CEC 352 – SATELLITE COMMUNICATION

Prepared

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UNIT V – SATELLITE APPLICATIONS

SYLLABUS

INTELSAT Series, INSAT, VSAT, Mobile satellite services: GSM, GPS, INMARSAT, LEO, MEO, Satellite Navigational System. Direct Broadcast satellites (DBS) Direct to home Broadcast (DTH), Digital audio broadcast (DAB)- World space services, Business TV (BTV), GRAMSAT, Specialized services– E–mail, Video conferencing, Internet.

CHAPTER 5

SATELLITEAPPLICATION

INTELSATSeries

INTELSAT stands for *International Telecommunications Satellite*.The organization wascreatedin1964andcurrentlyhasover140membercountriesandmorethan40investingentities.InJuly 2001 INTELSAT became a private company and in May 2002 the company began providingend-to-end solutions through a network of teleports, leased fiber and *points of presence* (PoPs)aroundtheglobe.

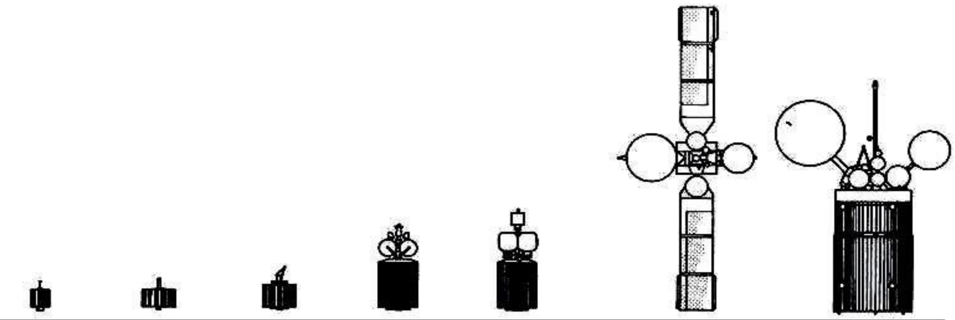
Starting with the Early Bird satellite in 1965, a succession of satellites has been launched atintervals of a few years. Figure 5.1 shows the evolution of some of INTELSAT satellites. In thefigure thecapacity,in termsofnumberof voicechannels,increaseddramatically with eachsucceeding launch, as well as the design lifetime. These satellites are in *geostationary orbit* - appear to be stationary in relation to the earth. The geostationary satellites orbit in the earth'sequatorialplaneandtheirpositionis specifiedbytheirlongitude.

Forinternationaltraffic,INTELSATcoversthreemainregions—the*AtlanticOceanRegion*(AOR), the *Indian Ocean Region* (IOR), and the *Pacific Ocean Region* (POR) and what is termed*Intelsat America's Region*. For the ocean regions the satellites are positioned in geostationary orbit abovetheparticularocean,wheretheyprovideatransoceanictelecommunicationsroute.Forexample,INTELSATsatellite905ispositionedat335.5°eastlongitude.

The INTELSAT VII-VII/A series was launched over a period from October 1993 to June1996. The construction is similar to thatof V and VA/VB seriesin that the VII series has solarsailsratherthanacylindricalbody.

The VII series was planned for service in the POR and also for some of the less demandingservices in the AOR. The antenna beam coverage is appropriate for that of the POR. Figure 5.2shows the antenna beam footprints for the C-band hemispheric cover- age and zone coverage, aswell as the spot beam coverage possible with the Ku-band antennas. When used in the AOR, theVIIseries satelliteisinverted north for south, minoradjustments then being needed only tooptimize the antenna pat- terns for this region. The lifetime of these satellites ranges from 10 to 15yearsdependingonthelaunchvehicle.

Recent figures from the INTELSAT Web site give the capacity for the INTELSAT VII as18,000two-way telephonecircuitsandthreeTVchannels;upto90,000two-way telephonecircuits can be achieved with the use of "digital circuit multiplication." The INTELSAT VII/A hasa capacity of 22,500 two-way telephone circuits and three TV channels; up to 112,500 two-waytelephone circuits can be achieved with the use of digital circuit multiplication. As of May 1999,foursatelliteswereinservice overthe AOR,one inthe IOR,andtwointhe POR.



Designation: Intelsat	I	II	III	IV	IV A	V	V A/V B	VI
Year of first launch	1965	1966	1968	1971	1975	1980	1984/85	1986/87
Prime contractor	Hughes	Hughes	TRW	Hughes	Hughes	Ford Aerospace	Ford Aerospace	Hughes
Width (m)	0.7	1.4	1.4	2.4	2.4	2.0	2.0	3.6
Height (m)	0.6	0.7	1.0	5.3	6.8	6.4	6.4	6.4
Launch vehicles		Thor Delta		Atlas-Centaur		Atlas-Centaur and Ariane	Atlas-Centaur and Ariane	STS and Ariane
Spacecraft mass in transfer orbit (kg)	68	182	293	1385	1489	1946	2140	12,100/3720
Communications payload mass (kg)	13	36	56	185	190	235	280	800
End-of-life (EOL) power of equinox (W)	40	75	134	480	800	1270	1270	2200
Design lifetime (years)	1.5	3	5	7	7	7	7	10
Capacity (number of voice channels)	480	480	2400	8000	12,000	25,000	30,000	80,000
Bandwidth (MHz)	50	130	300	500	800	2137	2480	3520

Figure5.1INTELSATSeries

The INTELSAT VIII-VII/A series of satellites was launched overtheperiod February1997 to June 1998. Satellites in this series have similar capacity as the VII/A series, and thelifetime is 14 to 17 years. It is standard practice to have a spare satellitein orbitonhigh-reliability routesandtohaveagroundspareincaseoflaunchfailure.

Thusthecostforlargeinternationalschemescanbehigh;forexample,seriesIXrepresentsa totalinvestmentofapproximately$1billion.

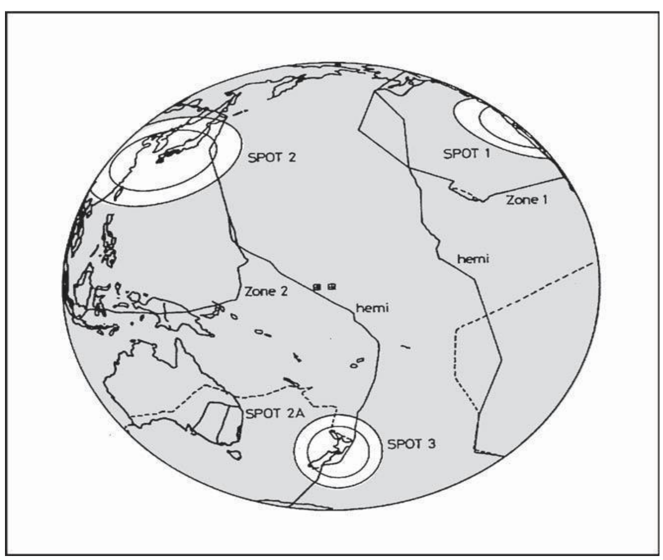


Figure5.2 RegionofGlobe

INSAT

INSAT or the ***Indian National Satellite System*** is a series of multipurpose geo-stationarysatellites launched by ISRO to satisfy the telecommunications, broadcasting, meteorology, andsearchandrescueoperationscommissionedin1983,INSATisthelargestdomesticcommunication system in the Asia Pacific Region. It is a joint venture of the Department of Space,DepartmentofTelecommunications,IndiaMeteorologicalDepartment,AllIndiaRadioandDoordarshan.TheoverallcoordinationandmanagementofINSATsystemrestswiththeSecretary-levelINSATCoordinationCommittee.

