Agenda

- Day 1 - Basics of Satellite Communications (cont.)
- Day 2 - Policy and Regulatory Guidelines for

  Satellite Services (Analog TV to DTT)*
- Day 3 - Network Planning (Satellite trends, Link budget)*
- Day 4 - Vsat Installation and Maintenance
- Day 5 - Vsat Equipment and Bandwith Procurement

Basics of Satellite Com

- Birth of satellite communications
- Development of satellite communications
- Configuration of a satellite communications service ..
- Type of orbits
- Orbital positions and radio interferences
- Type of antennas and performance measures..
- RF equipments..
- Earth Station Measurements
- Services
- Technology trends

Type of antenna and performance measurements

Type of service

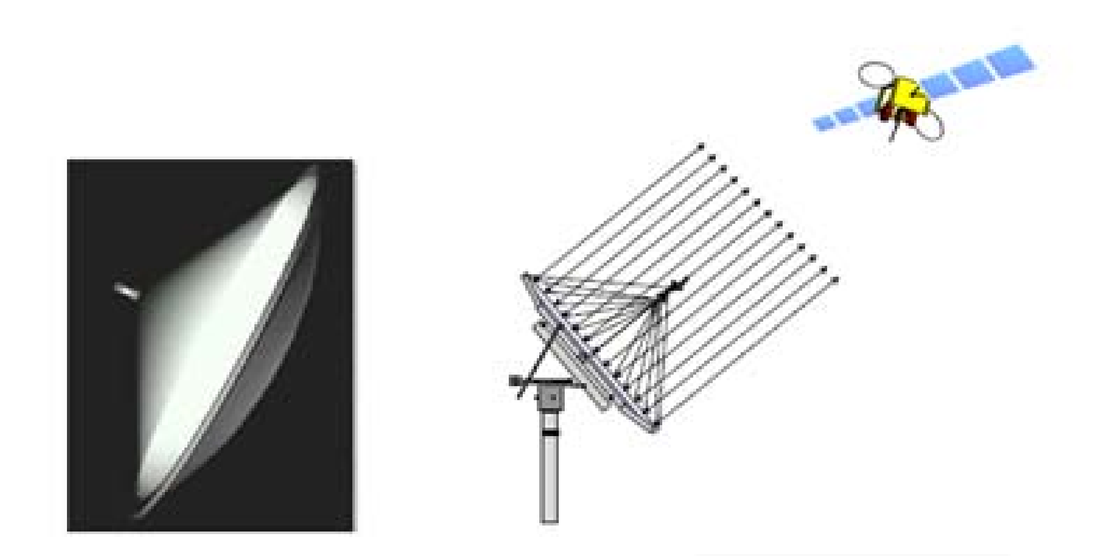
- Tx and Rx (fixed)
- Tx and Rx (transportable)
- Rx (Satellite News Gathering)
- Rx (TeleVision Receive Only)
- Telemetry
- Telescope (exoplanet study) tenders
- Sensoring (natural disasters mitigation) tenders

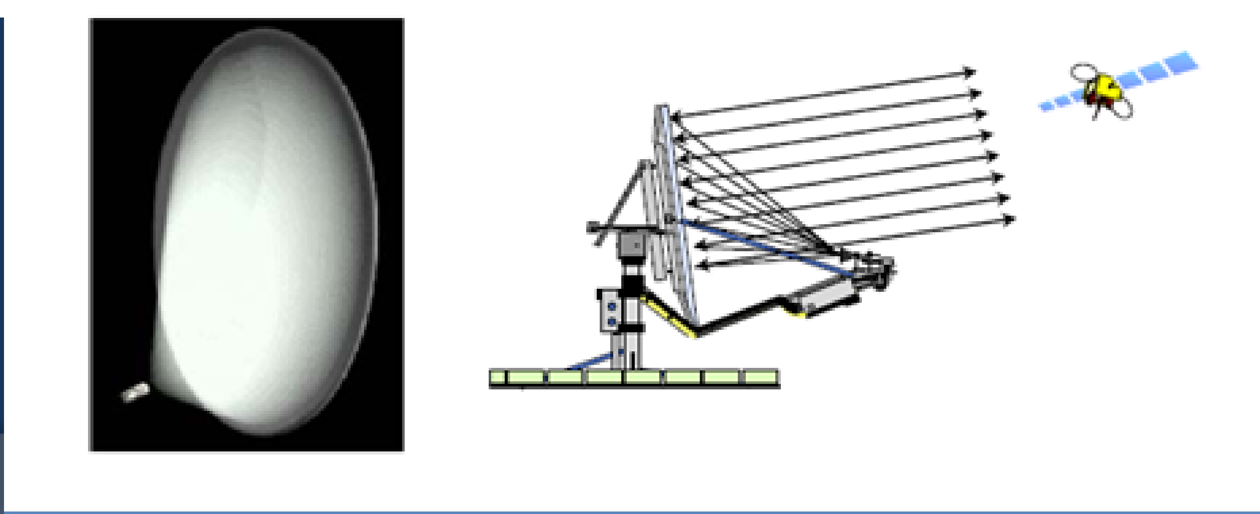
Type of antenna and performance measurements

Built in and drawing facilities

- Single paraboloid reflector antenna
  - Parabolic
  - Parabolic with *offset feed*
  - Parabolic with *multi offset feed*
- Adual reflector antenna
  - Cassegrain
  - Gregorian

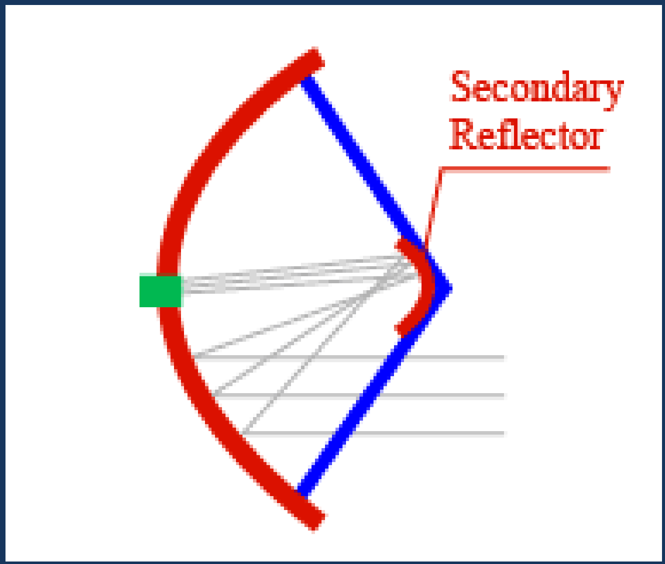
Type of antenna and performance measurements





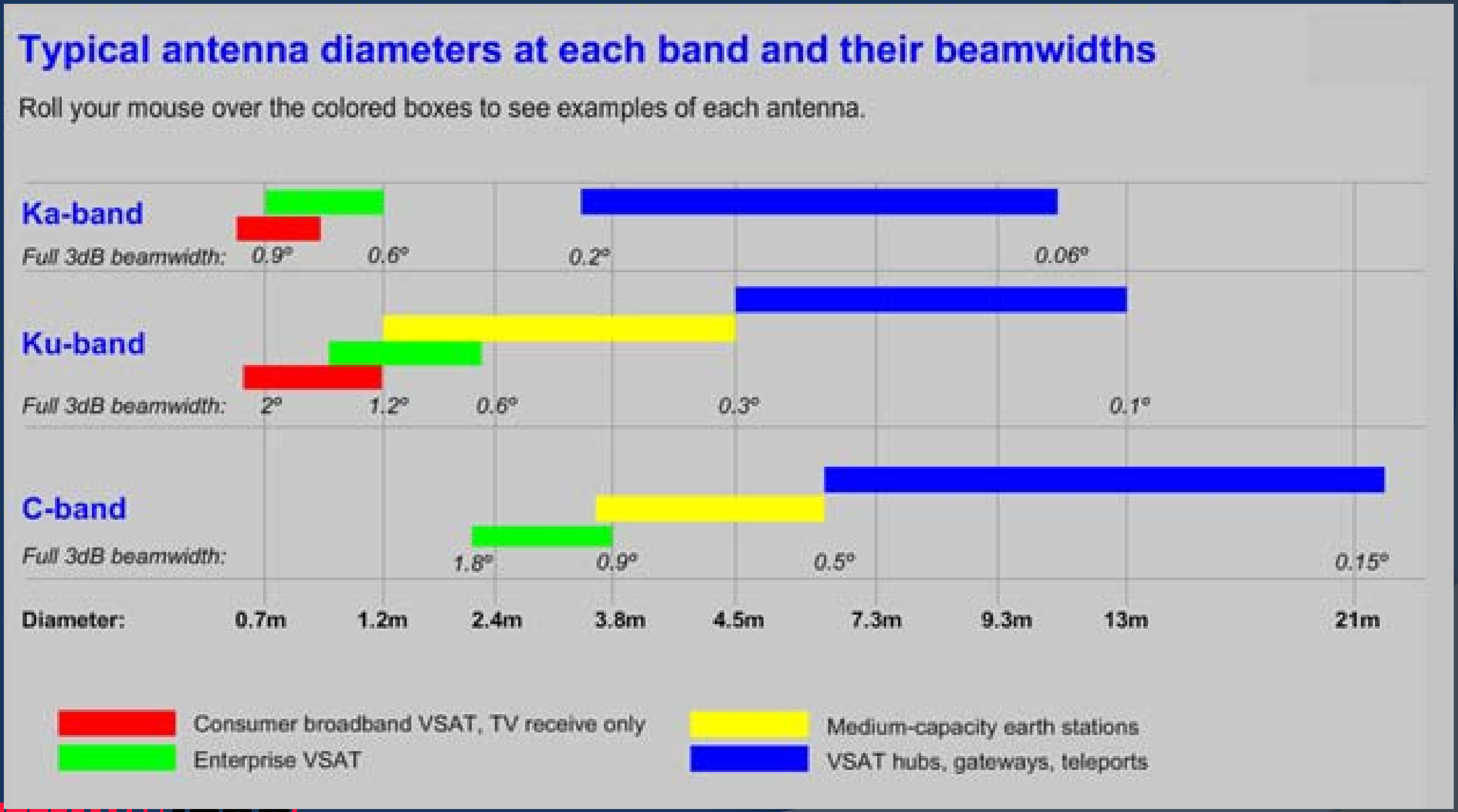
Type of antenna and performance measurements

