SVF Satellite. Solutions. The World.

MahdiBagh COMPUTERS PVT. LTD. MBC

ITU Satellite Symposium - Geneva, Switzerland
28th to 30th November 2018

NEW SYSTEM TECHNOLOGIES

SATELLITE FOR BROADBAND SERVICE:

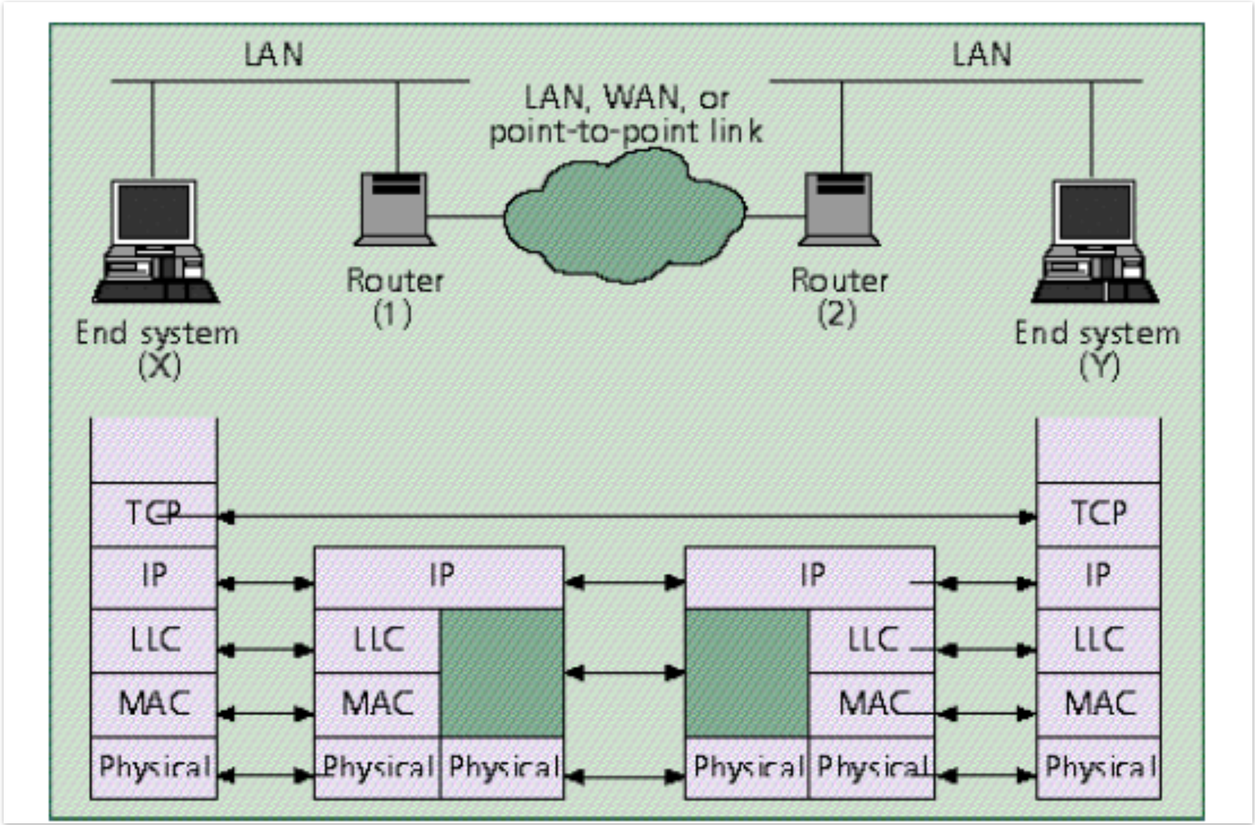
- “Broadband for All”, “Bridge the Digital Divide”- between urban, remote and rural.
- Consumer driven demand for broadband anywhere on any device.
- Broadband centric business and applications have grown everywhere.
- Affordable access to Internet – Satellites have the potential to enable equitable access.
- Challenges of broadband deficit through satellite access met through Geo as well as Non-Geo systems.
- Modern broadband applications are based on distribution of information to widely dispersed sites.
- Satellites are effective in this, especially for video links between multiple users.

HIGHER LAYER PROTOCOLS(TCP/IP) OVER SATELLITES:

TCP/IP: Internet is based on the protocol suit – Transport Control Protocol/Internet protocol. This protocol development took place without consideration for the long delay in the satellite links. It needs enhancement to carry larger data rates over GEO satellites.

INTERNET PROTOCOL: IP is a network layer protocol to permit exchange digital data between different transport mechanisms.

IP resides in the terminal devices and in routers which function as switches in the network. Which functions as switches in network routing packets towards their destination based on an address field in the datagram.



Different networks have their own address standards. For example:

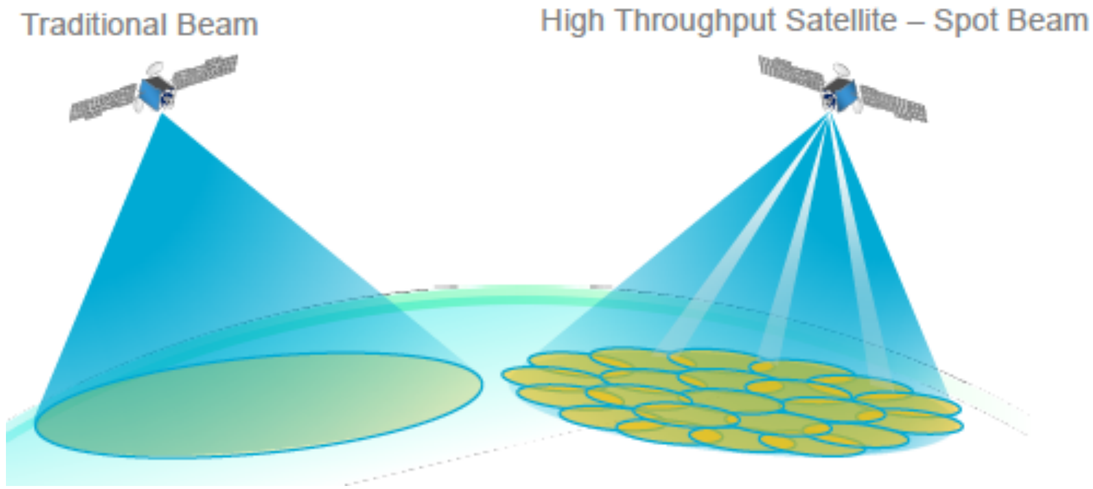
- IEEE LAN standard address attached devices with 16 or 48-bit binary addresses. An X.25 public packet-switching network uses 12-digit decimal addresses.
- The function of IP is to translate these different addressing schemes and provide a global scheme & directory service.
- Routers have another function of handling the size of packets in different networks – X.25 packets have max. size of 1000 bytes, Ethernet permits packets of 1500 bytes.
- The router breaks these datagrams into smaller packets(known as fragmentation) and get them reassembled when they reach their destination.
- IP protocol operation face a few situations like delays due to different paths the packets take, buffer size to handle the volume when they arrive, errors caused in the network.
- IP protocol does not guarantee delivery but engineered to make a best effort to deliver a message.

Transport Control Protocol (TCP):

- TCP protocol resides in the end device(computers) to ensure proper delivery of a completed message.
- Each byte of information is tagged with an unique number, the receiver keeps track of these numbers and sends acknowledgements(ACKS) to indicate that it has received each datagram up to a particular byte number.
- The TCP protocol with the set window size for sending data and the acknowledgement receipt for the packets finds constraints in handling larger data sizes.
- GEO satellite links with round trip delay of 600 ms and hence in the data acknowledgement TCP encounters problem in providing the throughput.
- To overcome this problem a method called “spoof” is used in TCP protocol which resides only in the user’s computer. Along with another change in the size of the window for sending data the throughput that can be achieved in the GEO delay path is enhanced to meet the high data rate requirement for applications.

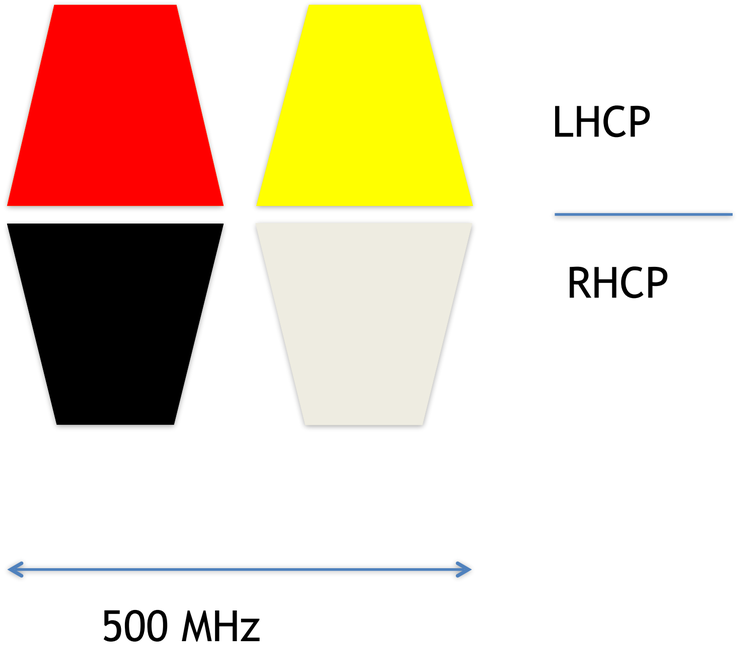
High Throughput Satellites(HTS)- Broadband Connectivity

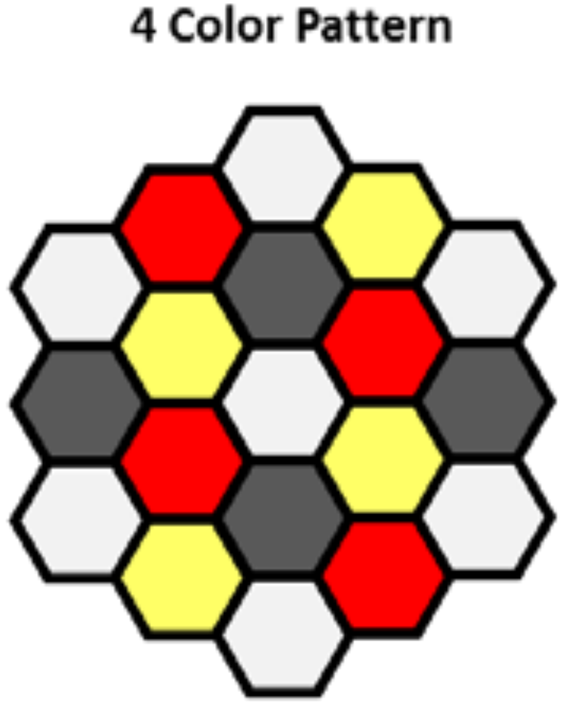
- Traditional satellites typically have capacity below 1 Gbps and deliver low data rate.
- HTS satellites use a large number of spot beams over a particular area and re-use the allocated frequency multiple times to increase the throughput several times.
- Spot beams provide high signal strength and signal gain(EIRP and G/T) for the small aperture terminals on ground.



