Chapter-XXII

Satellite Communication System

22.1   Very Small Aperture Terminal (VSAT) Network

22.1.1   Introduction

VSAT provides Point to Point or Point to Multi Point data connectivity using Geostationary Satellite as repeater location. As satellite is being used as repeating stations, the data originating and terminating point can be any where on the earth. VSAT networks are typically used for Video Surveillance, Video Conferencing, Consumer Internet, Point of Sale, Distance Education, Industrial ERP, Internet Kiosk etc. Railway is using them to provide data connectivity between various goods terminals and CRIS as well as for video conferencing applications. It shall also be used for Accident Site Communication for voice, data and video transmission.

22.1.2   VSAT Network Components

a)   The network works in Star as well as Mesh architecture and consists of

i)   Hub Earth Station
ii)   Remote Earth Station
iii)   Satellite Transponder & Space Link
iv)   Network Control Centre
v)   Interface Equipment

Each of above equipments has been described in detail later.

b)   At Data level, the Network uses TCP/IP for Data transmission. The Architecture of VSAT Network under development for Railways is given in Annexure-1. As can be seen all external Data Devices interact with interface units only both at Remote as well as Hub End thus making the VSAT Network system transparent to external systems. i.e. PC, Telephone through IP interface interacts with the interface unit i.e. DW 7700 at remote end. Similarly on Hub end, all external data devices interacts with Enterprise LAN level only thus making the VSAT Network transparent to external systems.

c)   At RF level, the Networks operate in 3 bands i.e. C Band, XC Band and Ku Band. Railway is using Ku band System. Ku Band system operates on up link frequency of 14.25 to 14.5 GHz and Down Link Frequency of 11.45 to 12.75 GHz. Up link frequency is the carrier frequency on which Hub or remote earth station transmits the Signal to Satellite. Down Link Frequency is the Carrier

frequency on which Satellite transmits the Signal to Hub or remote earth station.

22.2   Hub Earth Station

22.2.1   This station is Heart of the entire Network. The communication between remotes or remote to external networks is established through Hub Earth Station only. It is responsible for collecting the data from enterprise LAN's, Address Translation, converting data into IF and RF Signals and transmitting them to Satellite and further to remote earth stations, maintaining the integrity checks for all remote earth stations, time synchronization for all remote earth stations, tracking of Satellite, converting the RF received from Remote to Data Signals in appropriate format to be delivered at Enterprise level etc.

22.2.2   The Hub Earth Station consists of following

22.2.3 Antenna Sub Systems: It consists of 9 meter (or above) Cassegrain feed, parabolic reflector, Sub Reflector, Low Noise Amplifiers and its integration modules like Cables, Wave Guides, Connectors, Dehydrators, Tracking Mechanisms etc. This system should have clear line of sight availability towards the satellite. The Antenna Control system can position the Antenna any where in vertical and horizontal plane thus taking care of Satellite drifts as well as change of Satellite.

22.2.4   RF Sub System: It converts the IF Signals of 70 MHz typically to RF frequency signals suitable for Satellite transmission. It also amplifies the Signal for transmission to Satellite.

22.2.5   IF Sub System: The Modulated base band signals are first converted to IF Signals and also amplified here before they are fed to RF Sub Systems.

22.2.6   Base band Equipment: This sub system consists of elements for interacting with interface devices, time synchronization, modulating the data signals for transmission, demodulating the signals received, address translation, interacting with Network Monitoring Systems. All sub systems here work on proprietary software. Few Sub systems work on proprietary hardware also. Therefore, these equipments are highly Vendor specific.

22.2.7   Network Monitoring Systems: It is a high end Server. This equipment also works on proprietary software. The network is managed as well as configured using this system only. All history and configuration data is kept in Open End RDBMS. In Railway Network, they are kept in Oracle Enterprise. The system also provides SNMP (Simple Network Management Protocols) traps for all the devices working on IP. These traps can be used by Open End Software like HPOV etc which can generate many configurable reports for management purposes.

22.2.8   A typical Network Components for the Railway Hub under Construction is given in Annexure-2.

22.3   **Space Link i.e. Satellite**

22.3.1   The VSAT communication depends entirely on Satellite. A satellite is a nothing but a microwave repeater in Geo synchronous orbit above the earth. All Hub and Remote Earth Equipment communicates via Satellite.