INSATsatellitesprovidetranspondersinvariousbandstoservethetelevisionandcommunication needsofIndia.SomeofthesatellitesalsohavetheVeryHighResolutionRadiometer(VHRR), CCDcamerasformetrological imaging.The satellites alsoincorporatetransponder(s) for receiving distress alert signals for search and rescue missions in the South Asianand IndianOceanRegion,asISROisamemberofthe Cospas-Sarsatprogramme.

INSATSystem

The Indian National Satellite (INSAT) System was ccommissioned with the launch ofINSAT-1B In August 1983. INSAT System was ushered in a revolution in India's Television andRadioBroadcasting,TelecommunicationsAndMeteorologicalSectors.Itenabledtherapidexpansion of TV and Modern Telecommunication facilities to even the remote areas and Off-ShoreIslands.

SatellitesinService

Of the 24 Satellites launched in the course of the INSAT Program, 10 are still in operation.Insat-2E is the last of the five satellites in Insat-2 Series and it carries 17 C-band and lowerextended C-band transponders providing zonal and global coverage with an effective isotropicradiated power of 36dbw.Italsocarries a very High Resolution Radiometer(VHRR)withImaging Capacity in the visible (0.55-0.75 µm), Thermal Infrared (10.5-12.5 µm) andWaterVapour (5.7-7.1 µm) channels and provides 2x2 km, 8x8 km and 8x8 km ground resolutionrespectively.

INSAT-3A

ThemultipurposeSatellite,INSAT-3A,waslaunchedbyArianeinApril2003. Itis locatedat93.5degree eastlongitude.The payloads onINSAT-3Aare asfollows:

- 12 Normal C-Band Transponders (9 Channels provide expanded coverage from MiddleEast to South East Asia with an EIRP Of 38 dbw, 3 Channels provide India coverage withan EIRP Of 36 dbw and 6 extended C-Band transponders provide India coverage with anEIRPof36dbw).
- ACCDCameraprovides1x1Kmgroundresolution,inthevisible(0.63µm),nearInfrared(0.77-0.86µm)andshortwaveInfrared(1.55-1.70µm)bands.

INSAT-3D

Launched in July 2013, INSAT-3D is positioned at 82 degree East Longitude. INSAT-3Dpayloads include Imager, Sounder, Data Relay Transponderand Search & Rescue Transponder.All the transponders provide coverage over large part of the Indian Ocean region covering India,Bangladesh, Bhutan, Maldives, Nepal, Seychelles, Sri Lanka And Tanzania for rendering distressalertservices

INSAT-3E

Launched In September 2003, INSAT-3E is positioned at 55 degree East Longitude andcarries 24 normal C-Band Transponders provide an edge of coverage EIRP of 37 dbw over Indiaand 12extended C-Band Transponders providean edgeofcoverageEIRPof38dbwoverIndia.

KALPANA-1

KALPANA-1 is an exclusive Meteorological Satellite launched by PSLV in September2002. It carries very High Resolution Radiometer and DRT payloads to provide meteorologicalservices. It is located at 74 degree East Longitude. Its first name was METSAT. It was laterrenamedasKALPANA-1tocommemorateKalpanaChawla.

Edusat

It is configured for audio-visual medium employing Digital Interactive classroom lessonsand multimedia content. EDUSAT was launched by GSLV in September 2004. Its transpondersand theirgroundcoverageare speciallyconfiguredtocatertothe educationalrequirements.

GSAT-2

Launched by the second flight of GSLV in May 2003,GSAT-2islocated at 48 degreeEast Longitude and carries four normal C-Band Transponders to provide 36 dbw EIRP with Indiacoverage, Two $K_u$band transponders with 42 dbw EIRP over India and an MSS payload similar tothoseonINSAT-3B AndINSAT-3C.

INSAT-4Series

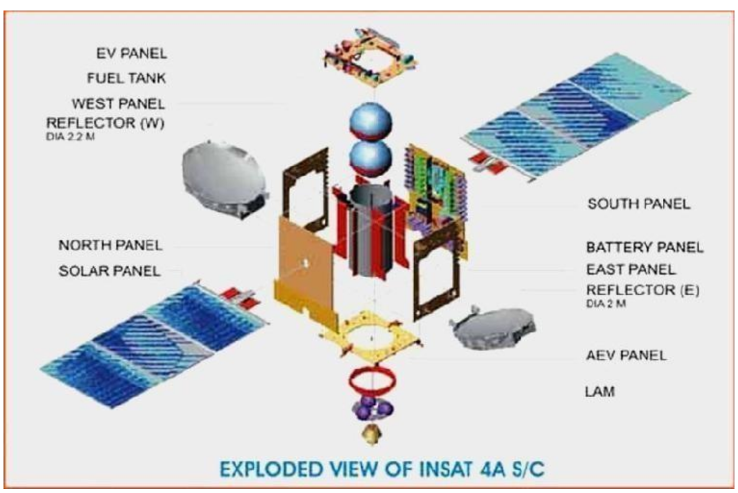


Figure5.3INSAT4A

INSAT-4A is positioned at 83 degree East longitude along with INSAT-2E and INSAT-3B. It carries 12 K_u band 36 MHz bandwidthtranspondersemploying 140 W TWTAs to providean EIRP of 52 dBW at the edge of coverage polygon with footprint covering Indian main land and12 C-band 36 MHz bandwidth transponders provide an EIRP of 39 dBW at the edge of coveragewith expanded radiation patterns encompassing Indian geographical boundary, area beyond Indiain southeast and northwest regions. Tata Sky, a joint venture between the TATA Group and STARusesINSAT-4AfordistributingtheirDTHservice.

- INSAT-4A
- INSAT-4B
- GlitchInINSAT4B
- China-StuxnetConnection
- INSAT-4CR
- GSAT-8/INSAT-4G
- GSAT-12/GSAT-10

VSAT

VSATstandsfor*verysmallapertureterminal*system.Thisisthedistinguishingfeatureofa VSAT system, the earth-station antennas being typically less than 2.4 m in diameter. The trend istowardevensmallerdishes,notmorethan1.5mindiameter.

In this sense, the small TVRO terminals for directbroadcastsatellites are labeled asVSATs,buttheappellationisusuallyreservedforprivatenetworks,providingtwo-waycommunications facilities. Typical user groups include banking and financial institutions, airlineandhotelbookingagencies,andlarge retailstoreswithgeographicallydispersedoutlets.

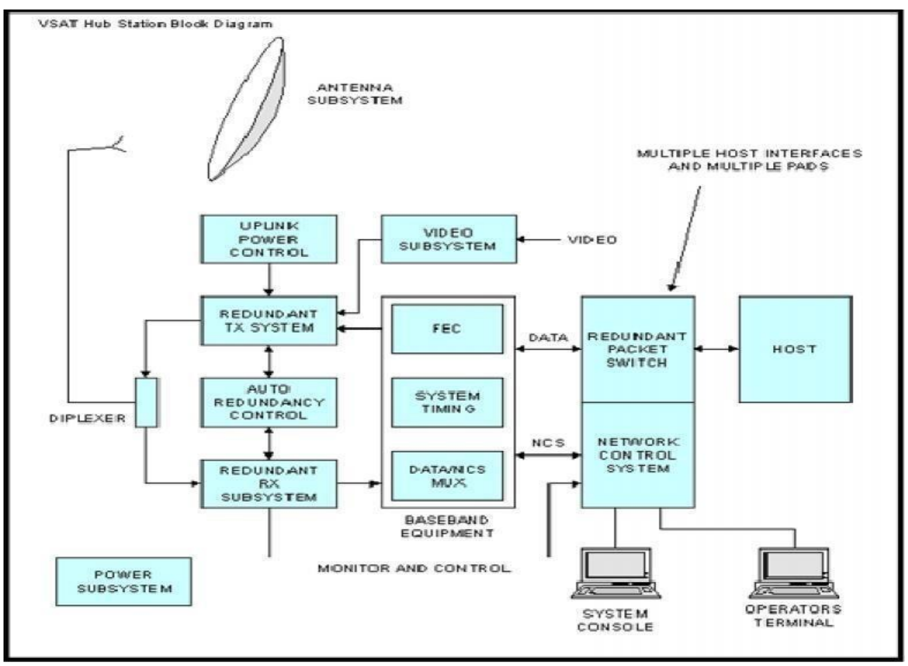


Figure 5.4 BlockDiagramofVSAT

VSATNetwork

ThebasicstructureofaVSATnetworkconsistsofahubstationwhichprovidesabroadcast facility to all the VSATs in the network and the VSATs themselves which access thesatelliteinsomeform ofmultiple-accessmode.Thehubstationisoperatedby theserviceprovider, and may be shared among a number of users, with each user organization has exclusiveaccesstoitsownVSATnetwork.

