry, Tracking and Command
TVRO	television receive-only system
UGC	University Grant Commission
VHRR	very high resolution radiometer
VSAT	very small aperture terminal