Cassegrain
Sub.r - parabolic
Focused beam



Gregorian
Sub.r - elipsoid

Antenna diameter and beamwidths



Intelsat Antennas Standard

Type	Reflector diam	Band (GHz)	EIRP (dBW)	G/T (dBK-1)
Std A	30 (15 revised)	C (6/4)	70-90	40,7
Std B	11-14	C	60-85	31,7
Std C	14-18	Ku(14/11)	72-87	39
Std D	5/11	C	53-57	22,7/31,7
Std E1	3,5	Ku	57-86	25
Std E2	5,5	Ku	55-83	29
Std E3	8-10	Ku	49-77	34
Std F1	4,5-5	C	63,91	22,7
Std F2	7,5-8	C	60-87	27
Std F3	9-10	C	59-86	29
Std Z small	6-8	C	49,3-51,7	24,5-26,9
Std Z large	11-13	C	46,3-48,7	31,7-33
Sdd Z tvro	4,5-5	C	(44)	22

Antenna performance measurements

- Satellite Operators define a set of rules for granting equipment approval within its network. In case of Intelsat there are the IESS - Intelsat Earth Station Services, that and the SSOG – Satellite Services Operation guide (Eutelsat equivalent ESOG), define the type of tests shall be performed to be submitted for technical approval :
  - System figure of merit - G / T
  - Transmit Gain and EIRP stability
  - Isolation Contour (ortogonal polarization)
  - Transmit and Receive antenna pattern

G / T performance 1

- Noise temperature is a useful concept in communication receivers, since it provides a way of determining how much thermal noise is generated by active and passive devices in the receiving systems. At microwave frequencies all objects with physical temperature T_n greater than 0ºK generate electrical noise at the receiving frequency. The noise power is given by:

$$\boxed{P_n = K\,T_n B \text{ where}}$$

K - constante Boltzman = $1{,}38 \times 10^{-23}$ J/ºK
T_n - Noise temperature at ºK
B - bandwith

G / T performance 2

- In satellite communications the reception system works always with very weak signals mainly due to distances so gain towards satellite shall be very high besides the performance of receivers .This combination known as G / T - Figure of Merit, represents the ratio - antenna gain over noise temperature - and is directly proportional to the ratio of power carrier and noise power density (C/N_0), achieved by:
  - Adjusting receiver IF bandwith for the signal (carrier and sidelobe) with minimum of noise using 3dB bandwith receiver technique
  - Using reception systems with low noise temperature or in case high dimension antennas, submerge the receiver amplifier in liquid nitrogen or helium reaching physical temperatures of about - 4 ºK (- 277 ºC)

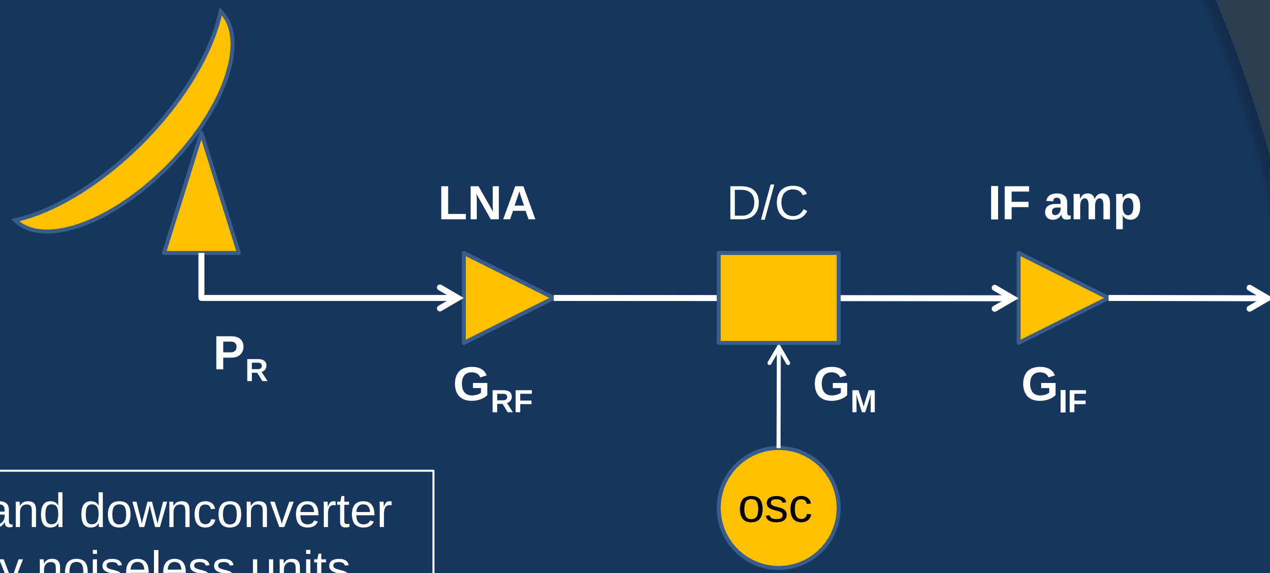
G / T performance 3

How to achieve this double goal ?

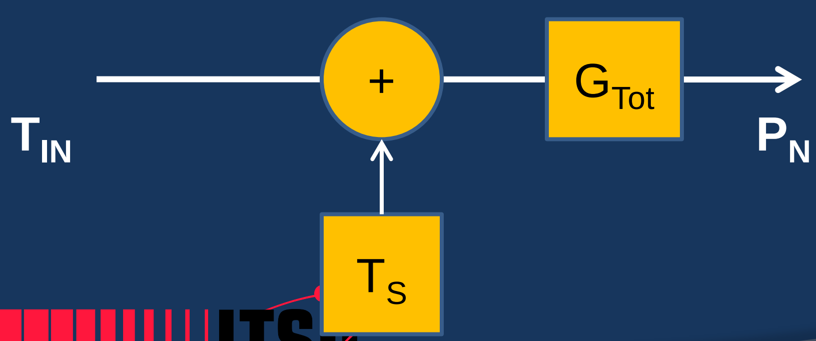
- Adjust the IF bandwidth of the receiver strictly for the signal (carrier and Sidebands), with the least possible noise, using the technique 3dB bandwidth of the receiver;

- Use systems with low noise temperatures or, in the case of large antennas, emerge the reception amplifier in liquid nitrogen (or helium) allowing physical temperature of 4º K (namely 296 °C negative)

G / T performance 4



If low noise amplifier and downconverter have been replaced by noiseless units
With equivalent noise generator at input



ou

$$P_N = K\,T_S B G_{Tot}$$

G / T performance 5

Another way the noise power has been calculated is by swapping the antenna by a global noise source at the receiver input and the several stages gain by G_{Tot}

So

$$\boxed{C / N = P_R \cdot G_{Tot} / K.T_S.B.G_{Tot}}$$

$P_R\ G_{Tot}$ represents signal at receiver output including carrier plus sidelobes

or relating to transmission once $P_R = P_{Tx}.G_{Tx}.G_R.[\lambda/4\pi R]^2$

$$\boxed{C / N = P_{Tx}.G_{Tx}.G_R / K.T_S.B\ .[\lambda / 4\pi R]^2}$$

And finally

$$\boxed{\mathbf{C / N = P_{Tx}.G_{Tx} / K.B\ .\ [\lambda/4\pi R]^2\ .\ \ G_R / T_S}}$$

G / T

Antenna gain 1

1. Measures the directivity of an antenna, e.g the capability that the antenna has to focus and direct the energy in a choosen direction.
2. Defined as the relation between the power radiated per unit solid angle (in a determined direction) and the power radiated also by a solid unit angle (by an isotropic antenna)
3. To this determination we use the concept of isotrópic source, transmiting with power P_T (EIRP) and we calculate the power density in a surface at a given distance