Time division multiplexing is the normal downlink mode of transmission from hub to theVSATs, and the transmission can be broadcast for reception by all theVSATs in a network. Aform of *demand assigned multiple access* (DAMA) is employed in some systems in which channelcapacity is assigned in response to the fluctuating demands of the VSATs in the network. MostVSATsystemsoperateintheKu band,althoughthere aresomeC-band systemsinexistence.

Applications:

- Supermarketshops(ATMmachines,stocksaleupdatesandstockordering).
- Chemistshops
- ShoppersDrugMart-Pharmaprix.
- Broadbanddirecttothehome.e.g.DownloadingMP3audiotoaudioplayers.
- Broadbanddirectsmallbusiness, officeetc, sharinglocalusewithmanyPCs.
- InternetaccessfromonboardshipCruiseshipswithinternetcafes,commercialshippingcommunica tions.

MobileSatelliteServices- GSM

GSMServicesandArchitecture

Ifaworkinvolvessomeformofwirelesspubliccommunications,wearelikelytoencounter the GSM standards. Initially developed to support a standardized approach to digitalcellular communications in Europe, the "Global System for Mobile Communications" (GSM)protocolsarerapidlybeingadoptedtothenextgenerationofwirelesstelecommunicationssystems. In the US, its main competition appears to be the cellular TDMA systems based on theIS-54 standards. Since the GSM systems consist of a wide range of components, standards, andprotocols.

The GSM and its companion standard DCS1800 have been developed over the last decadeto allow cellular communications systems to move beyond the limitations posed by the olderanalogsystems.

Analog system capacities are being stressed with more users that can be supported by theavailable frequency allocations. Compatibility between types of systems had been limited, if non-existent.By using digital encoding techniques,more users can share the samefrequencies thanhadbeenavailableintheanalogsystems.

As compared to the digital cellular systems in the US, the GSM market has had impressivesuccess. Estimates of the numbers of telephones run from 7.5 million GSM phones to .5 millionIS54phones to.3millionforIS95.

GSM has gained in acceptance from its initial beginnings in Europe toother parts of theworld including Australia, New Zealand, countries in theMiddle East and the far east. Beyond itsuse in cellular frequencies (900 MHz for GSM, 1800 MHz for DCS1800), portions of the GSMsignalingprotocolsarefindingtheirway intothenewly developingPCSandLEOSatellitecommunicationssystems.

While the frequencies and link characteristics of these systems differ from the standardGSM air interface, all of these systems must deal with users roaming from one cell to another, andbridgeservicestopubliccommunicationnetworksincludingthePublicSwitchedTelephoneNetwork (PSTN),andpublicdatanetworks(PDN).

TheGSMarchitectureincludesseveralsubsystems

The Mobile Station (MS) - These digital telephones include vehicle, portable and hand-held terminals. A device called the Subscriber Identity Module (SIM) is basically a smart-cardprovides custom information about users such as the services subscribed to and their identificationinthenetwork.

The Base Station Sub-System (BSS) -- The BSS is the collection of devices that supporttheswitchingnetworksradiointerface.MajorcomponentsoftheBSSincludetheBaseTransceiver Station (BTS) that consists of the radiomodems and antennaequipment. In OSIterms, the BTS provides the physical interface to the MS where the BSC is responsible for the linklayerservices totheMS.

The Network and Switching Sub-System (NSS)-- The NSS provides theswitchingbetween the GSM subsystem and external networks along with the databases used for additionalsubscriber and mobility management. Major components in the NSS include the Mobile ServicesSwitching Center (MSC), Home and Visiting Location Registers (HLR, VLR). The HLR and VLRdatabases are interconnected through the telecomm standard Signaling System 7 (SS7) controlnetwork.

The Operation Sub-System (OSS) -- The OSS provides the support functions responsiblefor the management of network maintenance and services. Components of the OSS are responsiblefornetworkoperationandmaintenance,mobileequipmentmanagement,andsubscriptionmanagementandcharging.

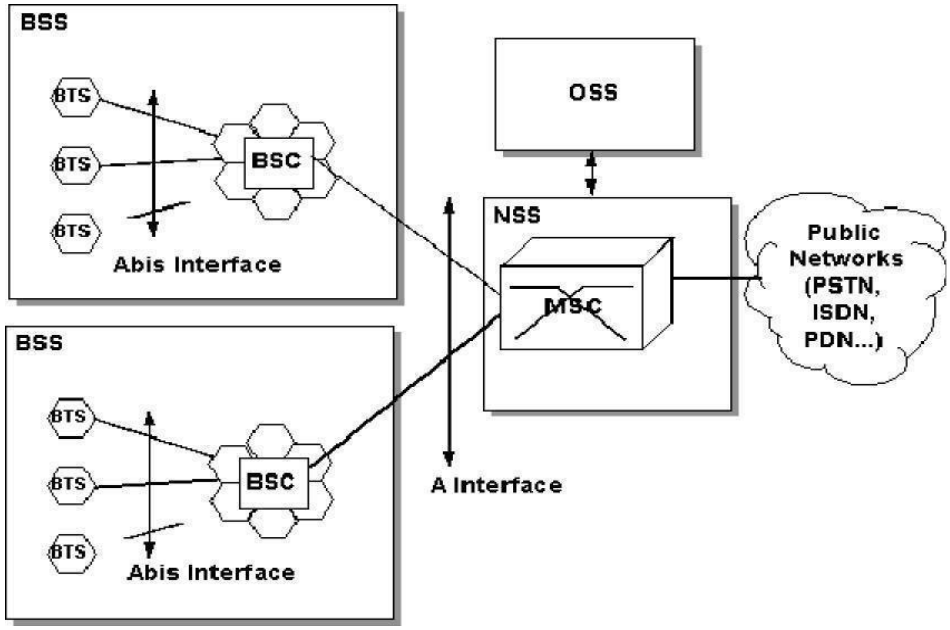


Figure5.5GSMBlockDiagrams

Severalchannelsareusedin theairinterface:

- **FCCH**-thefrequencycorrectionchannel-providesfrequencysynchronizationinformationinaburst
- **SCH**-SynchronizationChannel-followingtheFCCHburst(8bitslater),providesareference toallslotsonagivenfrequency
- **PAGCH**-PagingandAccessGrantChannelusedfortransmissionofpaginginformationrequestingthesetup ofacalltoaMS.
- **RACH**-RandomAccessChannel-aninboundchannelusedbytheMS torequestconnectionsfromthegroundnetwork.
- **CBCH-**CellBroadcastChannel-usedforinfrequenttransmissionofbroadcastsbythegroundnetwork.
- **BCCH** -Broadcast ControlChannel-providesaccessstatus informationtotheMS.
- **FACCH-**FastAssociated ControlChannelfor thecontrolofhandovers
- **TCH/F**-TrafficChannel,FullRateforspeechat 13kbpsordataat12,6,or3.6kbps
- **TCH/H-**TrafficChannel,HalfRateforspeechat7kbps,ordataat6or3.6 kbps

MobilityManagement

One of the major features used in all classes of GSM networks is the ability to supportroaming users. Through the control signaling network, the MSCs interact to locate and connect tousersthroughoutthenetwork.