Frequency and Polarisation – 4 colour re-use pattern

- Typically partition the available spectrum into smaller channels where each beam uses only one of the channels, thus allowing beams to be geographically adjacent without interfering

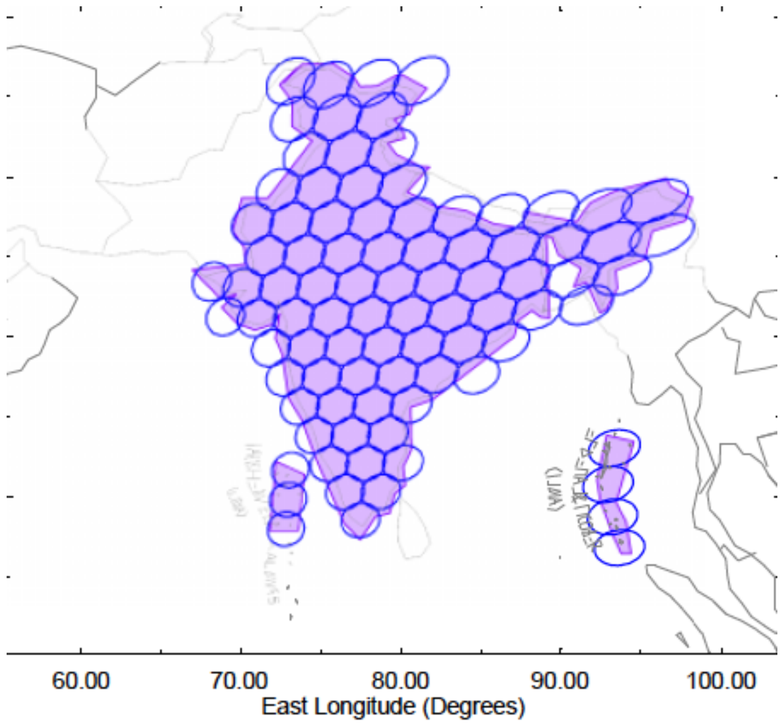




Capacity:

- A typical coverage of Indian geographical coverage using multiple spot beams

- With the allocated frequency spectrum of 500 MHz and “4 colour” system a frequency re-use more than 20 times achieving 10 GHz of capacity



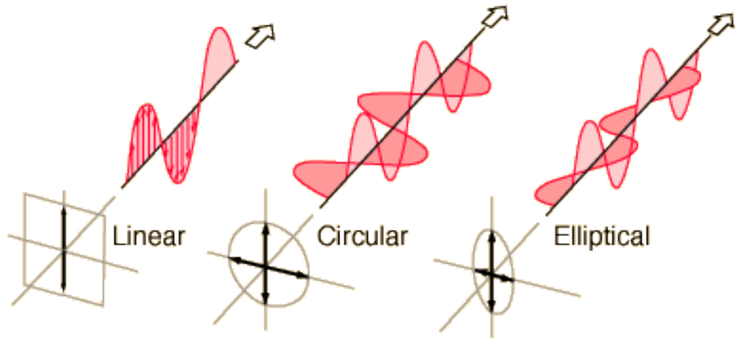
Electromagnetic wave consists of two fluctuating fields – one electric (E) and the other magnetic (B)

The two vectors are in phase and are at right angles (orthogonal) to one another , and are both perpendicular to the direction of travel..

POLARIZATION

Polarization of the radio wave is determined by the orientation of the electric vector at a fixed point in space.

The direction of the electric vector determines the sense of linear polarization.

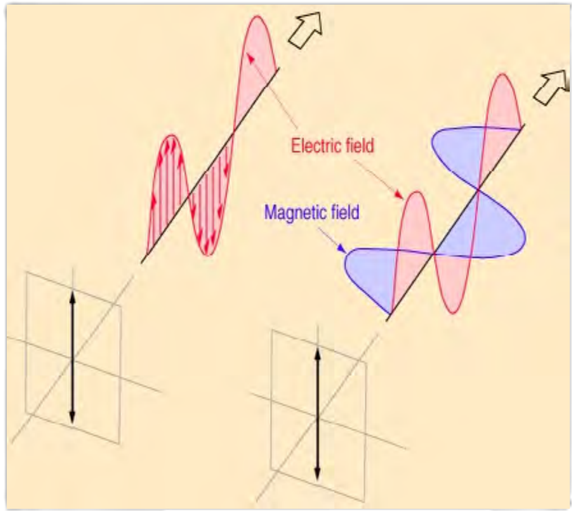


Radio Wave Propagation

LINEAR POLARIZATION

A linear polarization wave is a wave whose electric vector always lies along a fixed direction at a point in space as a function of time.

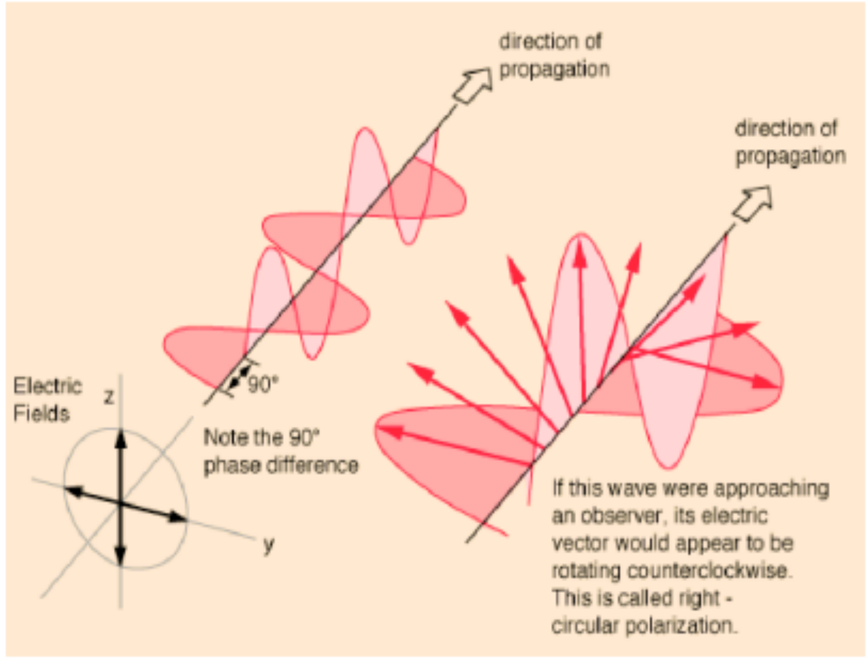
A horizontal electric vector results in horizontal polarization and a vertical electric vector results in vertical polarization.



Polarization

If instead of being confined to fixed direction, E rotates in the x-y plane with constant amplitude, it is said to be circularly polarised (either right- or left-hand circular (clockwise/anti-clockwise respectively)

Circularly polarised light consists of two perpendicular EM plane waves of equal amplitude and 90° difference in phase. The light illustrated is right-hand circularly polarised



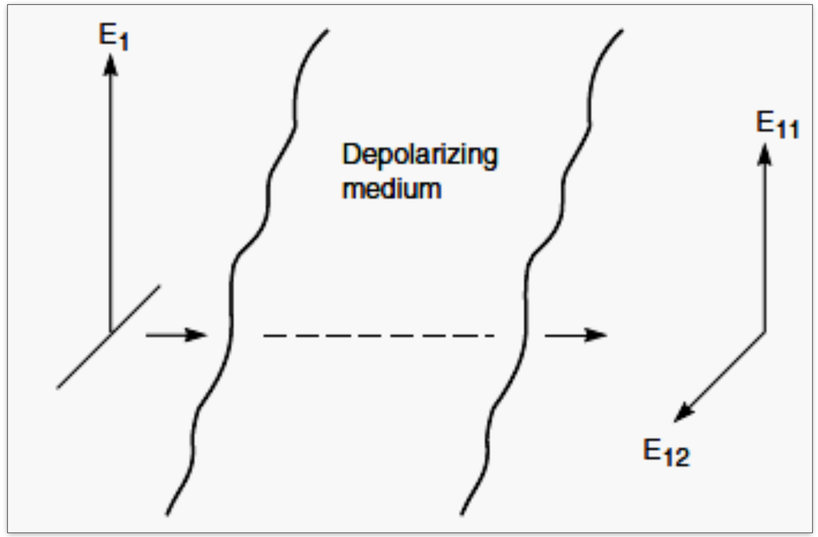
POLARISATION DISCRIMINATION:

- Depolarisation effect caused by: propagation path through ionosphere, cloud, rain, rain crystals etc.
- At the receiving end of the antenna the electric filed may have two components – Co-polar component and Cross-polar component.
- Cross Polarisation Discrimination (XPD) is the ratio of the amplitude of these two components.

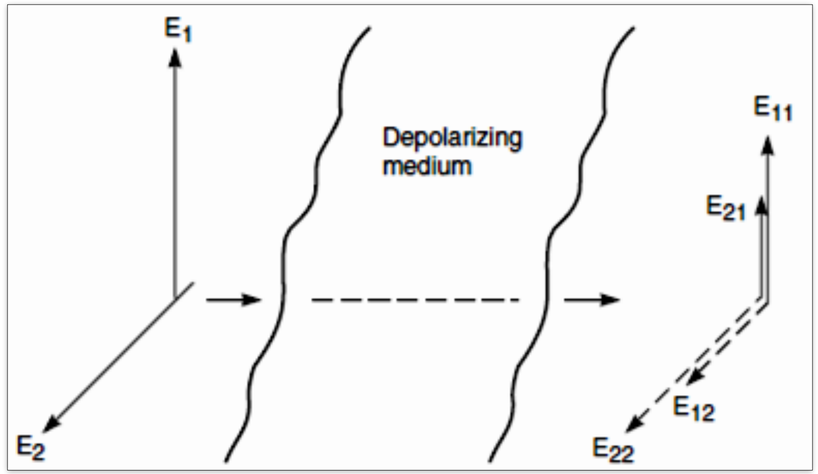
POLARISATION ISOLATION:

- In dual polarisation transmission the two orthogonally polarised signals carrying the information the medium depolarises both the component signal.
- The polarisation isolation is defined by the ratio of the received co-polar power to the received cross-polar power.