22.3.2   A typical Block Diagram of Satellite is shown in Annexure-3.

22.3.3   Satellites are of different types namely

   i)   Communications Satellites (Used for VSAT Network)
   ii) Weather Satellites
   iii) Remote Sensing Satellites
   iv) Science Research Satellites
   v)   GPS Satellites

22.3.4   Two elements which are common to all the four types of satellites are

   PAYLOAD - Equipment a satellite needs to do its job. Include antennas, cameras, radar and electronics. Payload is different for every satellite. For Example, payload for a weather satellite includes cameras, while payload for a communication satellite includes antennas.

   BUS - Part of the satellite that carries the payload and its equipment into space. It holds all the satellite parts together and provides electrical power, computers, and propulsion to the spacecraft.
   It also contains equipment that allows the satellite to communicate with earth.

22.3.5   Satellites rotate around earth in orbits. The different types of orbits are Equatorial Orbit, Polar Orbit, Inclined Orbit and Elliptical Orbit. The time of travel around earth is dependent on the distance of Satellite from earth. At altitude of 22300 miles, the Satellite takes exactly 24 hours to circle around earth. All orbits at this altitude are called Geosynchronous Orbits. If the Satellite is in Equatorial Orbit at the altitude of 22300 miles and is rotating in the same direction as of earth, it will be stationary with respect to earth. All communication Satellite use geosynchronous orbits only to avoid the need for realigning the Antenna.

22.3.6   Three geo synchronous satellites can be used for full earth coverage. The transmission of a signal up to the satellite and back down is called a hop. Transmission delay for one hop is between 240msec. and 270msec.

22.3.7   One geo synchronous satellite can transmit to approximately 42% of the earth's surface. North and South poles cannot receive signals from a geo synchronous satellite. The area covered by a single satellite antenna is called a "footprint". Annexure-4 indicates the footprint of one of the Satellites.

22.3.8   The Satellite position changes due to solar and lunar gravitational pull. The Satellite owner needs to monitor the position of satellite at all times and correct for satellite drift. The tracking mechanisms are therefore provided in the Hub equipment Antenna Sub Systems to take care of this drift.

22.3.9   The Satellite uses different types of beams for communicating with Earth Stations. The beams used are - GLOBAL BEAM: covering 42% of earth surface. Beam width 18degree, DUAL SPOT BEAMS,- MULTIPLE SPOT BEAMS,- DUAL POLARIZED SPOT BEAMS

22.3.10 Polarization of Electro Magnetic waves is used by Satellites to increase the channel capacity as multiple signals can be transmitted at same frequency. The Polarization used by Satellites is linear or Circular. Every Earth Station has to be configured to work on the Polarization being used by Satellites.

22.3.11 The Up link and Dn Link Frequencies which are in use in different bands are as under

UPLINK FREQUENCIES	DOWNLINK FREQUENCIES	BAND S
5.925-6.425 GHz	3.700-4.200 GHz	C
6.725-7.025 GHz	4.5-4.8 Ghz	Ext. C
14.25-14.50 GHz	11.45-11.7GHz	Ku (IN INSAT-3B)

22.3.12 Railways is using Ku Band for their VSAT Network which will work on INSAT 4C-R

22.3.13 The transponders provide the frequency space on Satellite. Each transponder is of 36 MHz. Different Satellites carry different number of transponders. A fraction of transponder can be used. Railway is hiring 9 Mhz frequency space on INSAT 4C-R for their VSAT Network.

22.3.14 VSAT Network operator has to divide the hired transponder space into Transmit and Receive Segment. As the transmission power of remote earth station is limited, their requirement of frequency spectrum is limited but higher number of smaller bands are required to cater for large number of remote stations. While one bigger band is required at transponder for

signal transmitted from Hub as it is high power signal and contains data for all remotes.

22.3.15 To adjudge the availability of Satellite communication, a link budget calculation is done taking the least available Satellite Power, Antenna Size, transponder sizing for receive and transmit segments etc.