Antenna gain 2

Isotropic source

EIRP = P_T (W)

$$F_{luxo} = P_T / 4\pi R^2 \ \ W\,m^{-2}$$

$$P_R = F \,.\, A$$

Being the efective area of one isotropic antenna:

$$A_{et} = A_{er} = \boxed{\lambda^2 / 4\pi}$$

The received power by isotropic:

$$P_{Risotr} = \frac{P_T}{4\pi R^2} \times \frac{\lambda^2}{4\pi}$$

$$G = \frac{4\,\pi}{\lambda^2} \times A_e = \frac{P_{Rparab}}{P_{Risotro}}$$

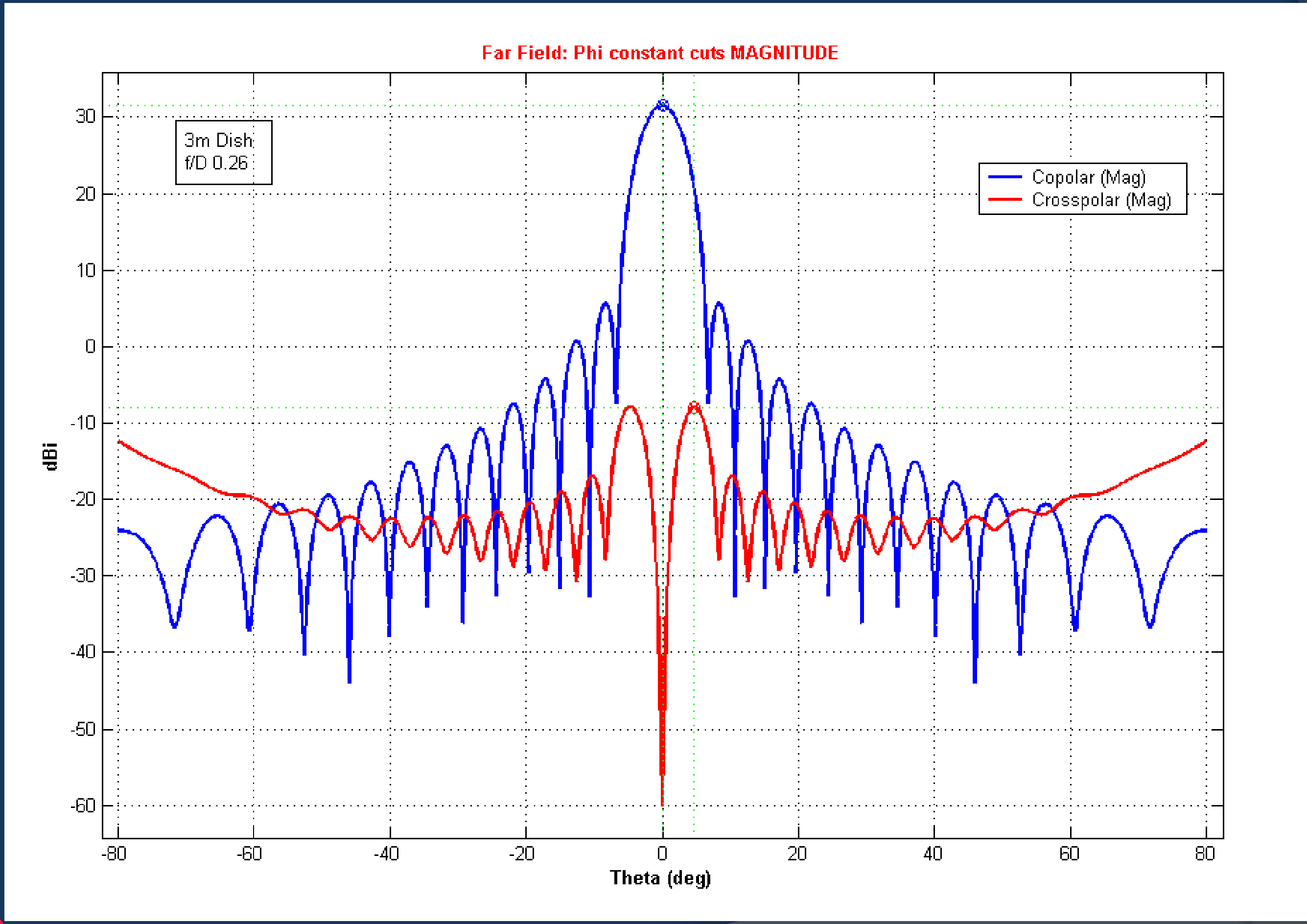
The received power by parabolic:

$$P_{Rparab} = \frac{P_T}{4\pi R^2} \times A_e \qquad \text{where } A_e = \eta \times A$$

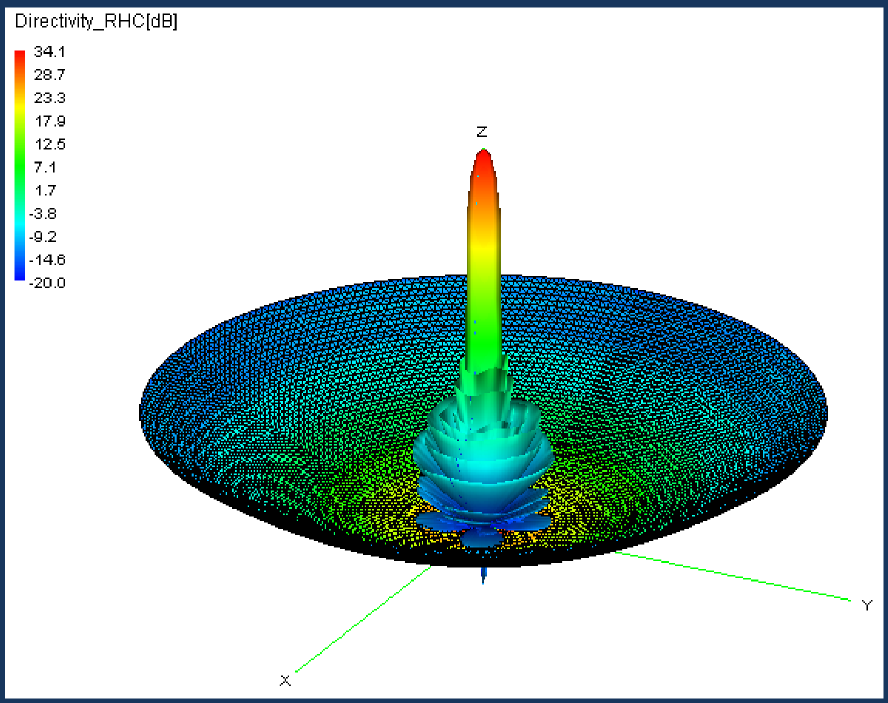
Isolation contour

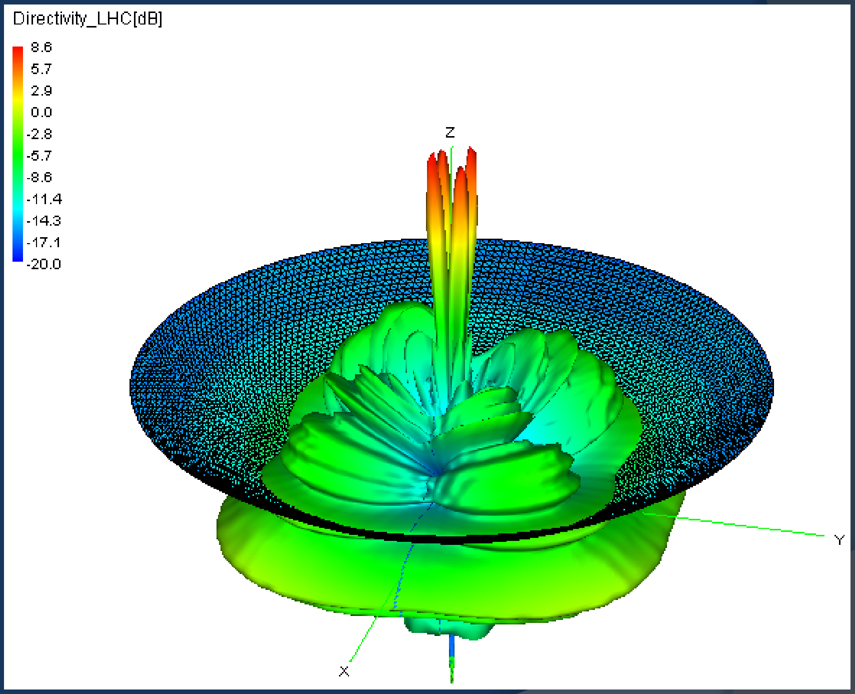
- Being quite common an antenna transmit the same frequency in orthogonal polarizations it is mandatory measure his efficiency at crosspolarization, to reduce minimal possibility of interferences.
- The purpose of the Isolation Contour Test is to measure the crosspol performance of the EUT Earth Station under Teste at the 0.5dB and 1 dB beamwidths of the antenna.
- Once made the here referred tests we reach the following

Ortogonal polarization 1



Ortogonal polarization 2

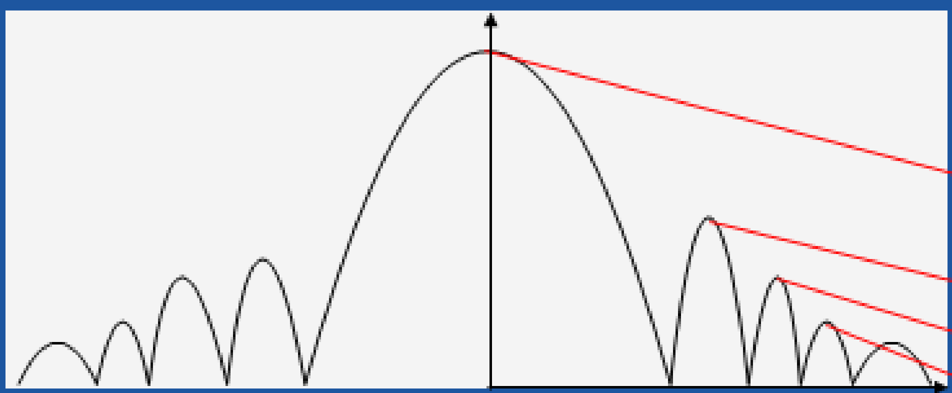




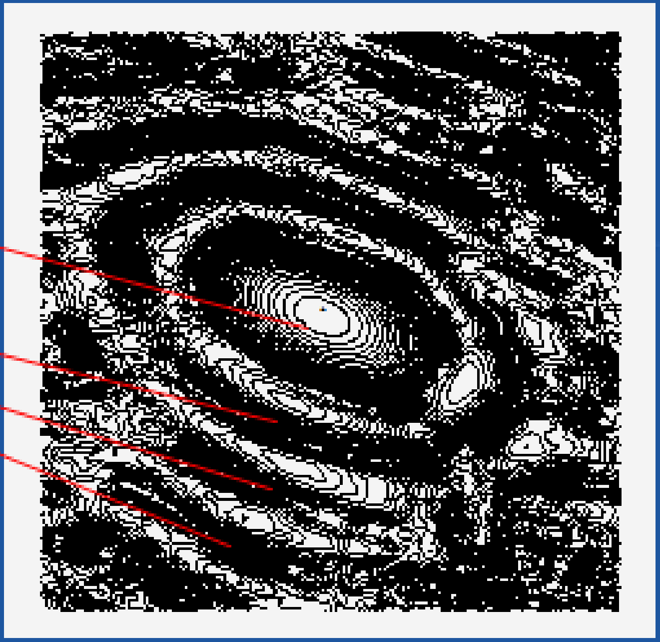
Antennas footprint

- How to visualize a footprint?