Vectors – Cross Polarisation Discrimination



$XPD = 20 \log E_{11} / E_{12}$

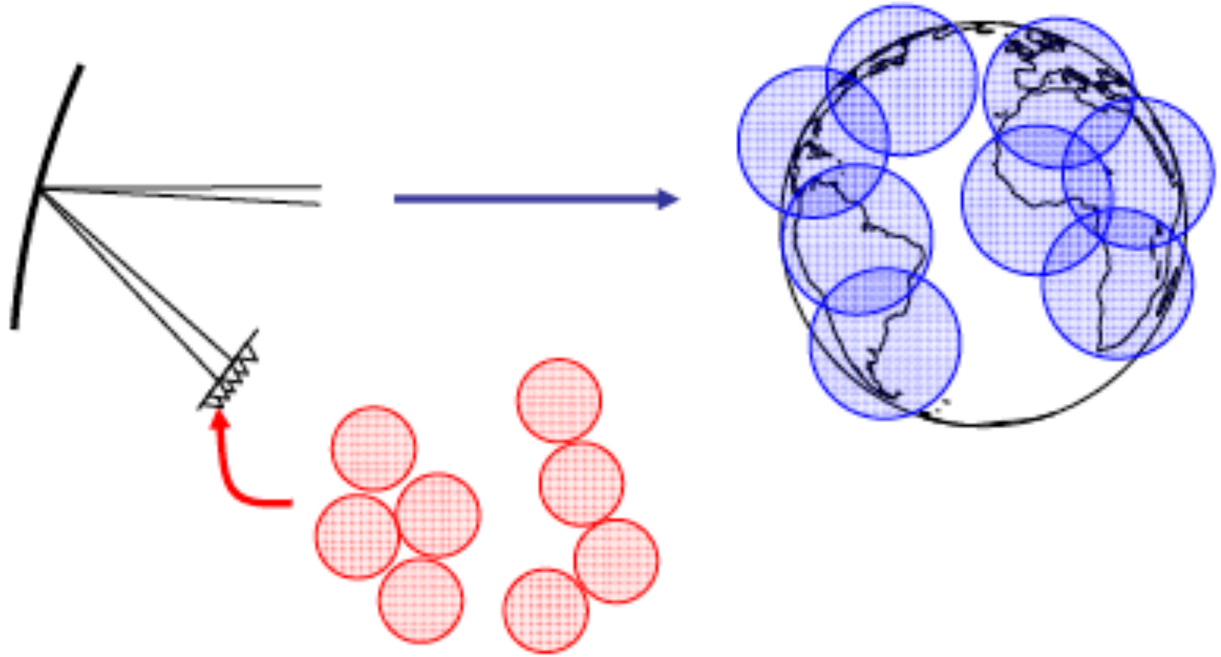


Vectors - Cross Polarisation Isolation

$I = 20 \log E_{11} / E_{12}$

Multiple Beams:

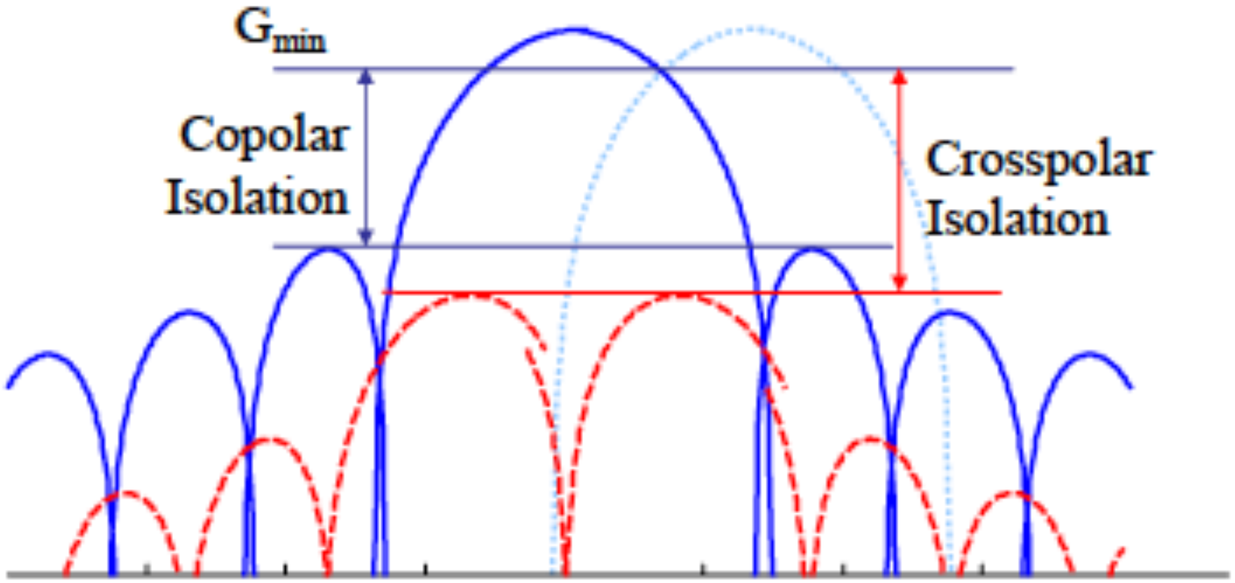
- With finite power capacity increase obtained by smaller beams to cover same area.
- Beams provide spatial diversity.



Isolation

Signals falling in the frequency band allocated to one beam and coming from others are an interference.

Beam orthogonality (spatial and polarisation diversity) requires some level of decoupling (isolation) among beams.



❖ HTS FACTS:

- HTS systems combine spectrum efficiency and performance of spot-beams to provide enhanced levels of bandwidth and throughput.

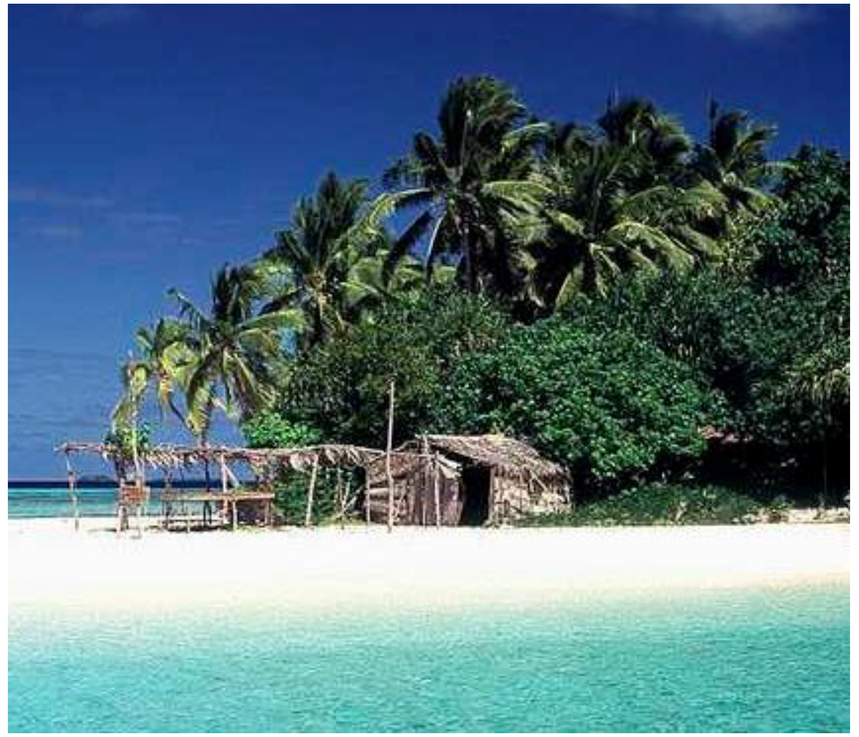
- A single HTS can provide 10 times the capacity of traditional satellites.

  - High data rate to a single site and improve application performance
  - Spot beams - 3dB beam widths between 0.5 and 1.5 degrees.
  - Number of beams 10 to 100 or more
  - Capacity generation – payload bandwidth of 5 to 10 GHz
  - Spot beams may be steered or fixed relative to the satellite
  - HTS systems have special Gateway beams and transponders to support connections with teleports.
  - HTS systems have resulted in a new generation of VSAT networking experience ,enabling better economics and higher performance broadband service capabilities.

❖ Broadband Internet Access - Remote Community

WiFi Hotspot terminals , Solar Powered Devices

- Connected Schools
- Extended Mobile Networks
- Connectivity to Islands
- Telemedicine Applications



SATCOM APPLICATIONS

TELE-HEALTH

- Tele-medicine allows for consultation with specialists and expert doctors for a patient in rural and inaccessible areas to get the same health facility as an urban area.
- Mobile VSAT vans are used for conducting health camps, specially for diabetology, ophthalmology, and cardiology.

TELEMEDICINE MULTIMEDIA:

- Requires very high bandwidth to provide timely transmission of large data sets.
- Hospital data encompasses the totality of voice, video and data. Diagnostics are rich in images.
- Data sets use long frames for efficiency, but bit errors in transmission can become frame errors.
- Scope of containing image file size is limited.

	Resolution	Intensity	Images per exam	File size (MB)
MRI	256 x 256	12	20	2
Ultrasound	512 x 512	8	20	5
Color Microscopy	512 x 512	24	20	16
Angiography	1024 x 1024	8	100	100
Compacted Radiography	2048 x 2048	12	1	10
Digitized Mammography	4096 x 4096	12	4	100

SATCOM APPLICATIONS

TELE-EDUCATION

- Tele-Education via satellite can bridge the gap between rural and urban areas for imparting high quality education by expert faculty.