22.3.16 All transponder space is allocated by Department of Space.

22.4 Remote Earth Station

22.4.1 Remote Earth Station consists of

i)   A Parabolic Antenna 1.2 or 1.8 Meters of Size for Ku band system and 3.2 to 3.8 meter size for C and XC band system with Feed for transmit Signals.
ii)   An outdoor unit called ODU and Low Noise Amplifier for received signal.
iii)   Indoor Unit
iv)   Power Supply Arrangements
v)   Protection and Earthing Arrangements

22.4.2 Indoor Unit interact with the Antenna System as well as external data devices through Ethernet LAN ports. A typical remote earth installation over Railway has been shown in Annexure-5.

22.4.3 All remote installations require feeding of latitude and longitude information which determines its location with respect to Satellite as well as Hub Earth Station.

22.4.4 The supported rates for data transmission in up-to 1 MBPS as per the guidelines of DOT.

22.4.5 The protocol and encryption used for transmission of Data between Hub and Remote station is usually proprietary items and therefore, the Hub and Remote devices have to be of same Vendor. As these are proprietary devices, the features supported by them differ from make to make. The features supported by the remote installed on Railway System are given in Annexure-6.

22.4.6 As these devices use proprietary protocol as well as encryption, the communication is highly secure.

22.5 Interface Equipment

22.5.1 The VSAT Network is interfaced with the external data devices by using Router or Router Switch combinations at Hub Earth Stations. At Remote Station, Ethernet LAN output is provided as standard interface. This can directly be connected to any device having Ethernet interface.

22.5.2   The applications Servers like FOIS Server of Railway, IP Exchange for Voice Networks and MPEG Server for Video Streaming applications and Web Servers for providing Internet application have to be interfaced with VSAT network through a router switch combination only.

22.6   **Network Control Center**

22.6.1 Network Control Center is responsible for administering and managing the whole of the VSAT Network as well as each of the application working on the Network. This is carried out through Network Management System specific to Network as well as using other tools mostly SNMP based.

22.6.2 This Center also generates various analysis reports not only for Network part but for day to day operation of each of application running on the Network.

22.6.3   One of the most important parameters is analyzing the traffic flow and taking corrective actions for optimum working of all applications. This has been described in detail in Bandwidth Management para.

22.6.4 This Center also tracks the performance of all the remote sites connected and get them attended in case of any fault.

22.7 Bandwidth Management

22.7.1   Management of Bandwidth is a very important parameter on VSAT networks as the cost of Bandwidth on Satellite is very high.

22.7.2 C and XC Band VSAT Networks worked on principles of dedicated bandwidth allotment for each application. The utilization of bandwidth in such systems was poor as most of the data devices remain dormant for considerable period.

22.7   .3   Ku Band VSAT Networks work on Shared bandwidth principles. Here only priorities and grouping of traffic can be defined. Priorities can be defined for a group consisting of Data Transmitting device, Data Receiving Device etc. With in the group each member will have an equal right for the bandwidth. Therefore as more and more member of the group become active, each one will get lesser bandwidth. As more and more member become dormant, the available bandwidth for the remaining members will be higher. Priorities can be set for different groups based on sensitivity of applications. Therefore a high priority group will get precedence for bandwidth allocation than a lower priority group. This results in a very effective utilization of Bandwidth.

22.7.4   Packet Shaper Software is used for management of bandwidth in transmit path. While it can be managed using Network Management System tool in receive path.