Like mountain's profile:



Antenna radiation pattern: Cartesian representation

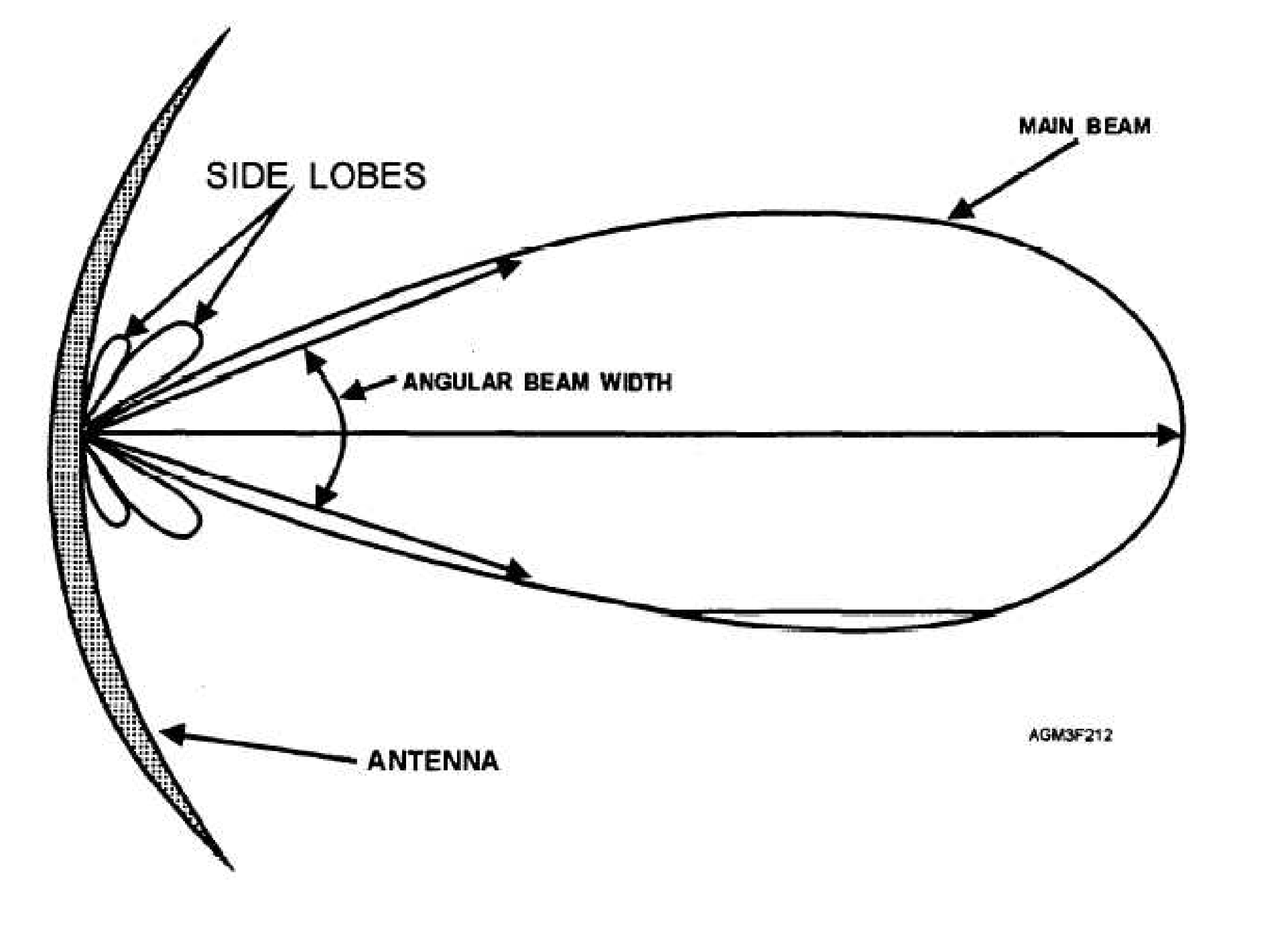


Full gain grid - 1 dB steps

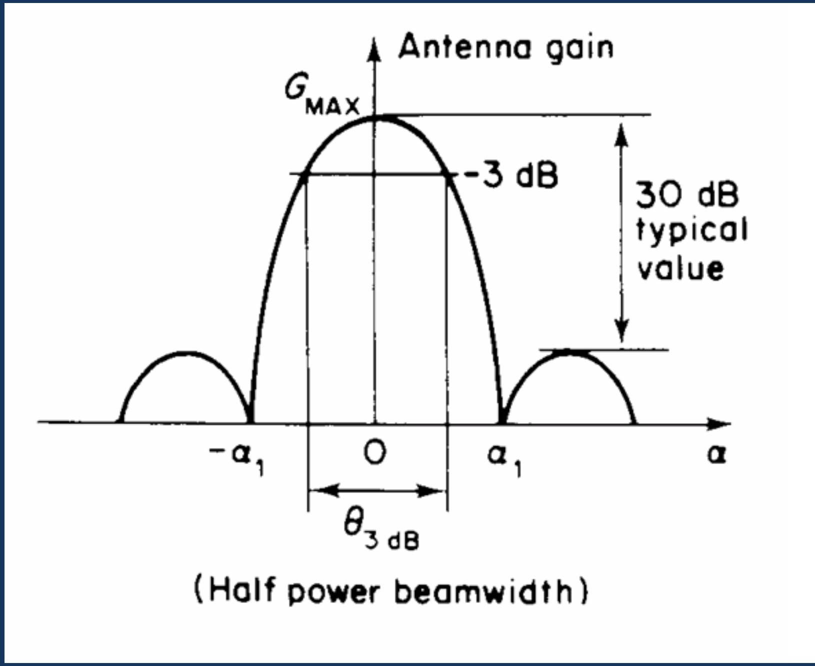
Antennas transmission pattern 1

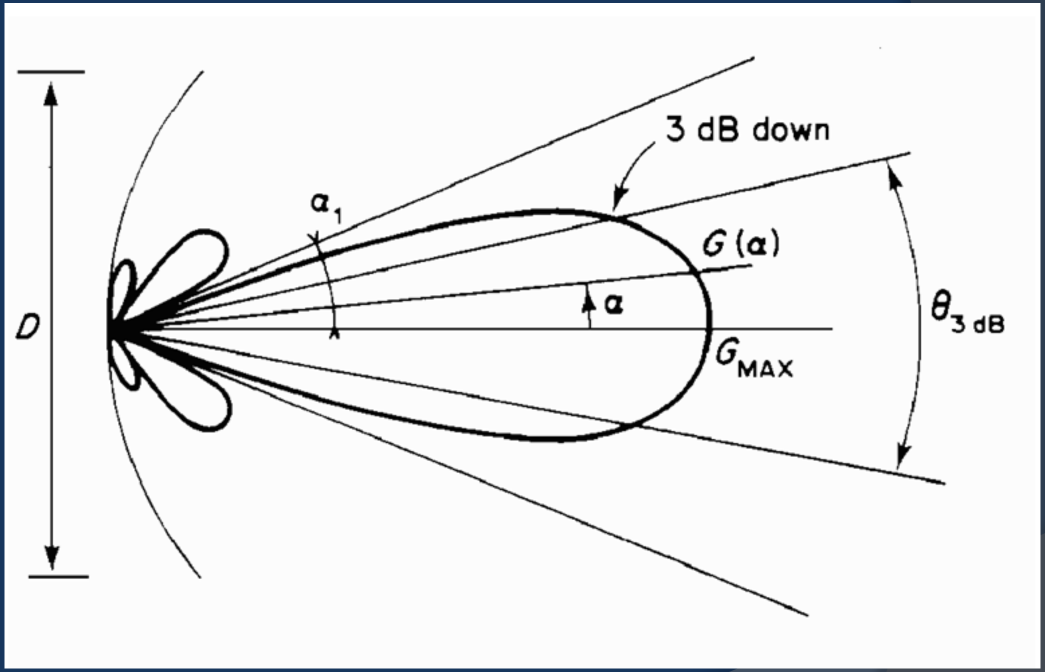
- Due to actual minimum arc spacing between two satellite (2º) and the potential interference power of sidelobes which is undesirable for the satellite itself but also to the earth stations, Intelsat and ITU imposed some restrictions on the pattern transmissions :
  - ITU defined standards to the sidelobe performance of antenna [contourG(θ)=32-25log(θ)]
  - Also Intelsat through IESS – Intelsat Earth Station Standards verify and imposes compatibility of antenna under tests, namely, transmission gain in such way that its sidelobes and "*offaxis"emissions (included in the cross-polarization).*