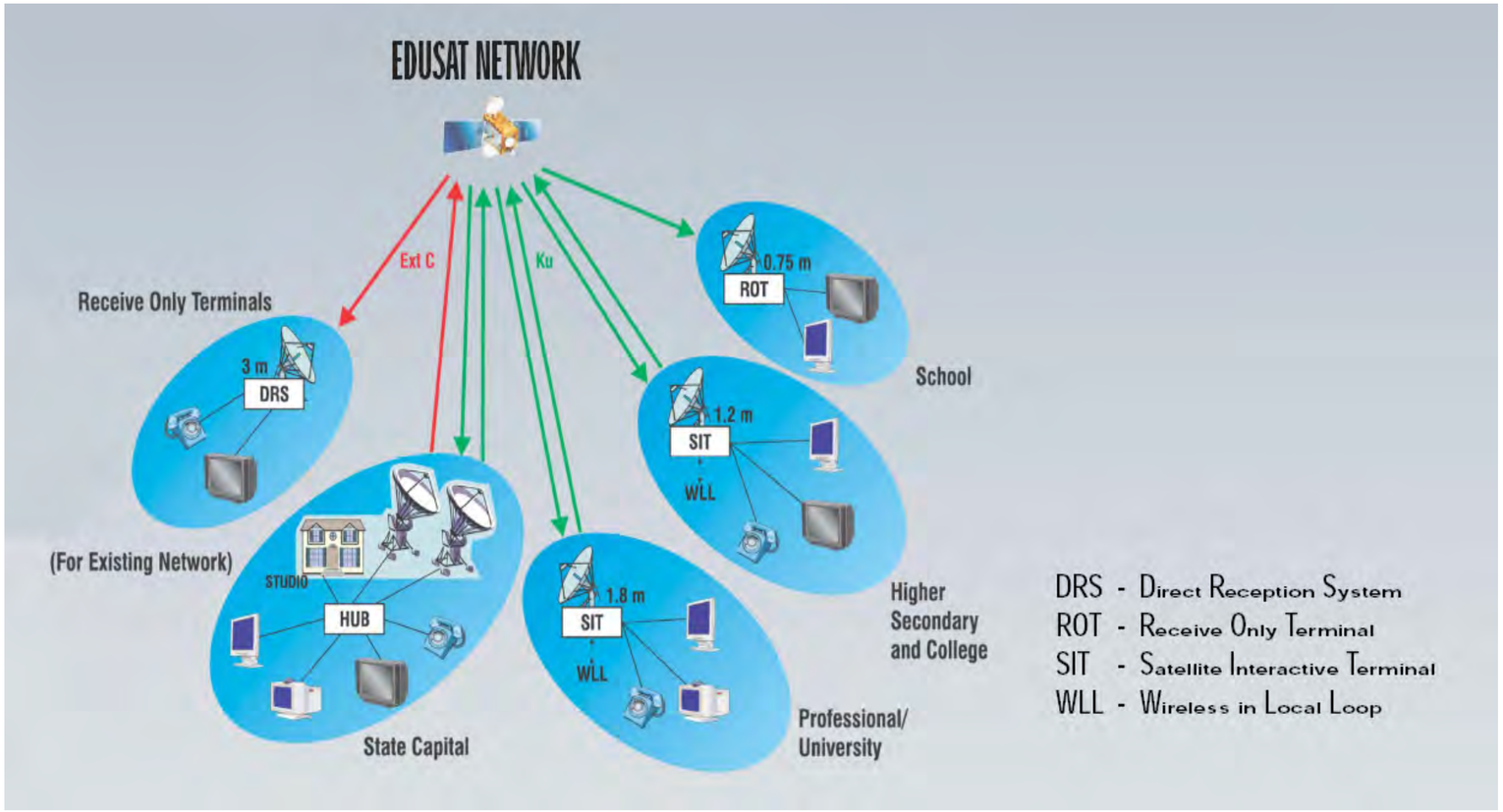


Figure 028-1-45— Edusat Network (Image: Vikram Sarabhai Space Centre)

ADVANCED TELE-EDUCATION SERVICES – SATELLITE-BASED DISTANCE LEARNING

Provision in remote geographically dispersed communities implies significant infrastructural and broadband connectivity requirements for rich media, quality assured delivery and interactivity.

- Virtual classroom service: Physical classroom-like learning environment; can hold face-to-face conversations and collaborate co-workers around the world.
- Tele-conferencing service: Live sessions connecting many geographically dispersed sites.
- Webinar/Webcast service.
- Other services: Pre-recorded educational content broadcast over satellite core and access networks or multicast over to group of distance learners.

High Speed Internet in Educational Institutions:

At a typical environment in schools or colleges is – a large number of devices will be connected and active on internet at any given time, thus driving the consumption of large amount of capacity.

HTS can deliver exceptional economics of internet access in such institutions where PCs are connected over a classroom WiFi cloud to a single satellite terminal.

Internet of Things (“IoT”) – New Emerging Applications

Refers to the set of the devices and systems that interconnect real-world Sensors and actuators to the internet – includes many different systems:

- Internet connected cars

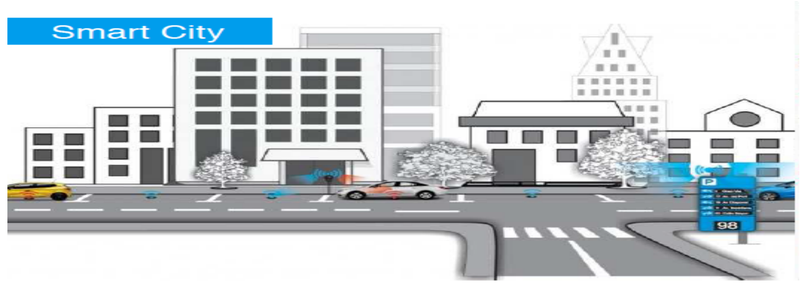
- Wearable devices – health & fitness monitoring devices, watches, and even human implanted devices

- Smart meters, and smart objects

- Home automation systems and lighting controls

- Wireless sensor networks that measure weather, flood defence, tides and more.

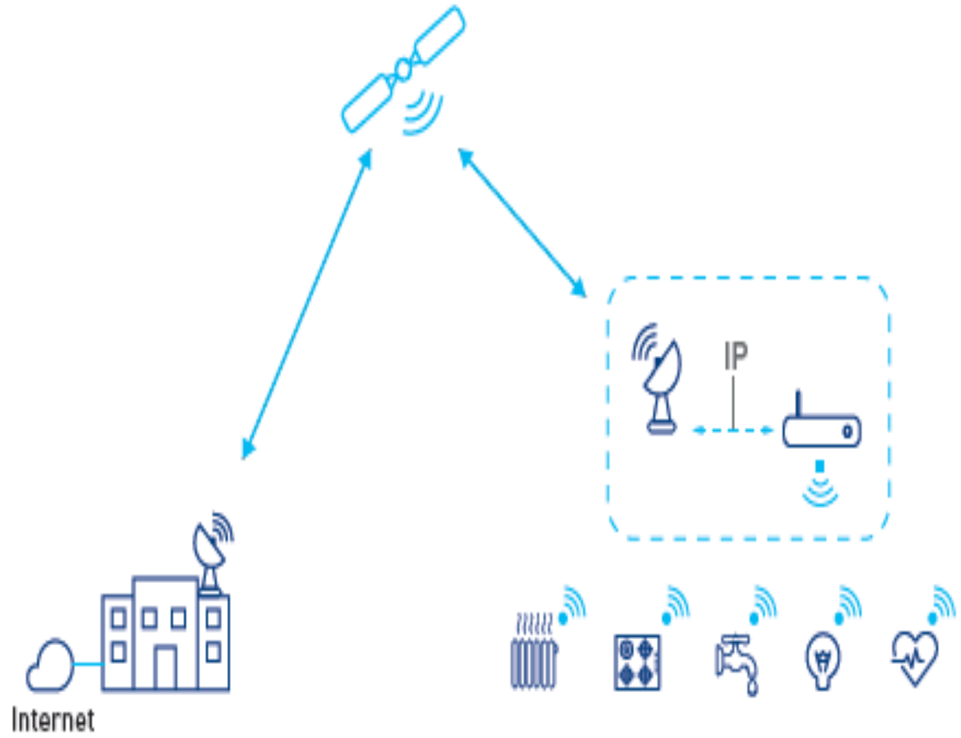

“Everything that benefits
from being connected
will be connected “
Ericsson, 2010


Smart City

Satellite technology: a key enabler for the IoT across industries – unique capability of satellite application where terrestrial network is non-existent or not viable:

Connectivity For :

- M2M
- lo T backhauling
- Home automation and security
- Smart Grid
- Smart Agriculture
- SCADA
- Remote diagnostic and telern
- Firmware and software update
- Environmental monitoring
- wireless Sensor Networks
- Data gathering
- e-Health



❖ SCADA (Supervisory Control and Data Acquisition) Services:

Remote monitoring through satellite communication is cost effective solution for sites where terrestrial or cellular communication infrastructure is unavailable , unreliable.

SCADA is a networked system that collects data from various sensors on mobile or unmanned fixed sites and transmits critical information to a centralised computer for analysis, management and control.

SCADA VSAT as an IP centric platform – a few bytes of data or even higher.

Some sites rely upon battery and solar power.

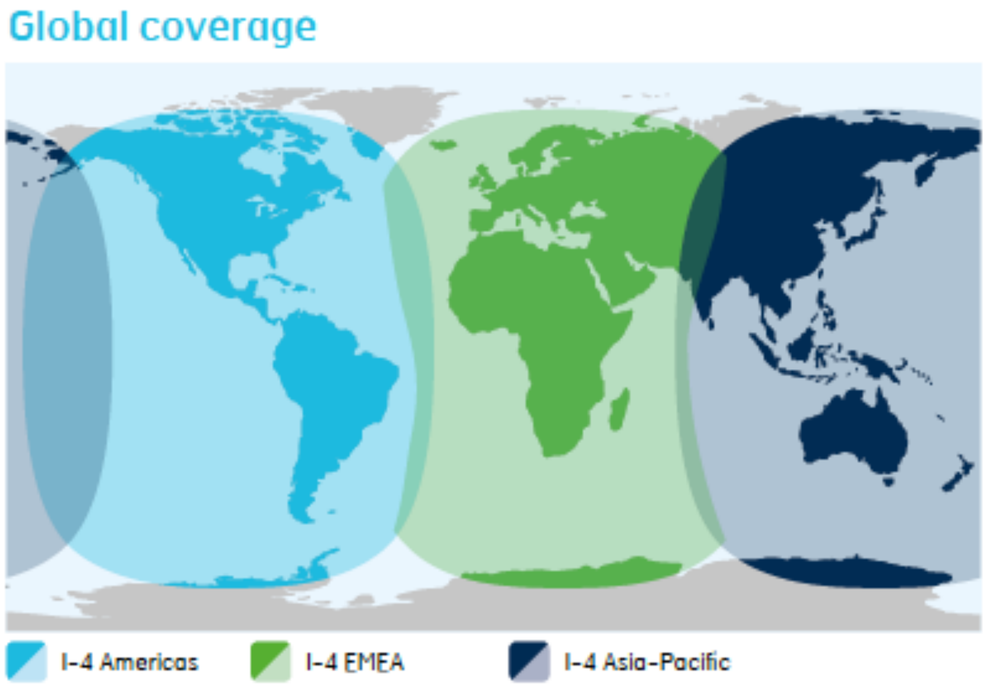
Satellite SCADA solutions suitable for organisations.