22.8   **Miscellaneous**

22.8.1   The performance of VSAT equipment both at Hub Earth Station and Remote Earth Station is affected by ambient conditions.
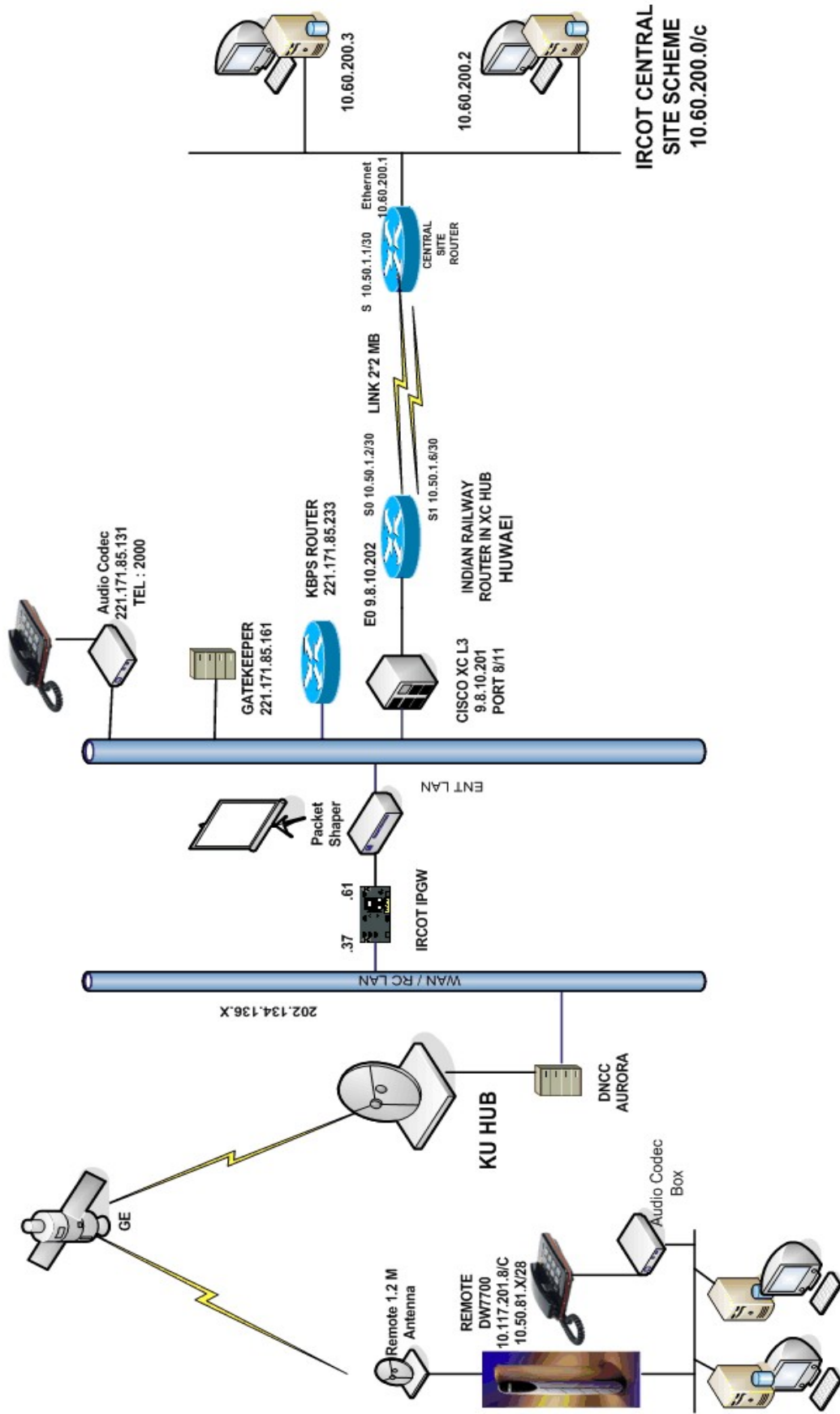
22.8.2 Hub Equipment generates a very high amount of heat. Continuous heat dissipation and marinating Normal temperature is an extremely important consideration for proper functioning of VSAT Hub Equipment.

22.8.3 Some of the important items which are considered necessary for proper functioning of Remote Earth Station are as given below