"Location Registers" are included in the MSC databases to assist in therole of determininghow, and whether connections are to be made to roaming users. Each user of a GSM MS isassignedaHomeLocationRegister(HLR)thatisusedtocontaintheuser'slocationandsubscribedservices.

Difficultiesfacingtheoperatorscaninclude-

- Remote/Rural Areas - To service remote areas, it is economically unfeasible to providebackhaulfacilitiesviaterrestriallines.
- Timetodeploy-Terrestrialbuild-outscantakeyearsto planandimplement.
- Areas of ‘minor’ interest - include small isolated centers such as tourist resorts, islands,mines,oilexplorationsites,hydro-electricfacilities.
- Temporary Coverage- Special events,even in urban areas,can overload the existinginfrastructure.

5.4.4.GSMServiceSecurity

GSM was designed with a moderate level of service security. GSM uses several cryptographicalgorithms for security. The A5/1, A5/2, and A5/3 stream ciphers are used for ensuring over-the-air voice privacy. GSM uses General Packet Radio Service (GPRS) for data transmissions likebrowsing the web. The most commonly deployed GPRS ciphers were publicly broken in 2011Theresearchersrevealedflawsinthe commonlyusedGEA/1.

GlobalPositioningSystem(GPS)

The Global Positioning System (GPS) is a satellite basednavigationsystem used to locatepositions anywhere on earth. Designed by the U.S. Department of Defense, it consists of satellites,control and monitor stations, and receivers. GPS receivers takeinformationtransmittedfrom thesatellites and uses triangulation to calculate a user’s exact location. GPS is used on incidents in avarietyofways,suchas:

- Todeterminepositionlocations;forexample.
- Tonavigatefromonelocationtoanother
- Tocreatedigitizedmaps.
- Todeterminedistancebetweentwopoints.

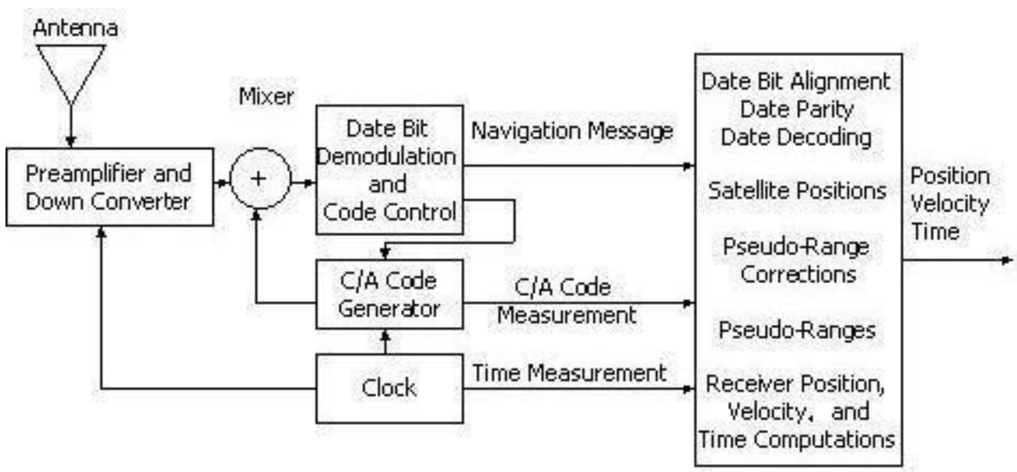


Figure 5.6 BlockDiagramofGPS

ThreeSegmentsofGPS

SpaceSegment-Satellitesorbitingtheearth

The space segment consists of 29 satellites circling the earth every12 hours at 12,000miles in altitude. This high altitude allows the signals to cover a greater area. The satellites arearranged in their orbits so a GPS receiver on earth can receive a signal from at least four satellitesatanygiventime.Eachsatellitecontainsseveralatomicclocks.

ControlSegment- Thecontrolandmonitoringstations

The control segment tracks the satellites and then provides them with corrected orbital andtime information. The control segment consists of five unmanned monitor stations and one MasterControl Station. The five unmanned stations monitor GPS satellite signals and then send thatinformation to the Master Control Station where anomalies are corrected and sent back to the GPSsatellitesthroughgroundantennas.

UserSegment- TheGPSreceiversownedbyciviliansandmilitary

Theusersegmentconsistsoftheusersandtheir GPSreceivers.Thenumberofsimultaneoususersisli mitless.

HowGPSDeterminesaPosition

TheGPSreceiverusesthefollowinginformationtodetermineaposition.

Preciselocation ofsatellites

When a GPS receiver is first turned on, it downloads orbit information from all the satellitescalled an almanac. This process, the first time, can take as long as 12 minutes; but once thisinformation isdownloaded,itisstoredinthe receiver'smemoryforfutureuse.

Distancefromeachsatellite

The GPS receiver calculates the distance from each satellite to the receiver by using the distanceformula: distance = velocity x time. The receiver already knows the velocity, which is the speedofaradiowaveor186,000miles persecond.

Triangulationtodetermineposition

The receiver determines position by using triangulation. When it receives signals from at leastthree satellites the receivershould be able tocalculateits approximate position (a 2D position).Thereceiverneedsatleastfourormoresatellitesto calculateamoreaccurate3Dposition.

UsingaGPSReceiver

ThereareseveraldifferentmodelsandtypesofGPSreceivers.Whenworkingonanincidentwitha GPSreceiveritisimportantto:

- Always haveacompassandamap.
- HaveaGPS downloadcable.
- Haveextrabatteries.
- Know memory capacity of the GPS receiver to prevent loss of data, decrease in accuracy ofdata,orotherproblems.
- Useanexternalantennaewhenever possible, especiallyunder treecanopy,incanyons,orwhileflyingordriving.
- SetupGPSreceiver accordingtoincidentoragencystandardregulation;coordinatesystem.

INMARSAT

Inmarsat-Indian Maritime Satelliteis still the sole IMO-mandated provider of satellitecommunications for the GMDSS. Inmarsat has constantly and consistently audited by IMSO andreported on to IMO. Now Inmarsat commercial services use the same satellites and network.Inmarsat A closes at midnight on 31 December 2007 agreed by IMO – MSC/Circ.1076. Successfulclosure programme almostconcludedOverseenthroughoutbyIMSO.

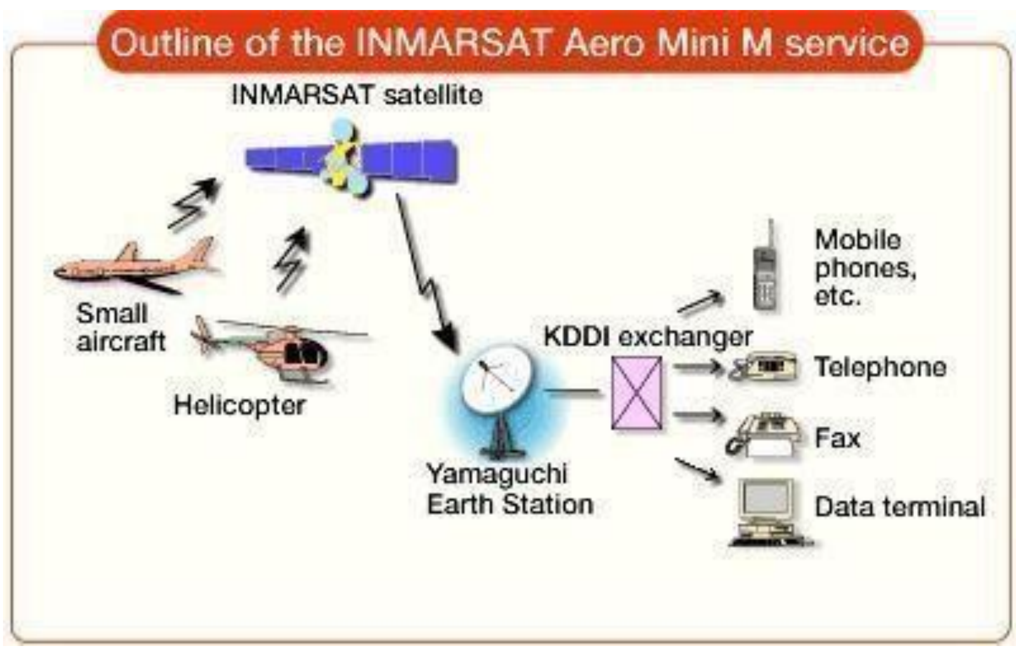


Figure5.7INMARSATSatelliteService

GMDSSservicescontinuetobeprovidedby:

- InmarsatB,InmarsatC/mini-CandInmarsatFleetF77
- PotentialforGMDSSonFleetBroadbandbeingassessed

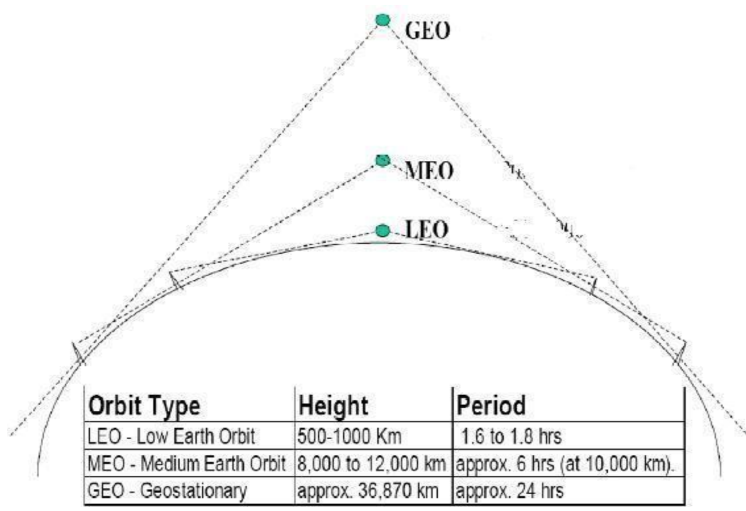
TheIMOCriteriafortheprovisionofMobileSatelliteCommunicationsSystems intheGlobalMaritime Distress andSafetySystem(GMDSS)-

- Amendmentswereproposedtomakeitsimplerforothersatellitesystemstobeapproved
- Theoriginalrequirementsremainandwereapproved byMSC83
- Nodilutionofstandards
- Minoramendmentsonly
- ReplacementResolutionexpected tobeapprovedbytheIMO
- Inmarsatremainsthesole,approvedsatcomprovider fortheGMDSS

LEO,MEOandGEO

LEO: LowEarthOrbitsatelliteshaveasmallareaofcoverage.Theyarepositionedinanorbitapproximately3000kmfromthe surfaceoftheearth.

- Theycompleteoneorbitevery90minutes
- Thelargemajorityofsatellitesareinlowearthorbit
- TheIridiumsystemutilizesLEOsatellites(780kmhigh)
- The satelliteinLEO orbitisvisible toa pointonthe earthforaveryshorttime



Orbit Type	Height	Period
LEO - Low Earth Orbit	500-1000 Km	1.6 to 1.8 hrs
MEO - Medium Earth Orbit	8,000 to 12,000 km	approx. 6 hrs (at 10,000 km).
GEO - Geostationary	approx. 36,870 km	approx. 24 hrs

Figure5.8LEO,MEO&GEORange

MEO:*MediumEarthOrbit*satelliteshaveorbitalaltitudesbetween3,000and30,000km. Theyarecommonlyusedin navigationsystemssuchasGPS.

GEO:*Geosynchronous(Geostationary)EarthOrbit*satellitesarepositionedovertheequator. Theorbitalaltitudeisaround30,000-40,000km

- Thereisonlyonegeostationaryorbitpossiblearoundtheearthlyingontheearth'sequatorialplane.
- The satelliteorbitingatthe same speedasthe rotationalspeedofthe earthonitsaxis.
- They complete one orbit every 24 hours. This causes the satellite to appear stationary withrespect to a point on the earth, allowing one satellite to provide continual coverage to a givenareaontheearth's surface.

- One GEO satellitecancoverapproximately1/3oftheworld'ssurface.Theyare commonlyusedincommunicationsystems.

Advantages:

- Simplegroundstationtracking.
- Nearlyconstantrange
- Verysmallfrequencyshift

Disadvantages:

- Transmissiondelayofthe orderof250msec.
- Largefreespaceloss.
- Nopolar coverage

Satelliteorbitsintermsoftheorbitalheight: Accordingtodistancefromearth:

- GeosynchronousEarthOrbit(GEO) ,
- MediumEarthOrbit(MEO),
- LowEarthOrbit(LEO)

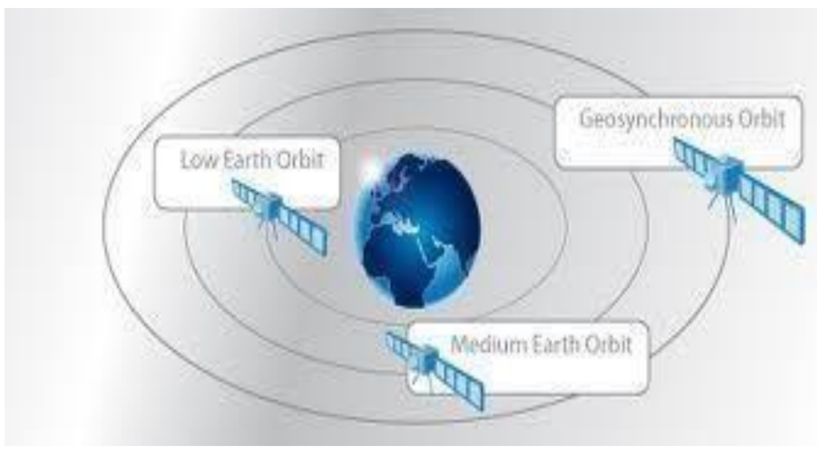


Figure5.9LEO,MEO&GEOOrbits

GEO: 35,786 km above the earth, MEO: 8,000-20,000 km above the earth & LEO: 500- 2,000 km abovetheearth.

SatelliteNavigationalSystem

A **satellite navigation** system is a system that uses satellites to provide autonomous geo-spatialpositioning.Itallowssmall electronic receiversto determine their location(longitude, latitude, and altitude/elevation) to high precision (within a few centimeters to meters)using time signals transmitted along a line of sight by radio from satellites.Thesystem can beused for providing position, navigation or for tracking the position of something fitted with areceiver. The signals also allow the electronic receiver to calculate the current local time to highprecision, which allows time synchronization. These uses are collectively known as Positioning,Navigation and Timing (**PNT**). Satnav systems operate independently of any telephonic or internetreception, though these technologies can enhance the usefulness of the positioning informationgenerated.

A satellite navigation system with global coverage may be termed a **global navigationsatellite system** (**GNSS**). As of October 2018, the United States' Global Positioning System (GPS)and Russia'sGlobalNavigationSatelliteSystem(GLONASS)arefullyoperationalGNSSs,with China's BeiDouNavigation Satellite System (BDS) and the EuropeanUnion'sGalileoscheduledtobefullyoperationalby2020.