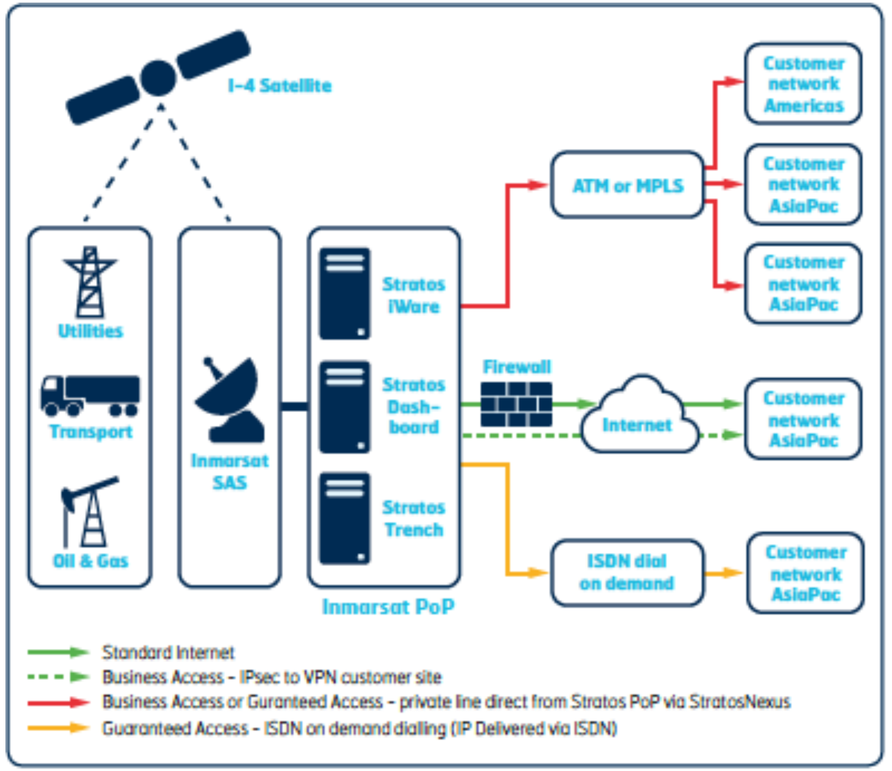
That manage remote assets and need real-time Critical data.

Flow monitoring and pipe line control

❖ Inmarsat SCADA Services:

M2M Applications over regional or global satellite platform

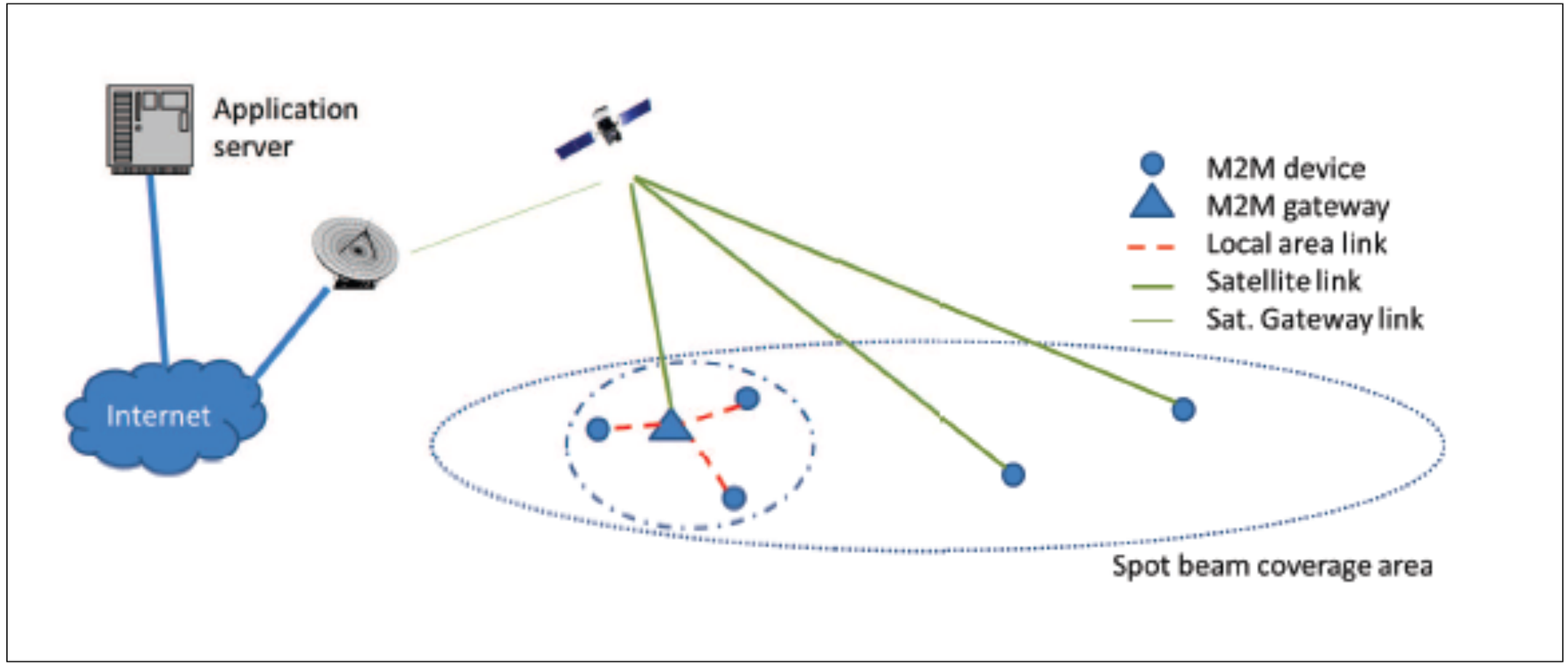




❖ Satellite M2M Applications - LEO Satellite Configurations:

Machine-to-Machine communications have a very large potential market – in the low-end segment – very large population of low cost devices, with low bandwidth requirements with severe cost and energy constraints.

A few organisations have started experimenting these applications over Micro, Nano configurations as LEO satellites.



Satellite M2M architecture

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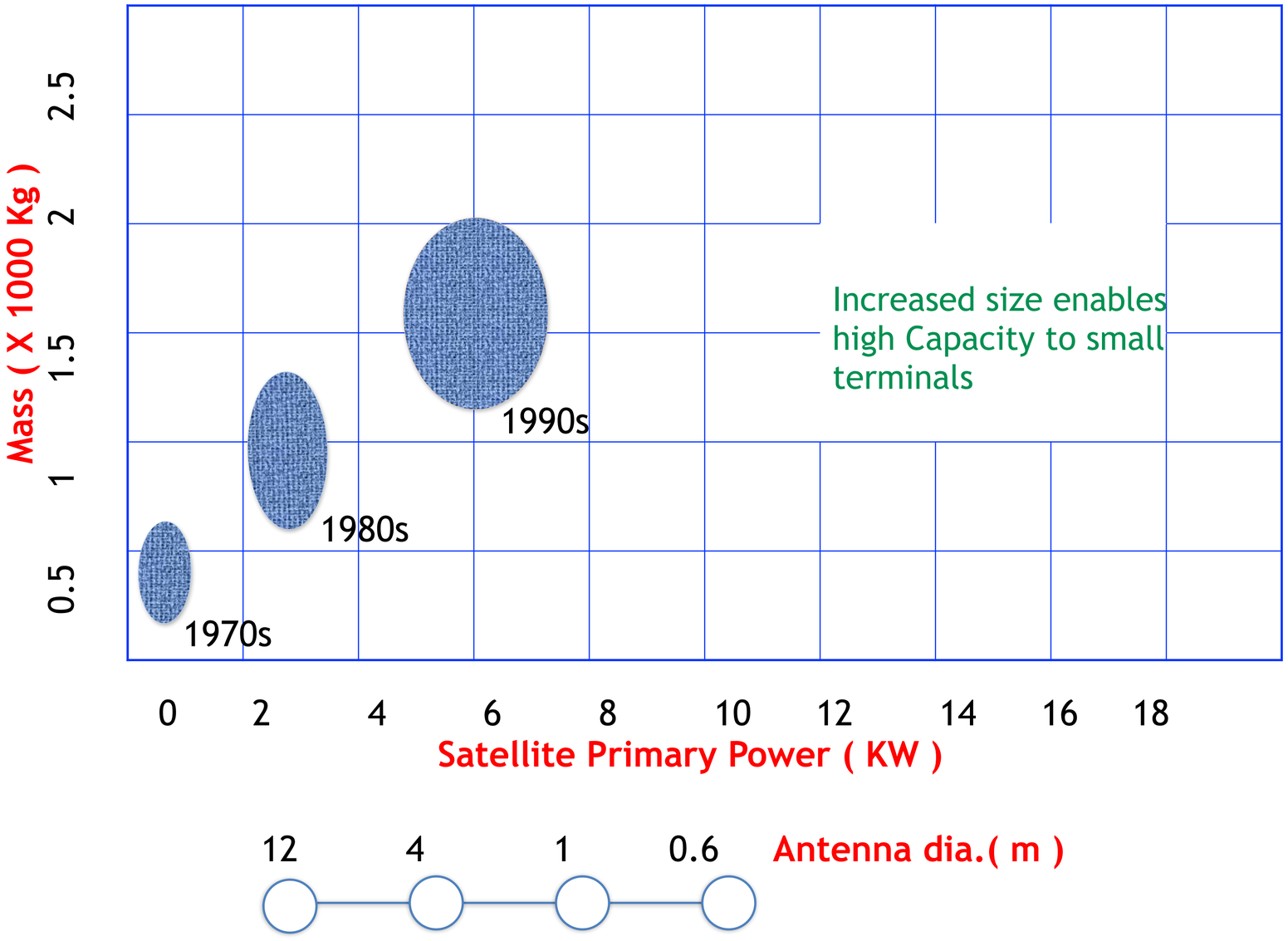
TECHNOLOGY TRENDS – SATELLITE SYSTEMS

Satellite Power/ Mass and Terminal antenna size trends



❖ Large GEO Satellite Platforms:

- Higher satellite primary power – higher efficient solar cells
- More power from the satellite – Large antenna designs, Higher TWTAs
- More number of transponders – increased bandwidth
- Heavy satellites add to the cost of the launch.