    i)   Maintain the Room Temperature.
    ii)   Use On line UPS.
    iii)   Good Quality Earthing to be maintained.
    iv)   Dust free environment to be maintained
    v)   Sufficient air circulation & access to Indoor Unit be there
    vi)   Switch on the VSAT first and then switch on other accessories
    vii)   Follow the Switch on Sequence strictly
    viii) Report any Problem related to any equipments to Hub
    ix)   While doing so report full Problems and complete observations to Hub
    x)   Use the Computer only for Intended applications
    xi)   Make Sure your Computers are Virus FREE
    xii)   Log all activities related to equipment failures & Engineer visits in a Log Book
    xiii)   Allow authorized and Trained People only to operate the system.
    xiv)   Do not switch on the VSAT immediately after switch off.
    xv)   Do not Move the Indoor Unit after installation.
    xvi)   Do not keep any article on Indoor Unit.
    xvii) Do not obstruct the air vents in front of the Indoor Unit.
    xviii) Do not Use air cooler (water) for cooling.
    xix)   Do not Bend IFL cable
    xx)   Do not use the PC for any other application
    xxi)   Do not do any local servicing of the equipments
    xxii) Do not shift the equipments from one place to another in absence of trained persons
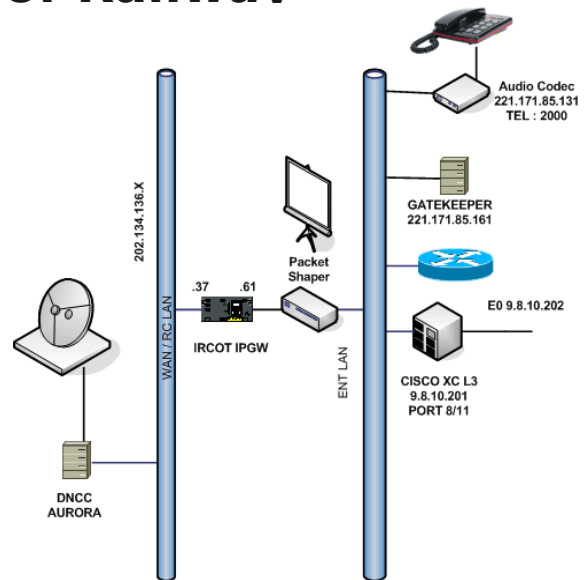   xxiii) Do not load any software programs on the PC except the application