Antennas transmission pattern 2

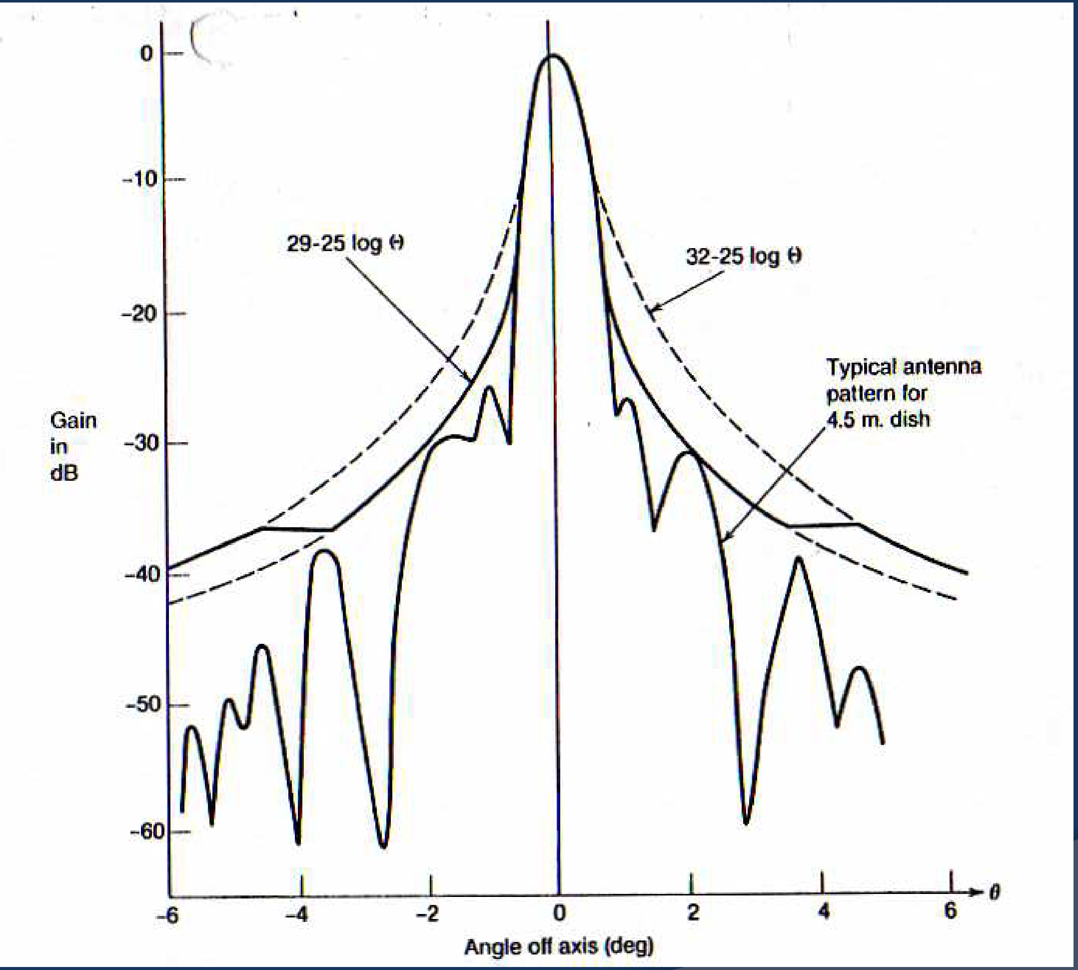


Antennas transmission pattern 3





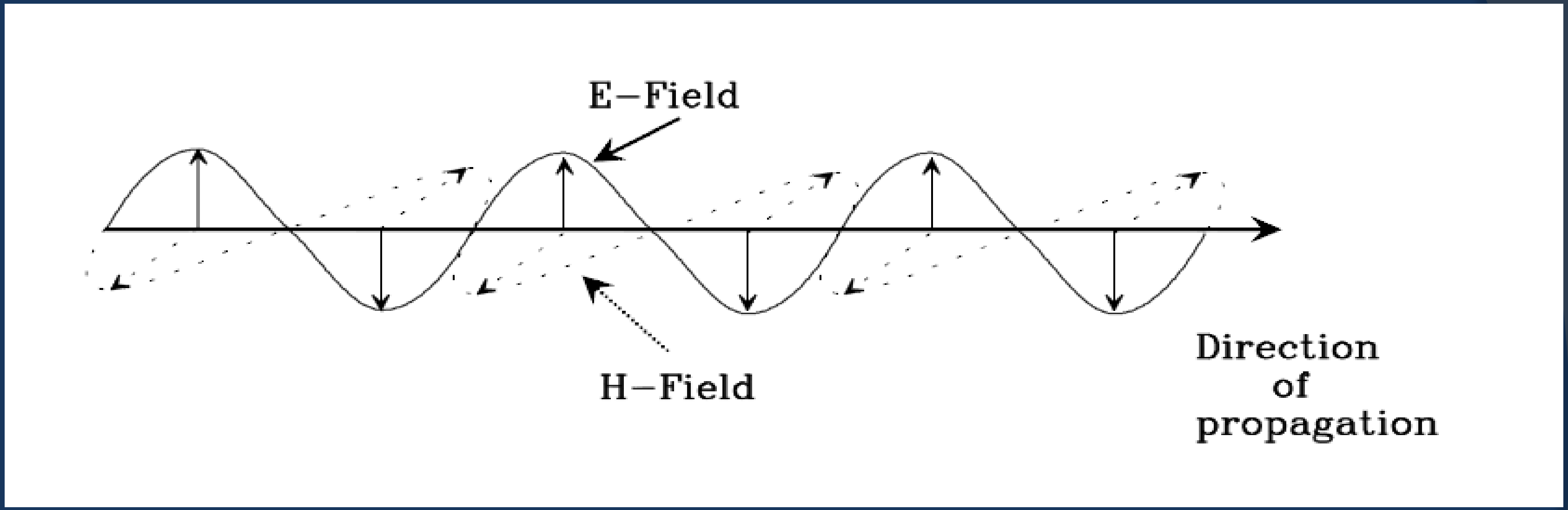
Antennas transmission pattern 4

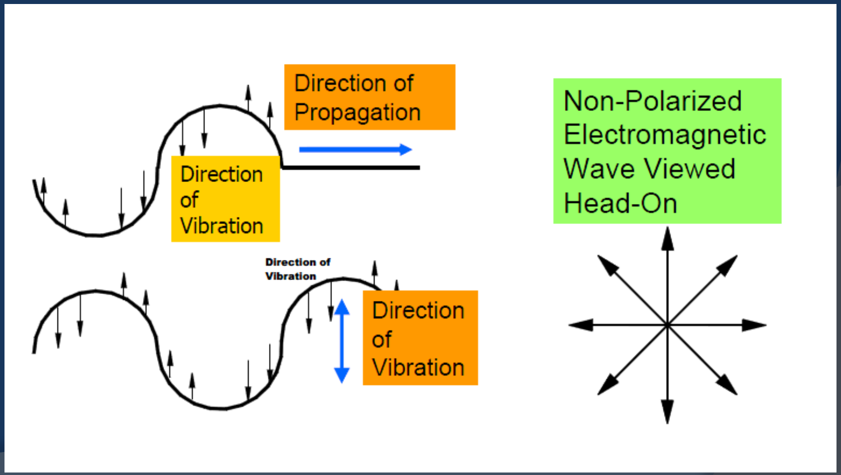


Why polarization?

- Due to scarcity of bandwith on the transponders, the reuse of frequencies could be a good alternative
- So frequency reuse is receiveing and transmitting signals at the same frequency but with orthogonal polarization
- Linear polarization needs absolute alignement, conpared to the circular, but then there are some problems with the rain
- Generally transponder frequencies are designed to minimize interference