Antennas:

- Satellite antenna technology – larger effective apertures, significantly higher number of beams.
- Higher effective radiated power (EIRP) – make earth stations smaller and cheaper.

- The power from satellite is critical to decrease the cost of ground terminal – new applications for satellite service emerge.

- Several mobile and high bandwidth data services depend on the existence of low cost terminal equipment. Satellites with combination of C, Ku band are common, making the satellite heavy.

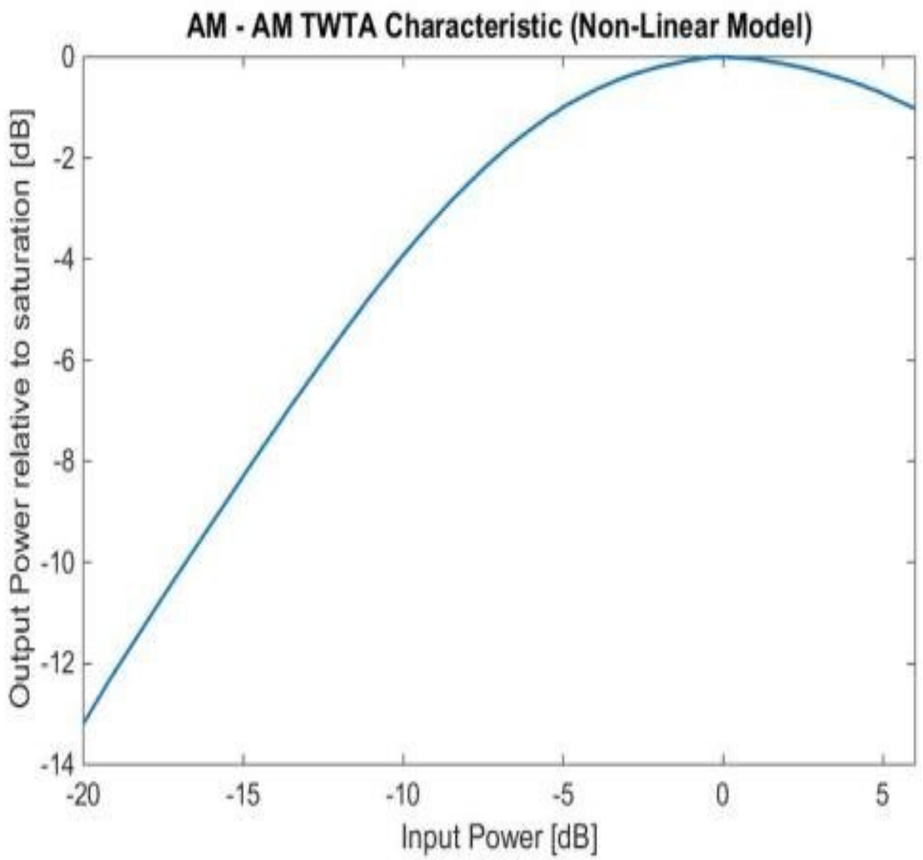
Advancement in TWTAs , EPCs, SSPAS:

- A principal element of the satellite payload is a transmitter consisting of a power amplifier and its associated power supply.
- TWTAs have power supply, called Electronic Power Conditioner (EPC) which supplies high voltages (usually several Kilovolts). Both have seen advancement to meet several performance demands and present design challenges.
- TWTAs are used in several frequency bands that satellites operate. Design improvements – frequency bandwidth , Power conversion efficiency.
- The power amplifiers are operated close to saturation(maximum output power) in order to obtain high efficiency of converting dc energy from the solar arrays into useful RF energy that carries the communication.

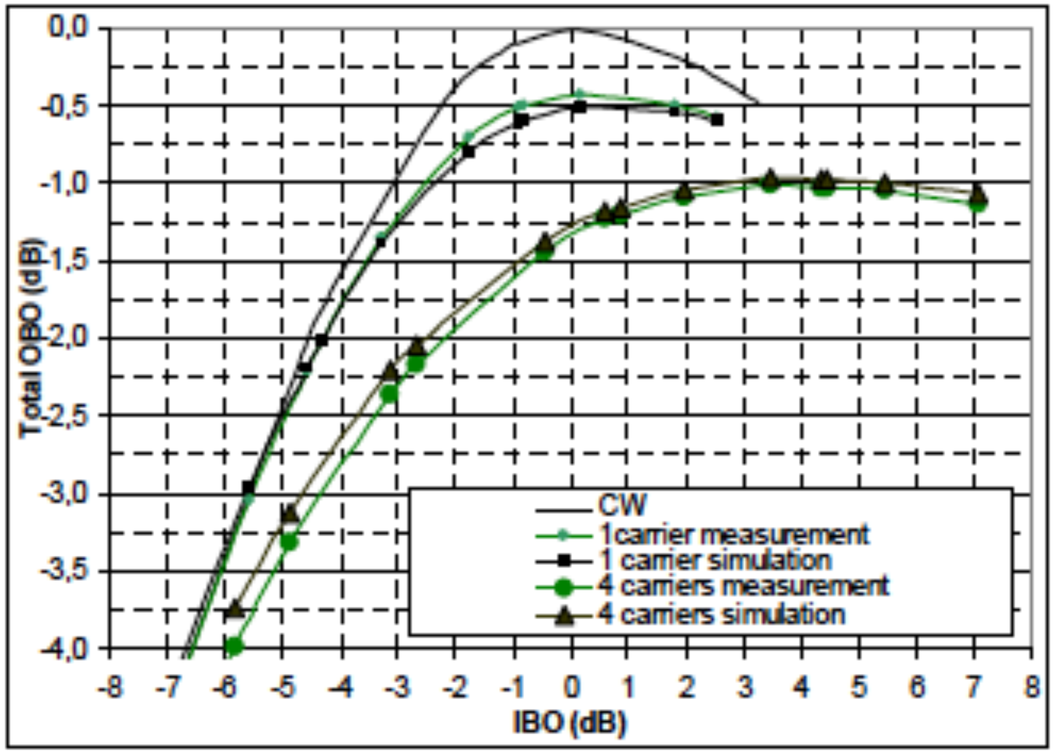
- There are TWTA designs for space use to operate in C, S, Ku and ka band frequencies available from manufacturers in the RF power ranging from 15 W to 250 W or more.
- The power efficiency and instantaneous bandwidth vary over frequency bands. The efficiency number is 65 % or more.
- The power efficiency represents the useful microwave power it can deliver out of the primary DC power it draws from the satellite.
- Within the frequency range of interest , TWTA Is a vacuum technology and SSPA is Solid-state-electronics.
- Within the performance domain achievable. They are selected judiciously for use depending on the superiority.

TWTAs on Payload panel

TWTA BEHAVIOUR

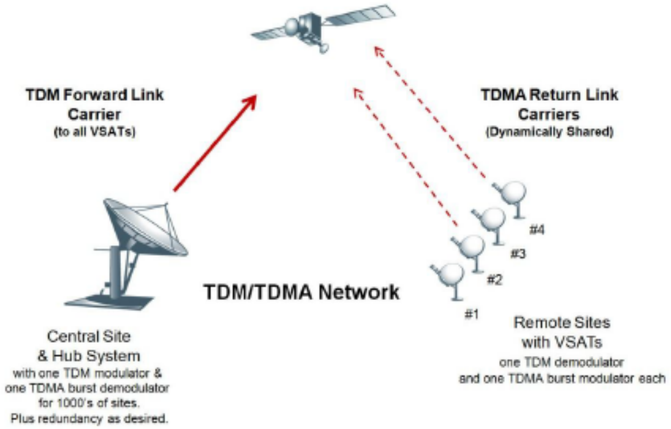


Single carrier input

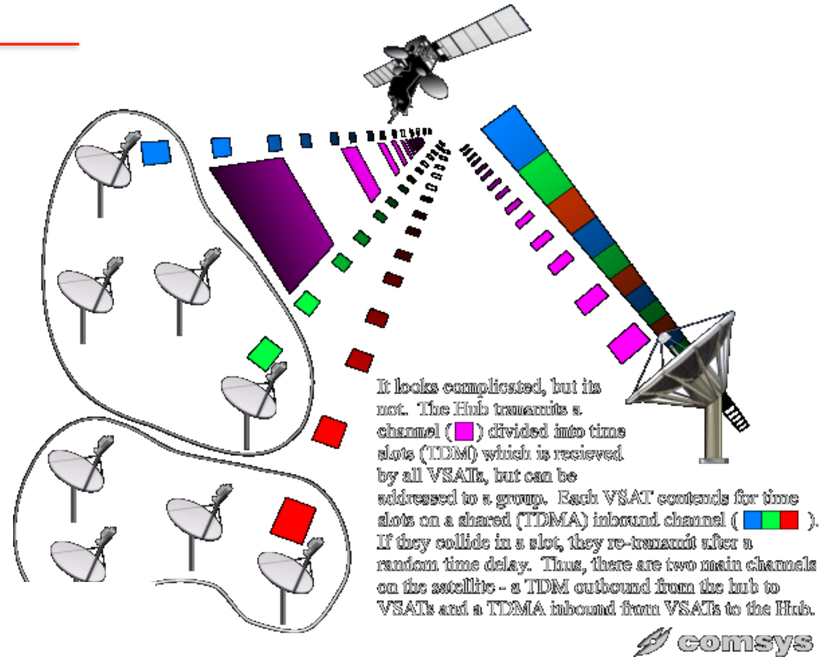


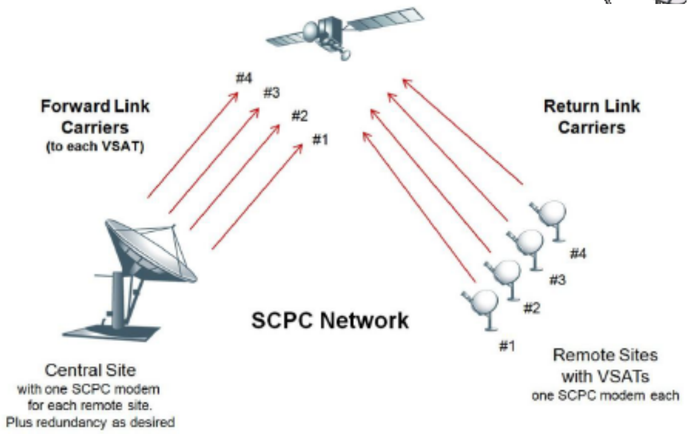
Multiple carrier input

TDM(DVB-S)/TDMA:
One high bit rate Outbound carrier(DVB-S) and a number of lower bit rate inbound carriers