Annexure 1

IRCOT CENTRAL SITE SCHEME
10.60.200.0/c

10.60.200.3

10.60.200.2

Ethernet
10.60.200.1

CENTRAL
SITE
ROUTER

S 10.50.1.1/30

LINK 2*2 MB

S0 10.50.1.2/30   S1 10.50.1.6/30

KBPS ROUTER
221.171.85.233

INDIAN RAILWAY
ROUTER IN XC HUB
HUWAEI

E0 9.8.10.202

CISCO XC L3
9.8.10.201
PORT 8/11

Audio Codec
221.171.85.131
TEL : 2000

GATEKEEPER
221.171.85.161

ENT LAN

Packet
Shaper

.61

.37   IRCOT IPGW

WAN / RC LAN

202.134.136.X

KU HUB

DNCC
AURORA

GE

Remote 1.2 M
Antenna

REMOTE
DW7700
10.117.201.8/C
10.50.81.X/28

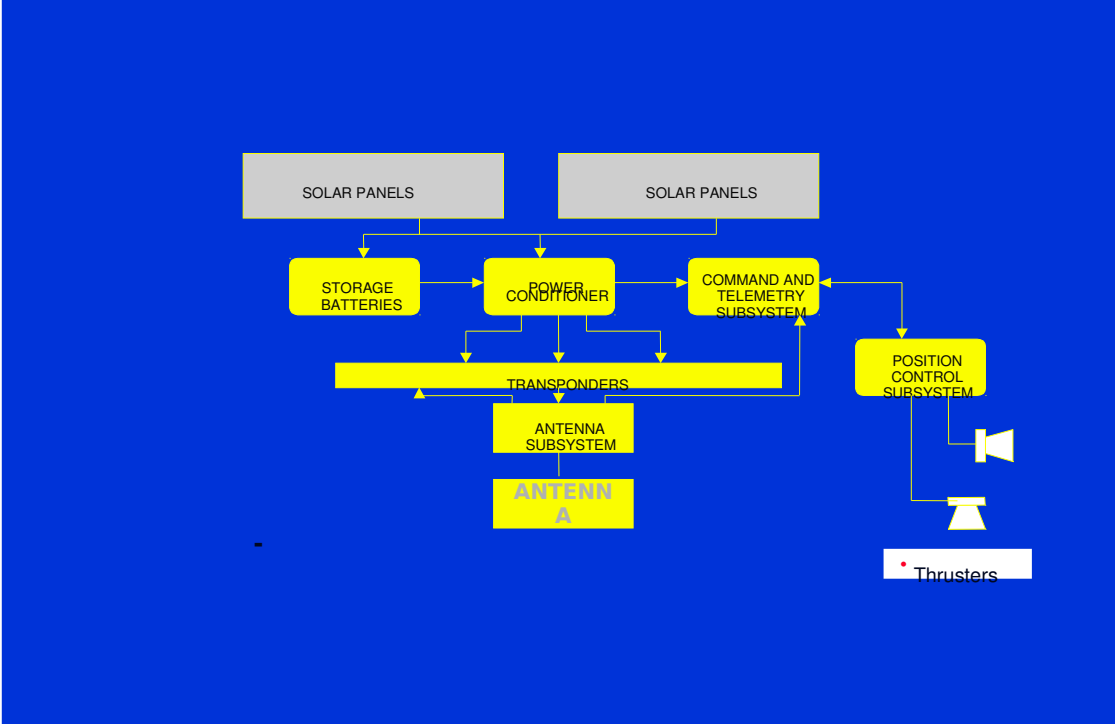Audio Codec
Box

PREPARED BY: HUB Engineering Group

Network Component Details
HUB Configurations of Railway

HUB LAN would consists of Following
1.DNCC : BA Allocation
2.IPGW : Packet Switching
3.Packet shaper : Monitor and Control
4.Gatekeeper : Call Setup
5.Audio Codec With phone : Test Call
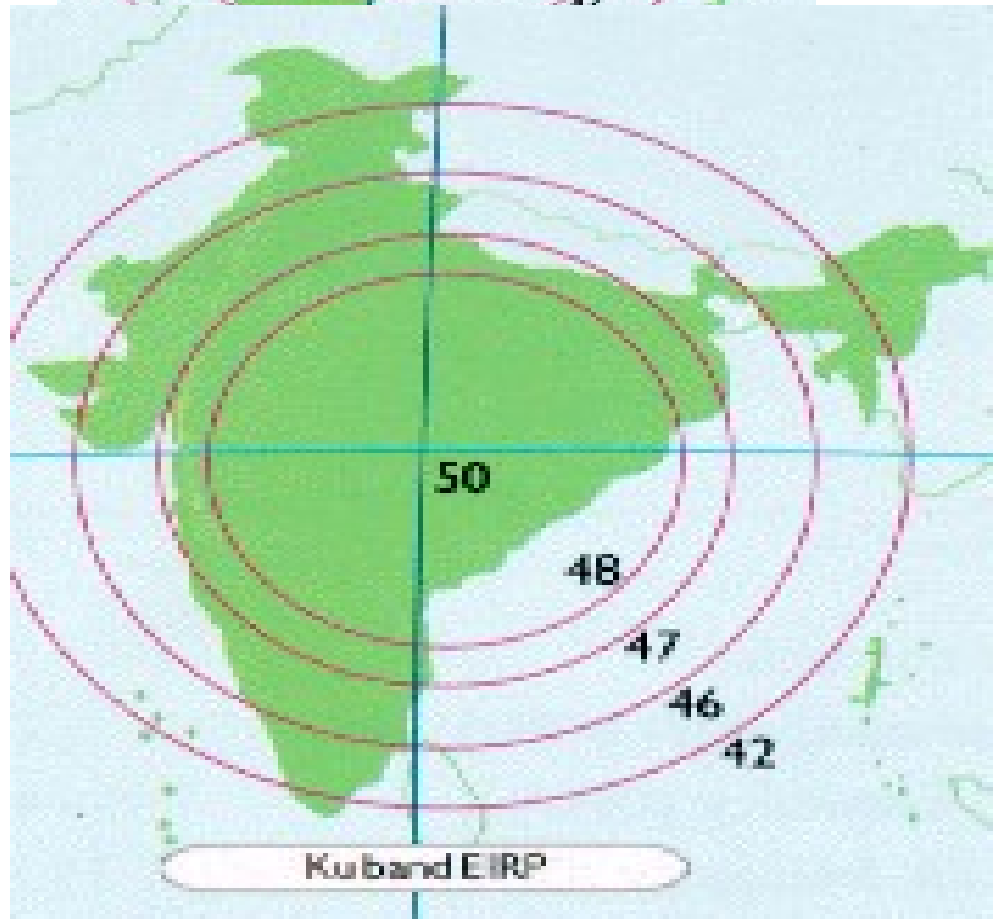**6.Cisco L3 : Route Traffic towards Central Site**