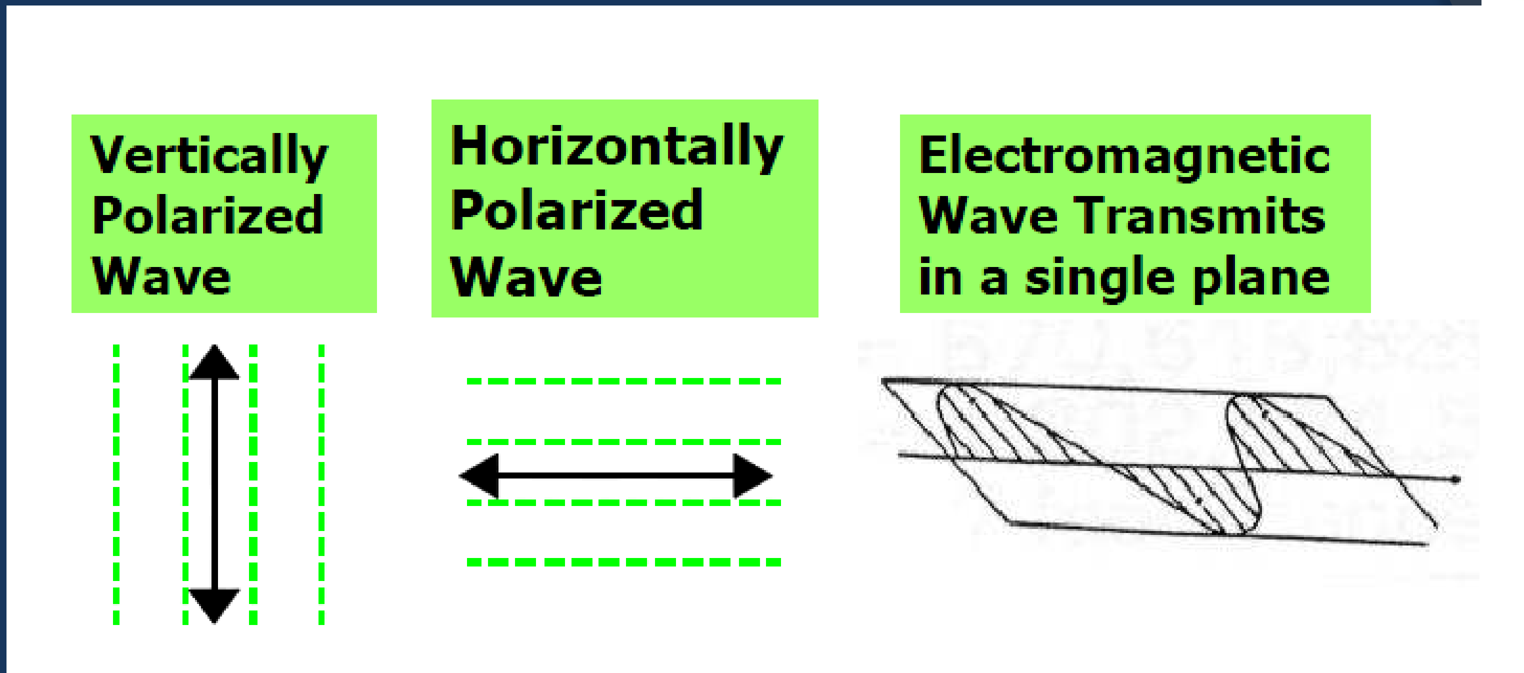
Electromagnetic wave behaviour

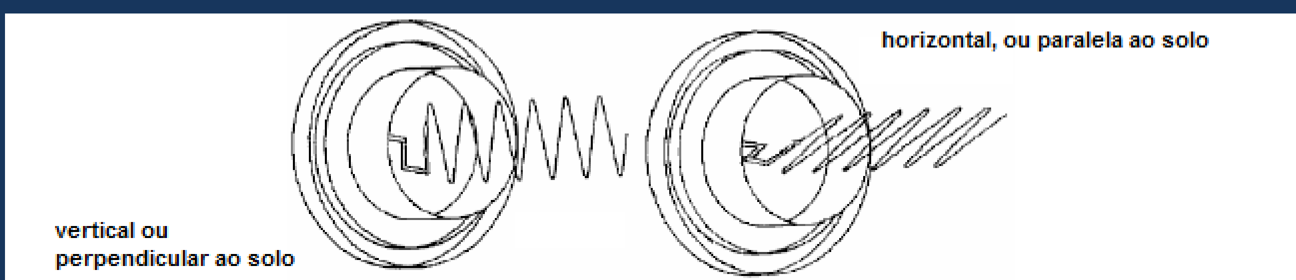




Polarization refers to the orientation of the electromagnetic field vector as a funtion of time

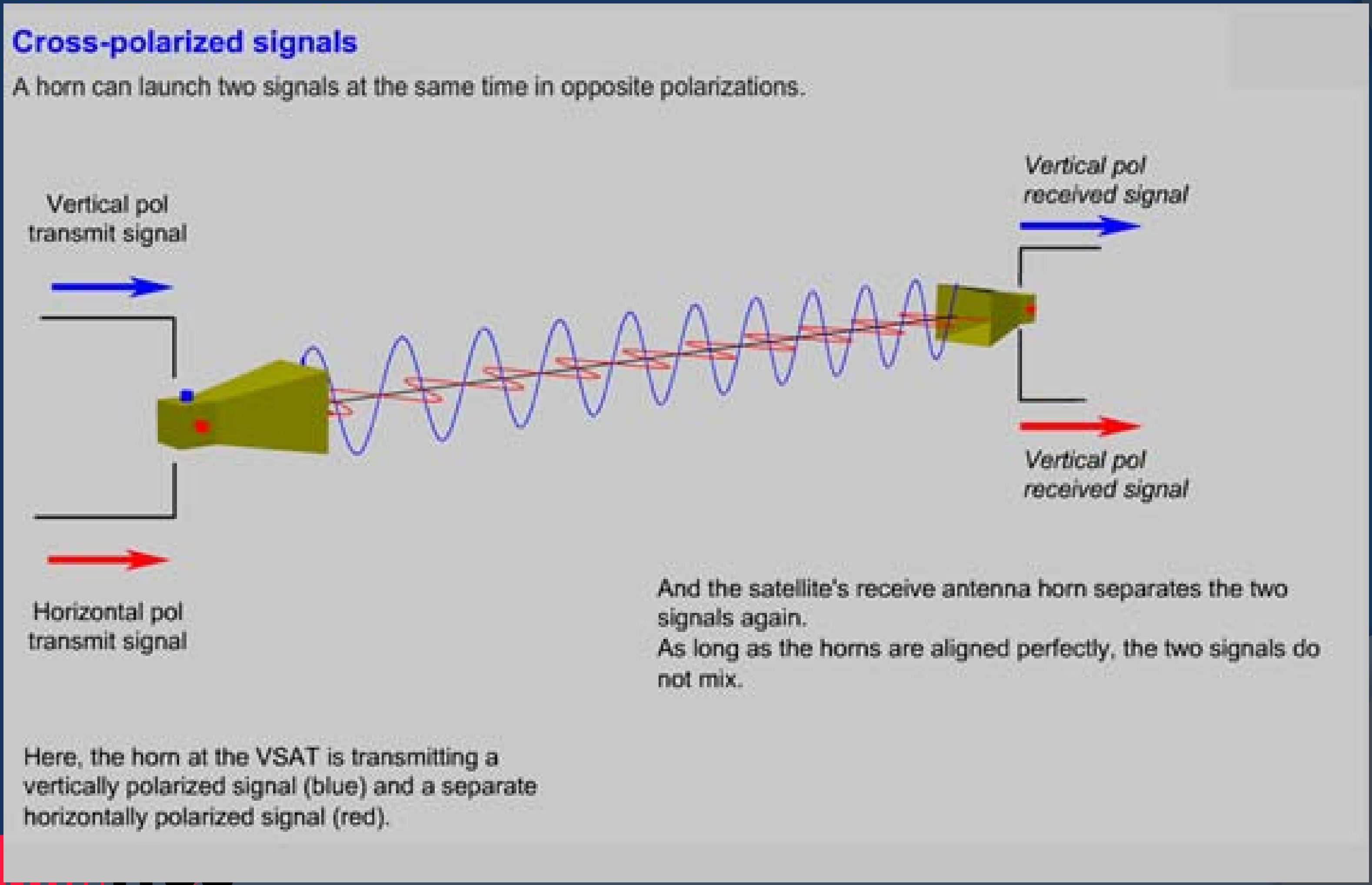
Linear polarization



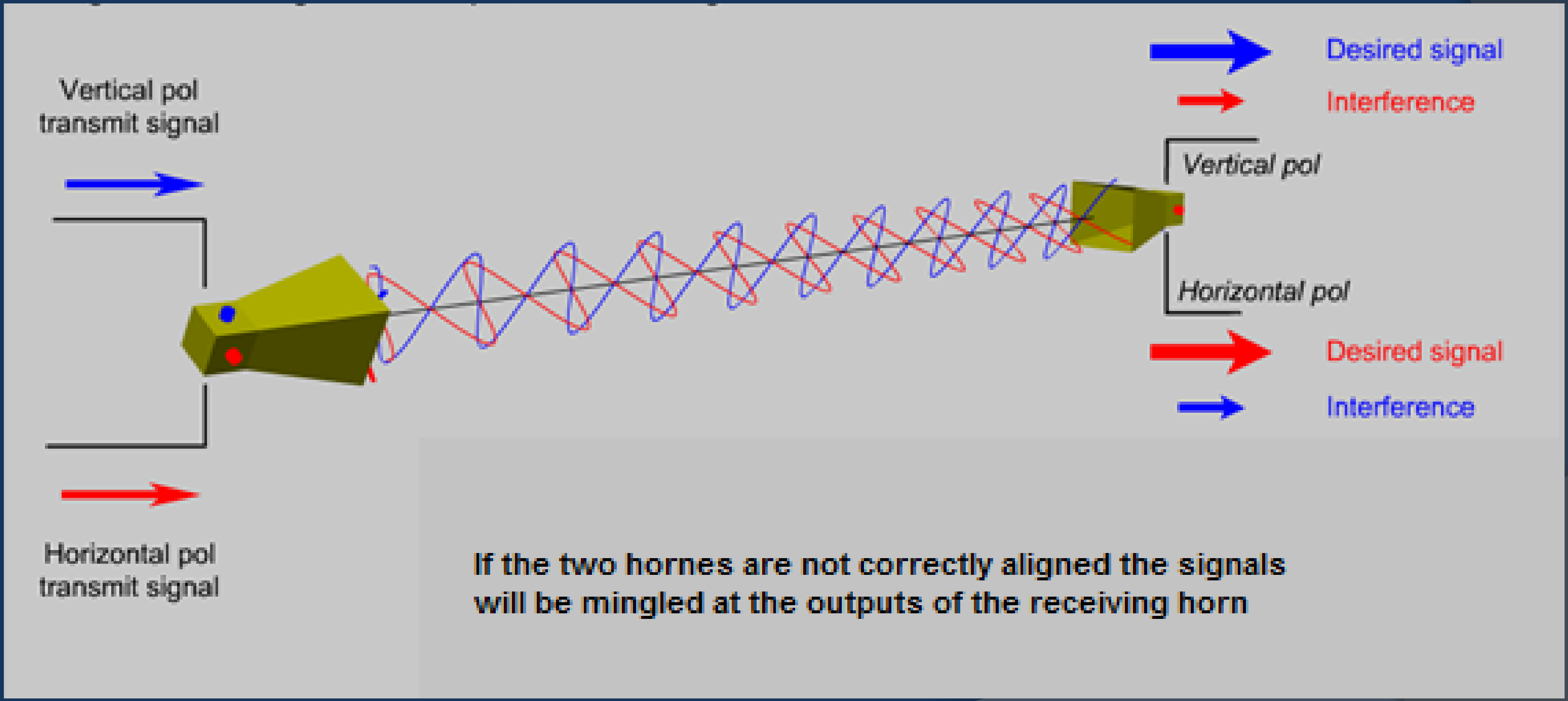


Linear polarization requieres precision alignement of the transmitter and receiver, meaning satellite and earth station