TDM/TDMA Network



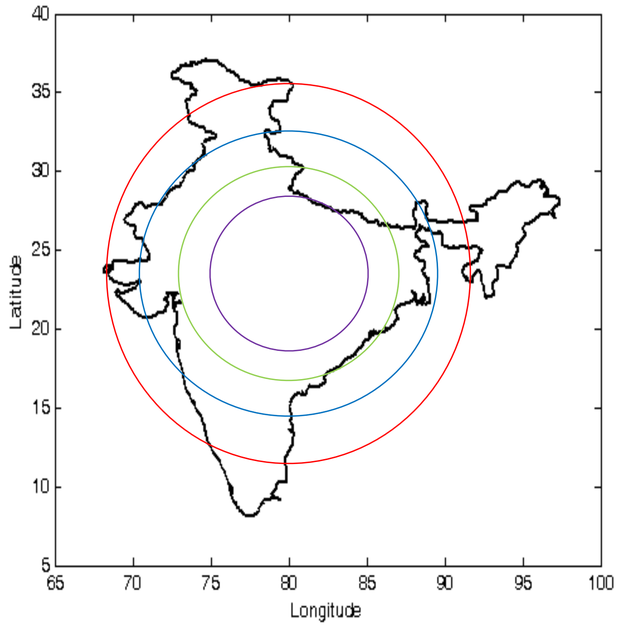


SCPC Network

Shaped-reflector Antenna:

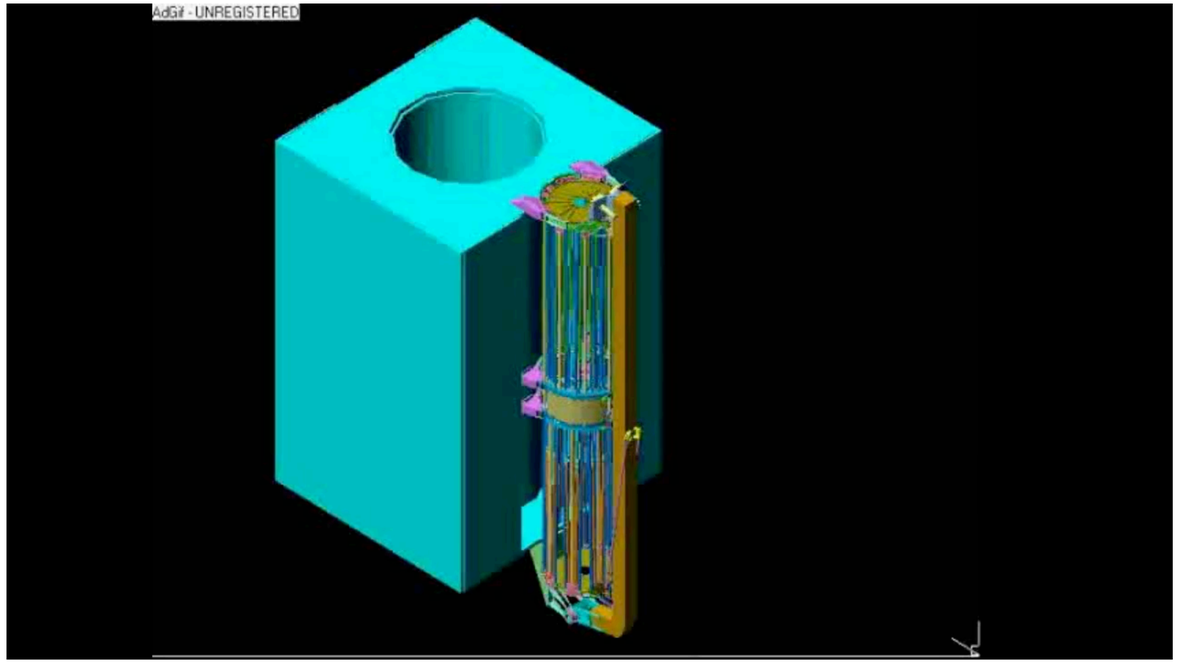
- These provide relatively uniform gain throughout the desired service area and Isolation to non-service territory for interference-free communication

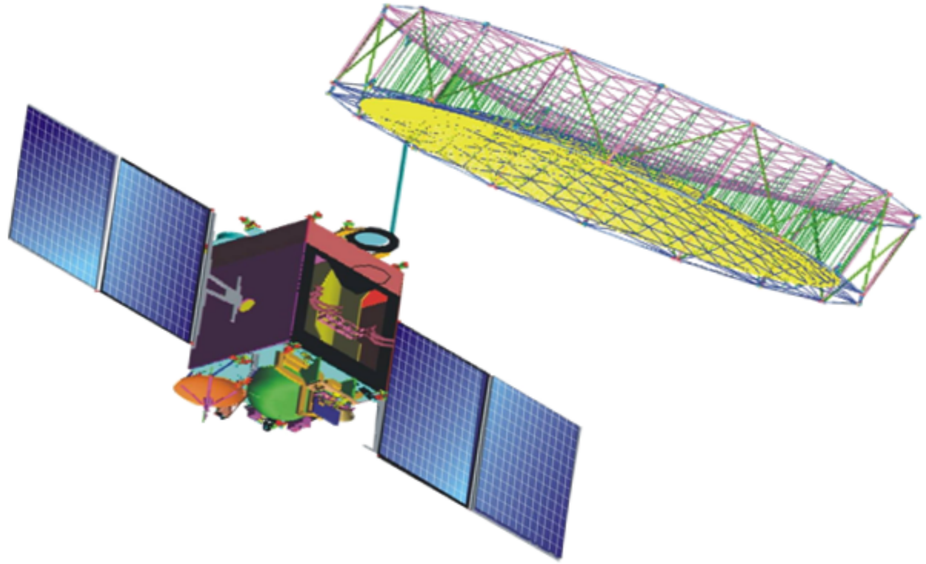
- This antenna technology evolved with the advent of an efficient software to generate the desired reflector profile on the basis of the requirements of the satellite orbital position and the desired coverage areas on the ground.



Large Reflector Antenna:

- Unfurl-able in orbit – expandable structure
- Large aperture antennas to generate smaller beam width
- ACeS use 12 m L-band antenna to generate 140 beams to serve handheld terminals.





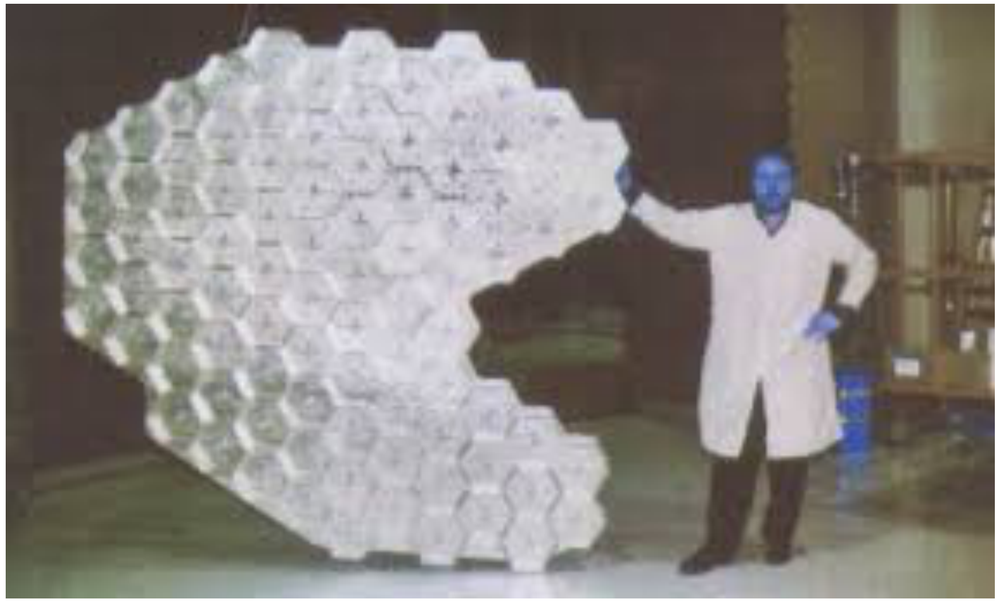
PHASED ARRAYS:

- A group of antenna radiating elements connected and arranged in a regular structure to form a single antenna it is able to produce radiation patterns not produced by individual elements of the antenna.
- The principle of the phased array is too synthesise a specified electric field (phase and amplitude) across an aperture.
- Adding phase shift to the signal received or transmitted by each element of the array allows the collective signal of these individual radiating elements.
    - Power : Combined signal; stronger
    - Beam shaping: The combined antenna pattern can be made much narrower.
    - Beam Steering: Antenna directivity can be altered.
    - Multiple Beams: With phase shift control electronics multiple beams can be synthesised.

ASIA CELLULAR SATELLITE (ACeS):

- Aces use 12 m L-band antenna to generate 140 beams to serve handheld terminals.

- Advancement in mechanical technology and manufacturing processes associated with large reflector antennas, minimising mass, surface deviation, thermal distortion, deployment mechanism.