Audio Codec
221.171.85.131
TEL : 2000

GATEKEEPER
221.171.85.161

Packet
Shaper

202.134.136.X

WAN / RC LAN

.37   .61

IRCOT IPGW

ENT LAN

E0 9.8.10.202

CISCO XC L3
9.8.10.201
PORT 8/11

DNCC
AURORA

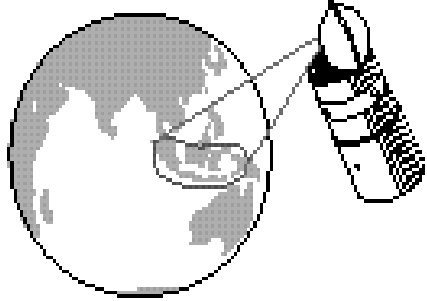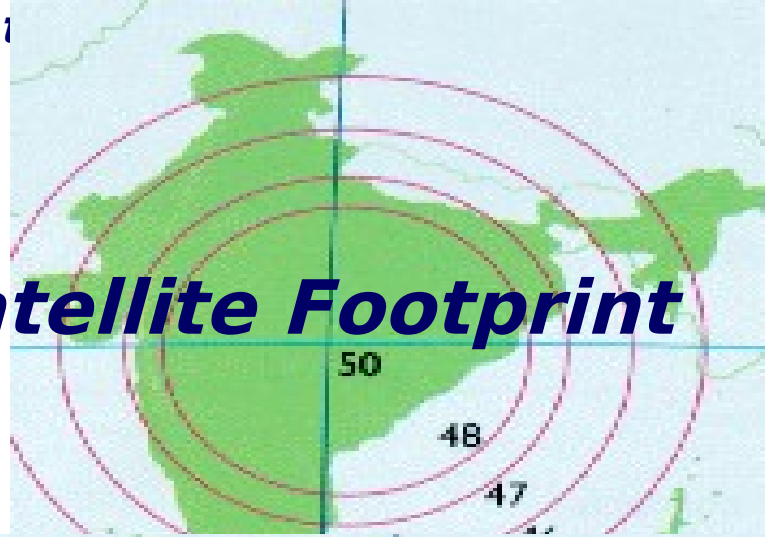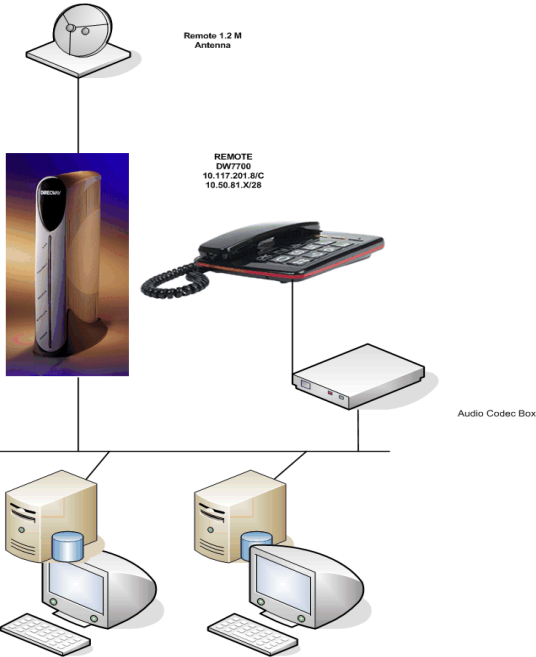# <u>Satellite Block Diagram</u>

Satellite Footprint

Network Component Details Remote Configuration

IRCOT Remote LAN consists of following:

1. Remote 1.2M Antenna
2. DW7700 IDU Unit
3. Remote Computers running Applications
4. Audio Codec Box
5. Telephone for Voice Connectivity

Remote 1.2 M
Antenna

REMOTE
DW7700
10.117.201.8/C
10.50.81.X/28

Audio Codec Box

<u>Remote Indoor Unit HN7700 Platform</u>

- ❖ **Inbound HIS 512Kbps / 1Mbps**
- ❖ **MPLS QoS**
- ❖ **DHCP server and relay support**
- ❖ **IGMPv2 for multicast to LAN**
- ❖ **VLAN Tagging**
- ❖ **ICMP support (pings, etc.)**
- ❖ **Embedded web server for remote status query and configuration**
- ❖ **NAT/PAT**
- ❖ **RIP V2**
- ❖ **DNS caching and preload**

- ❖ **Inroute IP header compression**
- ❖ **RTP header compression**
- ❖ **PEP and inroute prioritization**
- ❖ **PEP and TCP payload compression**
- ❖ **Secondary satellite frequency support**
- ❖ **CBR support for real-time applications**
- ❖ **VADB**