Linear polarization

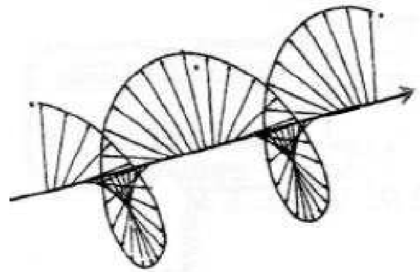


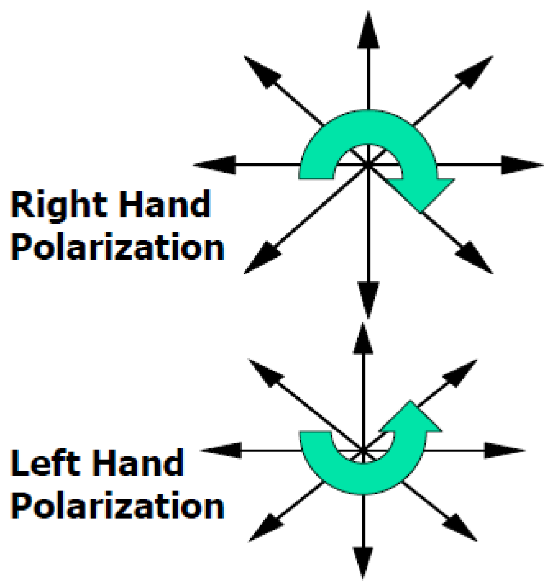
Linear polarization (interference)

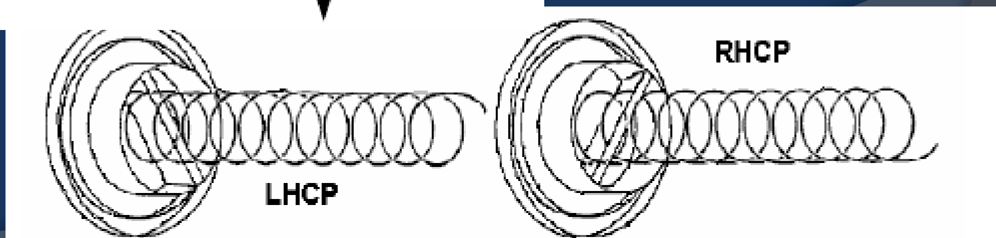


Circular polarization

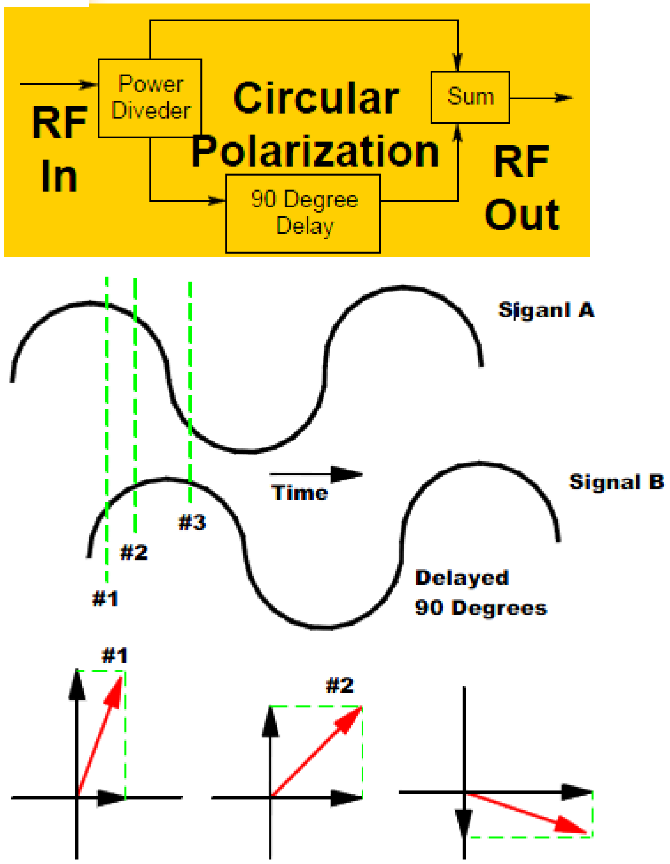
- Electromagnetic Plane rotates clockwise with time
  - Right Hand Polarization
- Electromagnetic Plane rotates counterclockwise with time
  - Left Hand Polarization
- A Right Hand Polarized Satellite signal is Left Hand Polarized at the Earth Station
  - Mirror Image -