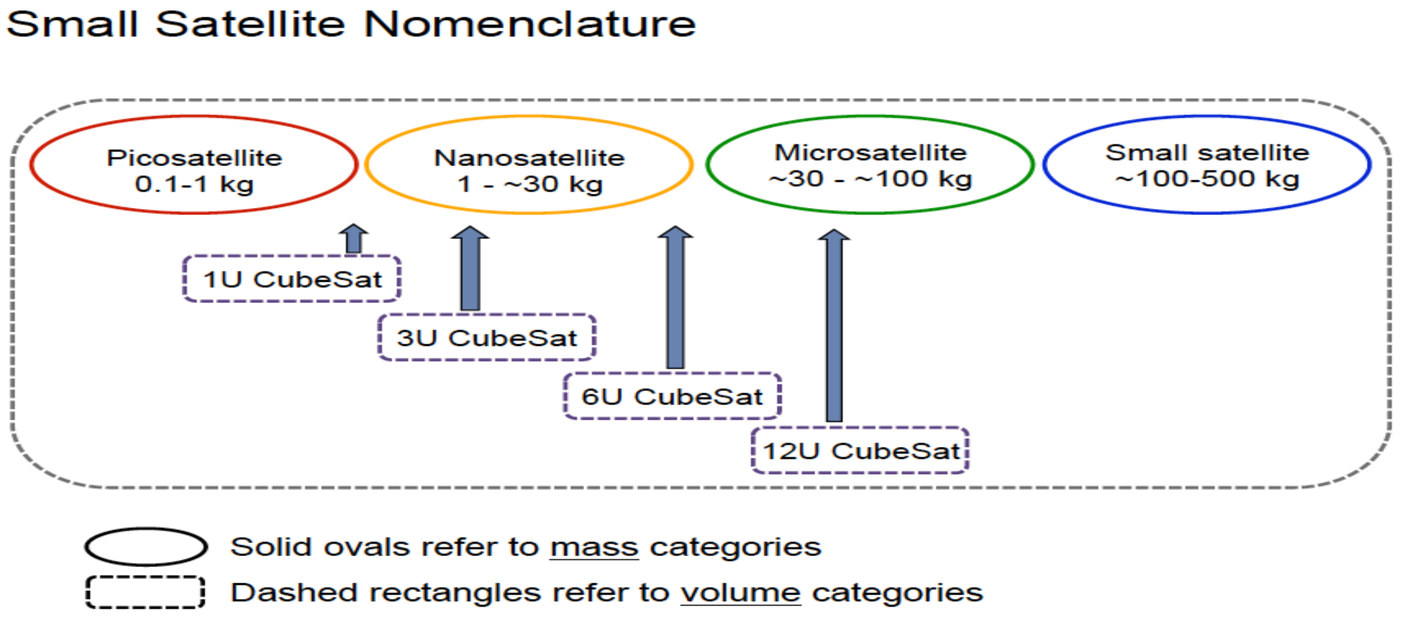
Phased array feed for the L-band antenna

Smaller Satellites (LEO and Micro-sats):

Many innovations in spacecraft design and manufacturing smaller satellites at lower cost to form LEO constellations.

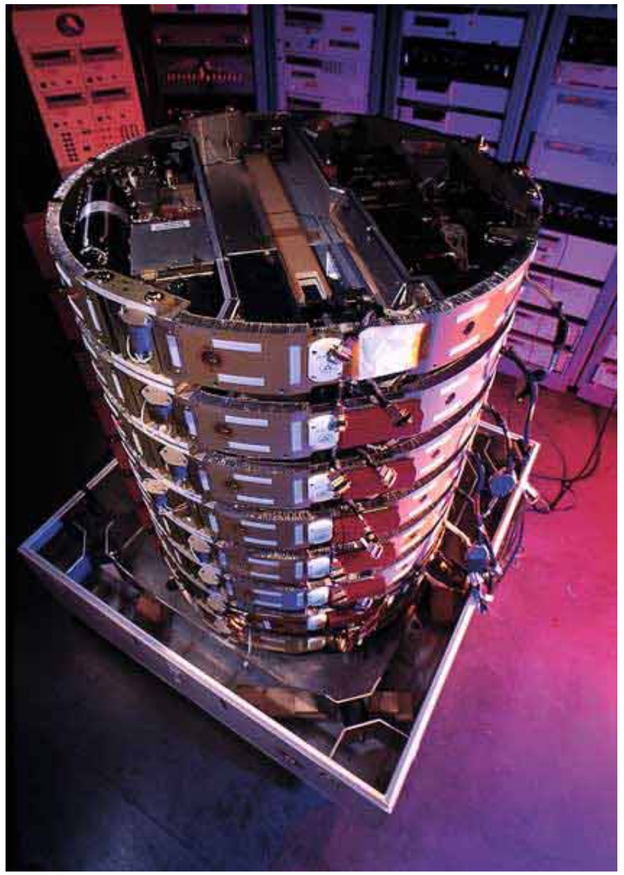
These novel missions promise new services – Remote sensing, Personal & mobile communications, Navigation, Paging & messaging, interactive services etc.

Commercially available, high-volume and hence low cost microelectronics – key to miniaturisation.



Orbcomm LEO Constellations:

- First and only commercial satellite network dedicated 100 % to M2M.
- Planned full constellation of 26 micro-satellites.
- VHF frequency for communication – unaffected by propagation and bad weather for message
- delivery, multiple access with 2400 bps uplinks and 4800 bps downlink to handheld terminals.
- Next level satellites – larger message sizes significantly increasing the capacity.
- Ground infrastructure – 16 Gateway stations worldwide track and establish two-way satellite communications ,process data, provide interconnection to terrestrial network.



Stack of 8 Orbcom satellites

One Web Communication network for internet access :

- Constellation of small satellites to take advantage of worldwide (Pole-to-pole coverage) Communication – LEO HTS.
- 650 satellites (18 planes of 36 satellites)
- Low latency (< 30 ms round trip delay)

Satcom Role - 5G Services

Satellite Strengths

High capacity – 1000 times data requirement – traffic video embedded.

Spectrum Crunch – smaller cells – denser network

IoT – massive device connectivity

Availability, reliability and robustness

Energy saving and cost reduction

UBIQUITY

MOBILITY

SIMULTANEITY

Backup, Emergency, Fill-in

Moving platforms- Planes, ships, trains

Multicast streams, content distribution

Mobile satellites – services to air, sea and land via Geo and Non-Geo

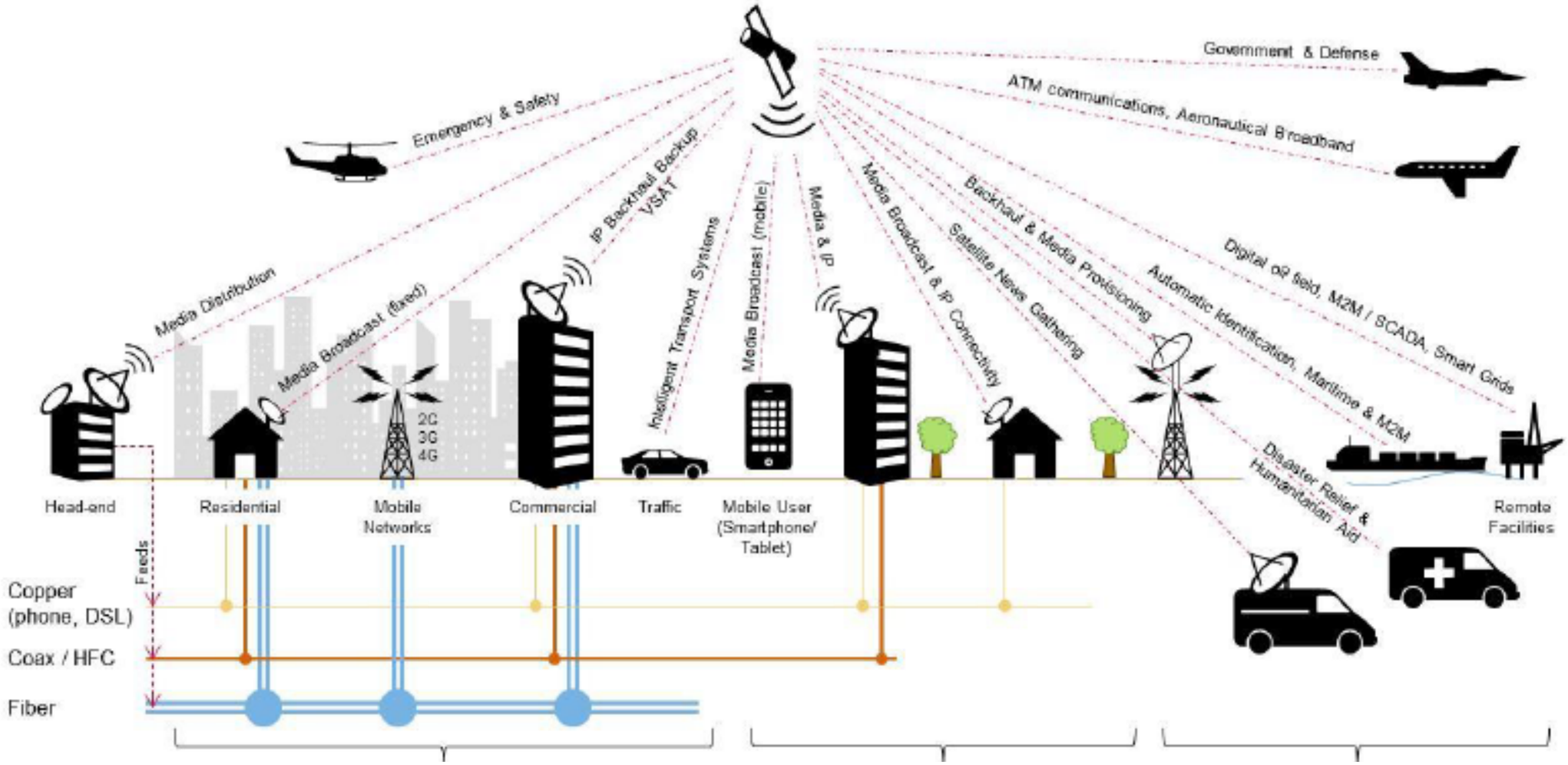
Backhaul services to Cellular
In C, Ku and ka bands

Integrated satellite and terrestrial S-band MSS standards

Satellite used extensively for SCADA services

Emergency services in case of cellular failure
Terabits/sec. satellites

Satellite - Terrestrial System Integration


Government & Defense
ATM communications, Aeronautical Broadband
Emergency & Safety
IP Backhaul Backup VSAT
Media Distribution
Media Broadcast (fixed)
Intelligent Transport Systems
Media Broadcast (mobile)
Media & IP
Media Broadcast & IP Connectivity
Backhaul & Media Provisioning
Satellite News Gathering
Digital oil field, M2M / SCADA, Smart Grids
Automatic Identification, Maritime & M2M
Disaster Relief & Humanitarian Aid
2G
3G
4G
Head-end
Residential
Mobile Networks
Commercial
Traffic
Mobile User (Smartphone/ Tablet)
Remote Facilities
Feeds
Copper (phone, DSL)
Coax / HFC
Fiber