India hasthe IndianRegionalNavigationSatelliteSystem (IRNSS),alsoknownasNavigationwithIndianConstellation(NAVIC),anautonomousregionalsatellite navigationsystem that provides accurate real-time positioning and timing services, with plans to expand to aglobal version in long term. Global coverage for each system is generally achieved by a satelliteconstellation of 18–30 medium Earth orbit (MEO) satellites spread between several orbital planes.The actual systems vary, but use orbital inclinations of >50° and orbital periods of roughly twelvehours.

Bytheir roles inthenavigationsystem, systemscanbeclassifiedas:

- CoreSatellitenavigationsystems(UnitedStates),GLONASS(RussianFederation),Galileo(EuropeanUnion)andBeidou(China).
- GlobalSatelliteBasedAugmentationSystems(SBAS)suchasOmnistarandStarFire.
- Regional SBAS including WAAS (US), EGNOS (EU), MSAS (Japan)andGAGAN(India).
- RegionalSatelliteNavigationSystemssuchasIndia'sNAVICand Japan'sQZSS.
- ContinentalscaleGroundBasedAugmentationSystems(GBAS).
- RegionalscaleGBASsuchasCORSnetworks.
- Local GBAS typified by a single GPS reference station operatingReal TimeKinematic(RTK)corrections.

As many of the global GNSS systems use similar frequencies and signals around L1, many "Multi-GNSS" receivers capable of using multiple systems have been produced. While some systemsstrivetointeroperatewithGPSaswellaspossiblebyproviding thesame clock,othersdonot.

BenefitsofSNS

- EnhancedSafety
- IncreasedCapacity
- ReducedDelay
- IncreasedFlightEfficiencies
- IncreasedSchedulePredictability
- EnvironmentallyBeneficialProcedures

DirectBroadcast Satellites(DBS)

Satellites provide *broadcast* transmissions in the fullest sense of the word, because antennafootprints can be made to cover large areas of theearth. The idea of using satellites to providedirect transmissions into the home has been around for many years, and the services provided areknown generally as *direct broadcast satellite* (DBS) services. Broadcast services include audio,television,andInternetservices.

PowerRatingandNumberofTransponders

TheSatellitesprimarilyintendedforDBShaveahigher[EIRP]thanfortheothercategories, being in the range 51 to 60 dBW. At a *Regional Administrative Radio Council* (RARC)meeting in 1983, the value established for DBS was 57 dBW. Transponders are rated by the poweroutputoftheirhigh-poweramplifiers.

Typically, a satellite may carry 32 transponders. If all 32 are in use, each will operate at thelower power rating of 120 W. The available bandwidth for uplink and downlink is seen to be 500MHz.Atotalnumberof32transponderchannels,eachofbandwidth24MHz,canbeaccommodated. The bandwidth is sometimes specified as 27 MHz, but this includes a 3- MHzguard band allowance. Therefore, when calculating bit-rate capacity, the 24 MHz value is used.The total of 32 transponders requires the use of both *right- hand circular polarization* (RHCP) and*left-hand circular polarization* (LHCP) in order to permit frequency reuse and guard bands areinsertedbetweenchannels ofagivenpolarization.

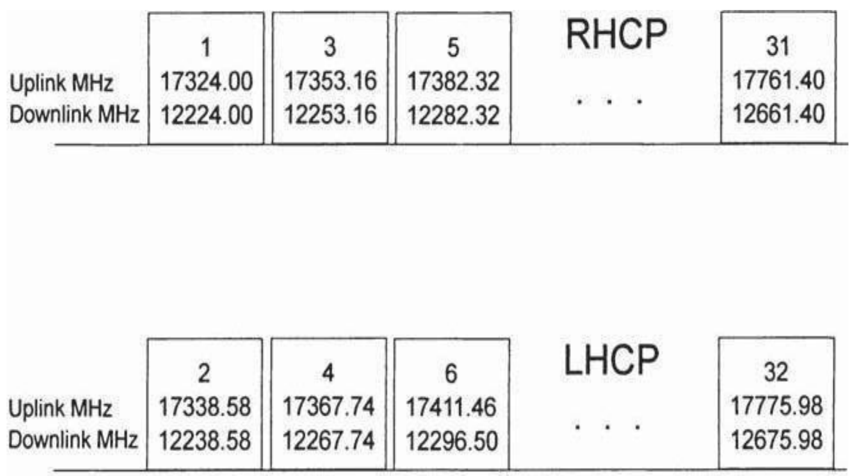


Figure5.10 DBSService

BitRatesforDigitalTelevision

The bit rate for digital television depends very much on the picture format. One way ofestimating the uncompressed bit rate is to multiply the number of pixels in a frame by the numberofframespersecond,andmultiplythisbythenumberofbitsused toencode eachpixel.

MPEGCompression Standards

MPEG is a group within the *International Standards Organization and the InternationalElectrochemicalCommission*(ISO/IEC)thatundertook thejobof definingstandardsforthetransmission and storage of moving pictures and sound. The MPEG standards currently available areMPEG-1,MPEG-2,MPEG-4,andMPEG-7.

DirectToHomeBroadcast(DTH)

DTH stands for Direct-To-Home television. DTH is defined asthereception of satelliteprogrammeswithapersonaldishinanindividualhome.

- DTHBroadcastingtohomeTVreceiverstakeplaceintheKuband(12GHz). Thisserviceisknownas DirecttoHomeservice.
- DTHserviceswerefirstproposedinIndiain1996.
- Finallyin2000, DTHwasallowed.
- ThenewpolicyrequiresalloperatorstosetupearthstationsinIndia

Within 12months of getting alicense, DTH licenses in Indiamay costabout$2.14 million andwill be valid for 10 years. Working principal of DTH is the satellite communication. Broadcastermodulates the received signal and transmitsit to the satellitein KU Band andfrom satellite onecan receive signal by dish and set topbox. A DTH network consists of a broadcasting centre,satellites, encoders, multiplexers, modulators and DTH receivers. The encoder converts the audio,video and data signals into the digital format and the multiplexer mixes these signals. It is used toprovide the DTH service in high populated area. AMulti Switch is basically a box that containssignal splitters and A/B switches. Aoutputs of group of DTH LNBs are connected to the A and BinputsoftheMultiSwitch.

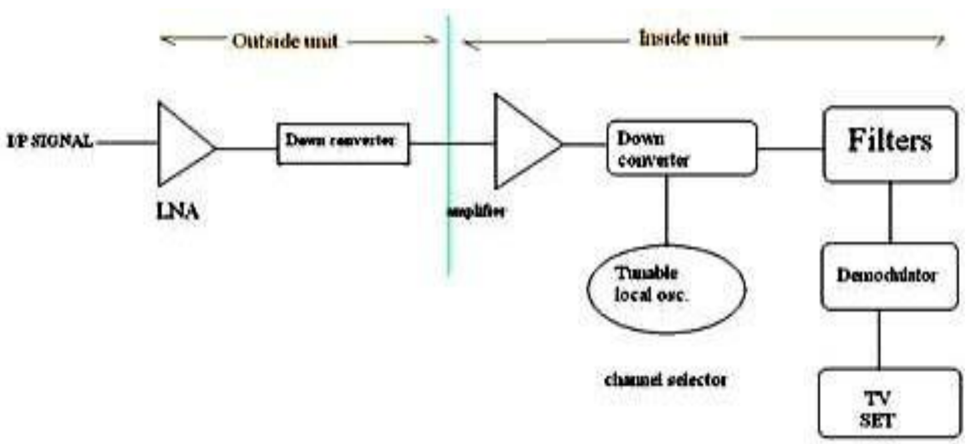


Figure5.11DTHService

- DTHalsooffersdigitalqualitysignalswhichdonot degradethepictureorsoundquality.
- It also offers interactive channels and program guides with customers having the choice toblockoutprogrammingwhichtheyconsiderundesirable.
- One of the great advantages of the cable industry has been the ability to provide local channels,but this handicap has been overcome by many DTH providers using other local channels or localfeeds.
- The other advantage of DTH is the availability of satellite broadcast in rural and semi-urbanareaswherecableis difficulttoinstall.

DigitalAudioBroadcast(DAB)

DAB Project is an industry-led consortium of over 300 companies.The DAB Project waslaunched on 10thSeptember, 1993. In 1995 it was basically finished and becameoperational.There areseveralsub-standards oftheDABstandard-

- DAB-S(Satellite)–usingQPSK–40Mb/s
- DAB-T(Terrestrial)–usingQAM–50Mb/s
- DAB-C(Cable)– usingOFDM–24Mb/s

These three sub-standards basically differ only in the specifications to the physical representation,modulation, transmission and reception of the signal. The DAB stream consists of a series of fixedlength packets which makeup a Transport Stream (TS). The packets support 'streams' or 'datasections'. Streams carry higher layer packets derived from an MPEG stream & Data sections areblocks of data carrying signaling and controldata. DAB is actually a support mechanism forMPEG. One MPEG stream needing higher instantaneous data can 'steal' capacity from anotherwithsparecapacity.

WorldSpaceServices

World Space is the world's only global media and entertainment company positioned to offer asatellite radio experience to consumers in more than 130 countries with five billion people, driving300 million cars. World Space delivers the latest tunes, trends and information from around theworldandaroundthecorner.

World Space subscribers benefit from a unique combination of local programming, originalWorld Space content and content from leading brands around the globe, including the BBC, CNN,Virgin Radio, NDTV and RFI. World Space's satellites cover two-thirds of the globe with sixbeams. Each beam is capable of delivering up to 80 channels of highquality digital audio andmultimedia programming directly to World Space Satellite Radios anytime and virtually anywherein its coverage area. World Space is a pioneer of satellite-based digital radio services (DARS) andwas instrumental in the development of the technology infrastructure used today byXM SatelliteRadio.

BusinessTelevision (BTV)-AdaptationsforEducation

Businesstelevision(BTV)istheproductionanddistribution,viasatellite,ofvideoprograms for closed user group audiences. It often has two-way audio interaction component madethrough a simple telephone line. It is being used by many industries including brokerage firms,pizzahouses,cardealersanddeliveryservices.

BTVisanincreasinglypopularmethodofinformationdeliveryforcorporationsandinstitutions. Private networks, account for about 70 percent ofall BTV networks. It is estimatedthat by the mid-1990s BTV has the potential to grow to a $1.6 billion market in North Americawith more and more Fortune1,000 companies getting involved. The increase in use of BTV hasbeendramatic.

Institution updates, news, training, meetings and other events can be broadcast live tomultiplelocations.Theexpertiseofthebestinstructorscanbedeliveredtothousandsofpeople without requiring trainers to go to the site. Information can be disseminated to all employees atonce, not just a few at a time. Delivery to the workplace at low cost provides the access to trainingthat has been denied lower level employees. It may be the key to re-training America's workforce. Television has been used to deliver training and information within businesses for more than40 years. Its recent growth began with the introduction of the video cassette in the early 1970s.Even though most programming is produced for video cassette distribution, business is using BTVtoprovideefficientdeliveryofspecializedprogramsviasatellite.

The adventof smaller receiving stations- calledvery small aperture terminals (VSATs)has made private communication networks much more economical to operate. BTV has a numberof tangible benefits, such as reducing travel, immediate delivery of time-critical messages, andeliminatingcassetteduplicationanddistributionhassles.

The programming on BTV networks is extremely cost-effective comparedto seminar feesand downtime for travel. It is an excellent way to get solid and currentinformationveryfast.Some people prefer to attend seminars and conferences where they can read, see, hear and askquestions in person. BTV provides yet another piece of the education menu and is another way toprovide professional development. A key advantage is that its format allows viewers to interactwith presenters by telephone, enabling viewers to become a part of the program. The satelliteeffectively places people in the same room, so that sales personnel in the field can learn about newproductsatthesametime.

Speed of transmission may well be the competitive edge which some firms need as theyintroduce new products and services. BTV enables employees in many locations to focus oncommon problems or issues that might develop into crises without quick communication andresolution.

BTV networks transmit information every business day on a broad range of topics, andprovide instructional courses on various products, market trends, selling and motivation. Networksgivesubscribersthe toolstoapplytheinformationtheyhave to realworldsituations.

GRAMSAT

ISRO has come up with the concept of dedicated GRAMSATsatellites,keepingin mindthe urgentneedtoeradicateilliteracyinthe rural beltwhichisnecessaryforthe all rounddevelopment of the nation. This Gramsat satellite is carrying six to eight high powered C-bandtransponders, which together with video compression techniquescandisseminate regional andcultural specific audio-visual programmes of relevance in each of the regional languages throughrebroadcastmodeonanordinaryTVset.

The high power in C-band has enabled even remote area viewers outside the reach of theTV transmitters to receive programmers of their choice in adirect reception mode with a simpledishantenna.

ThesalientfeaturesofGRAMSATprojectsare:

- Its communications networks are at the state level connecting the state capital to districts,blocksandenablingareachtovillages.
- It is also providing computer connectivity data broadcasting, TV- broadcasting facilitieshaving applications like e-governance, development information, teleconferencing, helpingdisastermanagement.
- Providingrural-educationbroadcasting.

However,theGramsatprojectshaveanappropriatecombinationoffollowingactivities.

- Interactivetrainingatdistrictandblocklevelsemployingsuitableconfiguration
- Broadcastingservices forruraldevelopment
- Computerinterconnectivityanddataexchangeservices
- Tele-healthandtelemedicineservices.

SpecializedServices

Emailservices

The addition of Internet Access enables Astrium to act as an Internet Service Provider(ISP) capable of offering Inmarsat users a tailor-made Internet connection. With Internet servicesadded to our range of terrestrial networks, we will no longer need to subscribe to a third party forInternetaccess.

WetreatInternetinthesamewayastheotherterrestrialnetworksandthusofferunrestricted access to this service. There is no time-consuming log-on procedure, as users are notrequiredtosubmitauser-IDorpassword.

DescriptionofE-mailService

Astrium's E-Mail service allows Inmarsat users to send and receive e-mail directly throughthe Internetwithoutaccessingapublic telephonenetwork.

FeaturesandBenefits

- Noneedtoconfigure ane-mailclienttoaccessaAstrium e-mailaccount
- ServiceoptimizedforusewithlowbandwidthInmarsatterminals
- Filtere-mailbypreviewingtheInboxanddeletinganyunwantede-mailspriortodownloading
- Nosurchargeormonthlysubscriptionfees
- ServicebilledaccordingtostandardairtimepricesforInmarsatserviceused.

VideoConferencing

Video conferencing technology can be used to provide the same full, two-way interactivityof satellitebroadcastatmuchlowercost.ForMulti-Sitemeetings,videoconferencingusesbridgingsystems toconnecteachsitetotheothers.

It is possible to configure a video conference bridge to show all sites at the same time on aprojection screen or monitor. Or, as is more typical, a bridge can show just the site from which apersonis speakingormakingapresentation.

The technology that makes interactive video conferencing possible, compresses video andaudiosignals,thuscreatingan image qualitylowerthanthatofsatellitebroadcasts.

SatelliteInternetAccess

Satellite Internet Access is Internet access provided through communications satellites.Modern satellite Internet service is typically provided to users through geostationary satellites thatcan offer high data speeds, with newer satellites using Ka band to achieve downstream data speedsupto50Mbps.

Satellite Internet generally relies on three primary components: a satellite in geostationaryorbit (referred to as a geosynchronous Earth orbit, or GEO), a number of ground stations known asgateways that relay Internet datato and from the satellite via radio waves (microwave), and aVSAT (very-small- aperture terminal) dish antenna with a transceiver, located at the subscriber'spremises.

Other components of a satellite Internet system include a modem at the user end whichlinks the user's network with the transceiver, and a centralizednetwork operations center (NOC)formonitoringtheentiresystem.

POSTTESTMCQ:

1. TheapplicationsofRadarsatare-
   a) Shipping&fisheries
   b) Ocean featuremapping
   c) BothShipping,fisheriesandoceanfeaturemapping
   d) NoneofothermentionedoptionsA

NSWER:c

2. Forglobalcommunication, theminimumnumberofsatellitesneededis
   a) 1
   b) 3
   c) 7
   d) 11

ANSWER:b

3. The frequencybandusedbymostsatellitesis
   a) UHF
   b) VHF
   c) SHF
   d) EHF

ANSWER:c

4. Theoptimumworkingfrequencyforsatellitesystemsliesbetween
   a) 20MHzand100MHz
   b) 2GHzand12GHz
   c) 20GHzand100GHz
   d) 100GHzand200GHzA

NSWER:b

5. TheroleofaCompanderis -
   a) Giveapoorratioofsignalto quantizingerror,forweakersignals
   b) Givepreferentialtreatmenttostronger partsofthesignal
   c) Compressesthehigheramplitudepartsof asignalbeforemodulationandexpandthembacktonormalagainafterdemodulation
   d) None of the other mentioned

optionsANSWER:c

6. InTVbroadcastviasatellitetheTVsignalfromthemainbroadcaststationisroutedtothe earthstationvia-
   a) Lowpowertransmitters
   b) Microwavelinks
   c) TVrelaystations
   d) Microwaverepeaterstations

ANSWER:d

7. Satelliteusedforintercontinentalcommunicationsareknownas
   a) COMAT
   b) DOMSAT
   c) INTELSAT
   d) EARSAT

ANSWER:c

8. Acommunicationsatelliteisarepeater between-
   a. onetransmittingandonereceivingstation
   b. onetransmittingandmanyreceivingstation
   c. manytransmittingandonereceivingstation
   d. manytransmittingandmanyreceivingstationA

NSWER:d

9. GPSsatellitesbelong tothefollowingcategory-
   a) GEO
   b) MEO
   c) LEO
   d) noneoftheabove

ANSWER:b

10. Broadcastservicesincludethefollowing-
    a) Audioservices
    b) Televisionservices
    c) Internetservices
    d) Allofthese

ANSWER:d

APPLICATIONSOFSATELLITES:

Satellites that are launched in to the orbit by using the rockets are called man-made satellites orartificial satellites. Artificial satellites revolve around the earth because of the gravitational forceof attraction between the earth andsatellites.Unlike the natural satellites (moon), artificialsatellitesareusedinvariousapplications. Thevariousapplicationsofartificialsatellites include:

1. Weatherforecasting
2. Navigation
3. Astronomy
4. Satellitephone
5. Satellitetelevision
6. Militarysatellite
7. Satelliteinternet
8. Satelliteradio.

1. Weatherforecasting

Weather forecasting is the prediction of the future of weather. The satellites thatare used topredictthefutureofweatherarecalledweathersatellites.Weathersatellitescontinuouslymonitorthecl imateandweatherconditionsofearth.Theyusesensorscalledradiometersfor measuring the heat energy released from the earth surface. Weather satellites also predict themostdangerous storms suchashurricanes.

2. Navigation

Generally, navigation refers to determining the geographical location of an object. The satellitesthat are used to determine the geographic location of aircrafts, ships, cars, trains, or any otherobjectarecallednavigationsatellites.GPS(GlobalPositioningSystem)isanexampleofnavigation system. Itallowstheusertodeterminetheirexactlocationatanywhereintheworld.

3. Astronomy

Astronomy is the study of celestial objects such as stars, planets, galaxies, natural satellites,comets, etc. The satellites that are used to study or observe the distant stars, galaxies, planets, etc.are called astronomical satellites. They are mainly used tofind the newstars, planets, andgalaxies. Hubble space telescope is an example of astronomical satellite. It captures the high-resolutionimages ofthedistantstars,galaxies,planets etc.

4. Satellitephone

Satellitephoneisatypeofmobilephonethatusessatellitesinsteadofcelltowersfortransmitting the signal or information over long distances.Mobile phones that use cell towerswill work only within the coverage area of a cell tower. If we go beyond the coverage area of acell tower or if we reach the remote areas, it becomes difficult to make a voice call or send textmessageswith themobilephones. Unlikethemobilemobiles,satellitephoneshaveglobalcoverage. Satellites phones uses geostationary satellites and low earth orbit (LEO) satellites fortransmitting the information. When a person makes a call from the satellite phone, the signal issent to the satellite. The satellite will receives that signal, processes it, and redirects the signalback to the earth via a gateway. The gateway then send the signal or call to the destination byusing the regular cellular and landline networks. The usage of satellite phones is illegal in somecountrieslike Cuba,NorthKorea,Burma,India,andRussia.

5. Satellitetelevision

Satellite television or satellite TV is a wireless system that uses communication satellites todeliverthe televisionprogramsortelevisionsignalstothe users orviewers.

TV or television mostly uses geostationary satellites because they look stationary from the earth.Hence, the signal is easily transmitted. When the television signal is send to the satellite, itreceives the signal, amplifies it, and retransmit it back to the earth. The first satellite televisionsignalwas sendfromEuropetoNorthAmericabyusingtheTelstarsatellite.

6. Militarysatellite

Militarysatelliteisanartificialsatelliteusedbythearmyforvariouspurposessuchasspyingonenemycountries,militarycommunication,andnavigation.

Militarysatellitesobtainthesecretinformationfromtheenemycountries.Thesesatellitesalsodetectthe missileslaunchedbytheothercountriesinthe space.

Military satellites are used by armed forces to communicate with each other. These satellites alsousedtodeterminethe exactlocationofanobject.

7. Satelliteinternet

Satellite internet is a wireless system that uses satellites to deliver the internet signals to users.High-speed internet is the main advantage of satellite internet. Satellite internet does not usecablesystems,butinsteaditusessatellitestotransmittheinformationorsignal.

8. Satelliteradio

Satelliteradioisawirelesstransmission servicethatusesorbitingsatellitestodelivertheinformationorradiosignalstotheconsumers.Itisprimarilyusedinthecars.Whentheground

stationtransmitsignal
tothesatellitethatisrevolvingaroundtheearth,thesatellitereceivesthesignal,amplifiesit,and redirectsthesignalback totheearth(radioreceiversinthecars).

CONCLUSION:

At the end ofthe unit,the studentswillbe ableto –

- TounderstandthevariousapplicationsofSatellites
- TounderstandthevariousapplicationsofWorldSpaceServices

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ASSIGNMENT:

1. DescribebrieflythevideocompressionprocessusedinMPEG-2.
2. Explainaboutindoorandoutdoorunitofhomereceiver.
3. Explainaboutfrequenciesandpolarization,transpondercapacityandbitratesfordigitaltelevision.
4. Explainindetailaboutsatellitemobileservices.
5. DescribetheoperationoftypicalVSAT system.StatebrieflywhereVSATsystemsandfindwidestapplications.
6. DescribethemainfeaturesofRadarsat.Explainwhatis meantbydawntoduskorbitandwhytheRadarsatfollows suchonorbit.
7. Explain why a minimum of four satellites are visible at an earth location utilizing theGPSsystemforpositiondetermination.Whatdoesthetermdilutionofprecisionreferto?