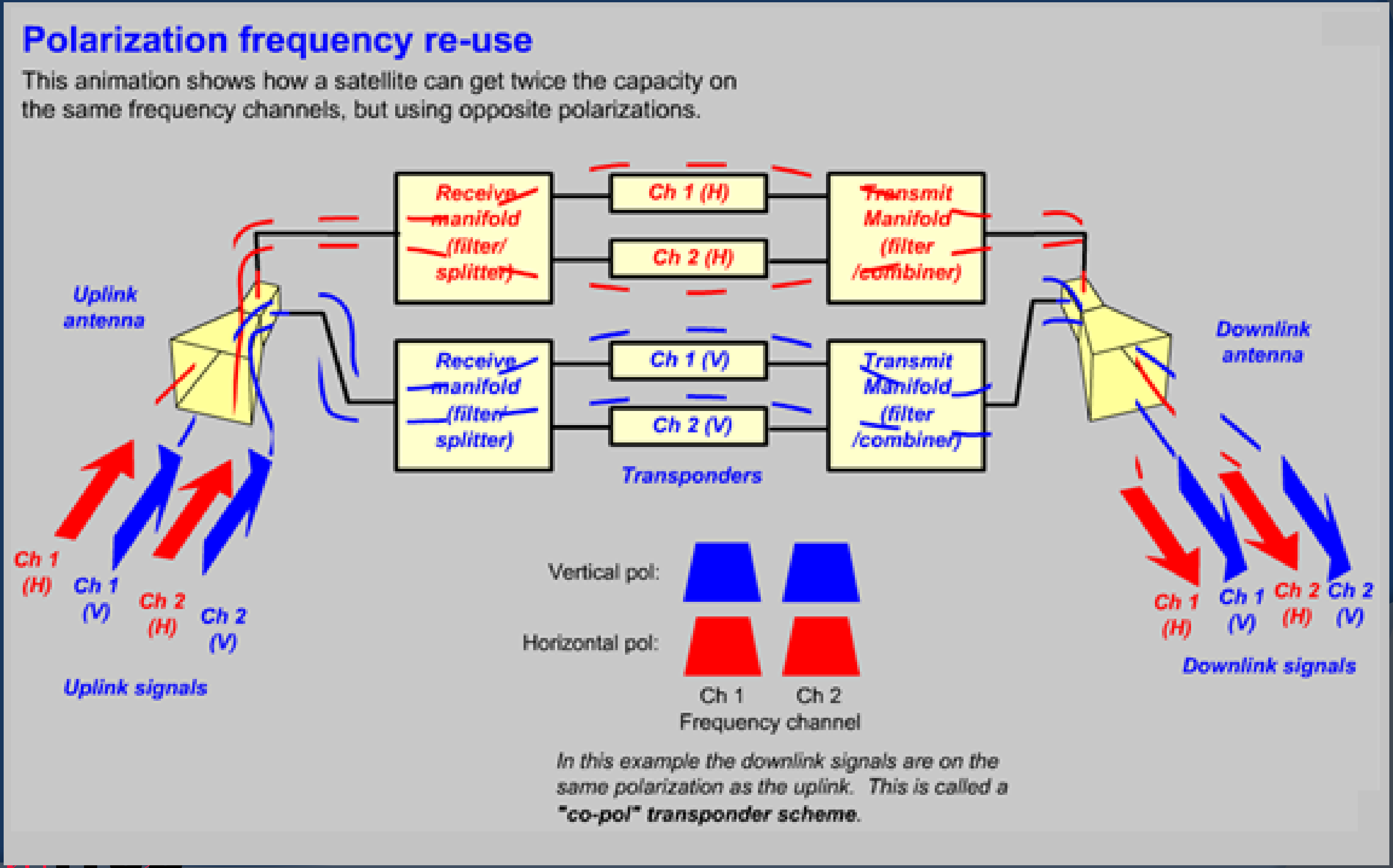


Circular polarization creation

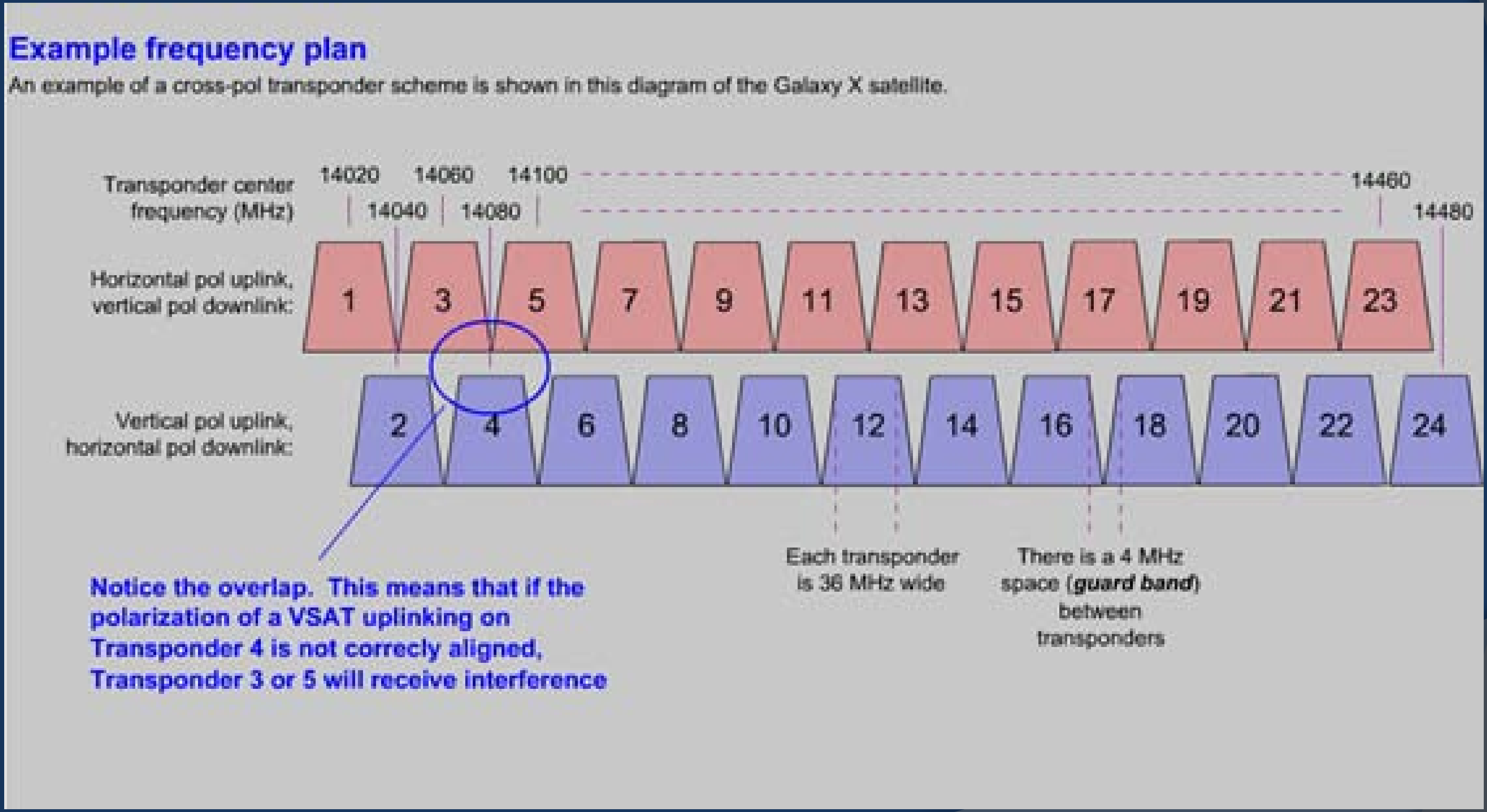


- Circular polarization is achieved
  - Splitting the linearly polarized signal into two orthogonal vectors
  - Delaying one with respect to the other by a quarter wave length (90°)
  - Summing the vectors

Transponder frequencies & polarization reuse

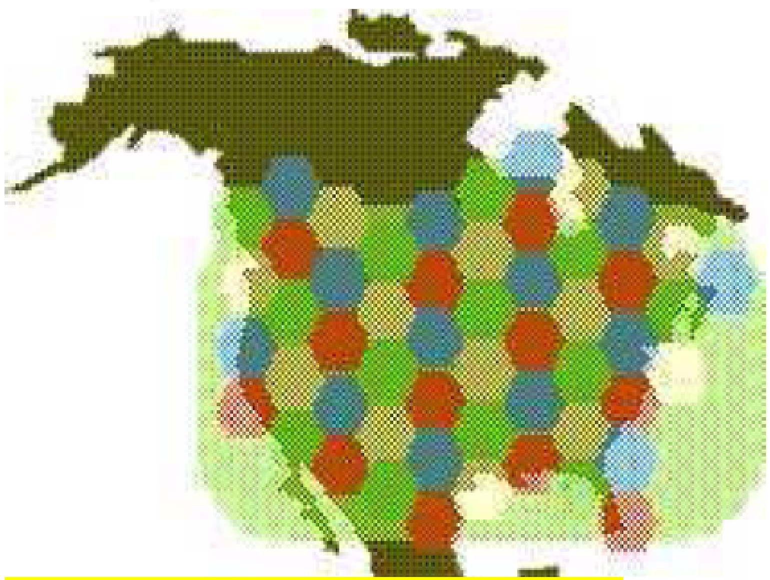


Transponder frequencies & polarization reuse



Transponder frequencies & polarization reuse (spot Ka)

Spatial Reuse – Spot Beams



- •Each color is a different frequency range
- •Similar colors don't touch -

- Ka Band uses multiple narrow beams
- Focused beams cover a much smaller area
- Hundreds of miles across, rather than thousands of miles with Lower Frequency FSS
- Form coverage cells
- Adjacent cells use different frequency ranges
- Frequency range reused many times over a wide geographical area

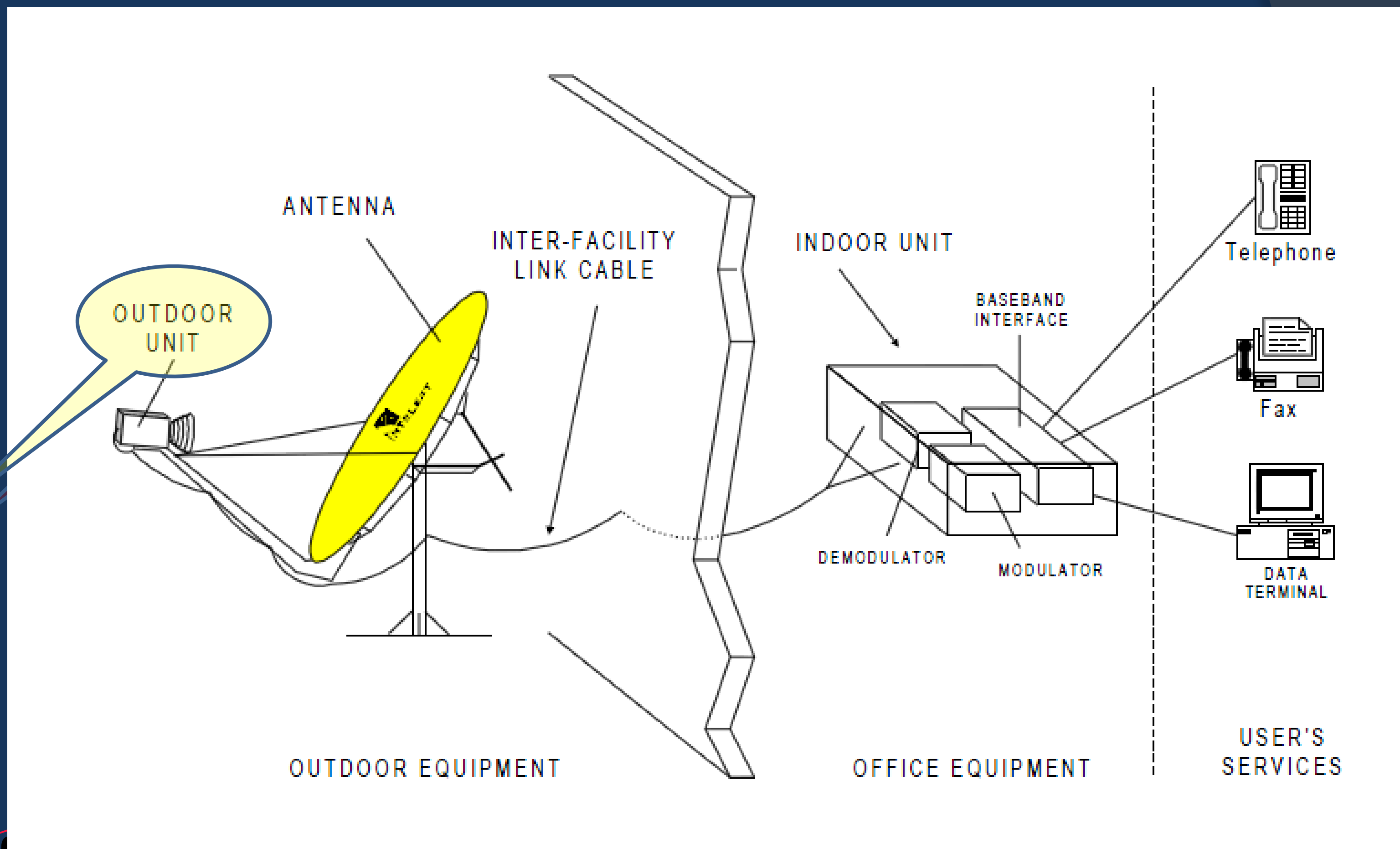
RF equipments

Under this designation we gather the elements of guided waves where we include the LNA - Low Noise Amplifier, the HPA - High Power Amplifier and the translators from RF(4GHz and 6GHz) to VHF (70MHz or 140MHz) namely:

ODU

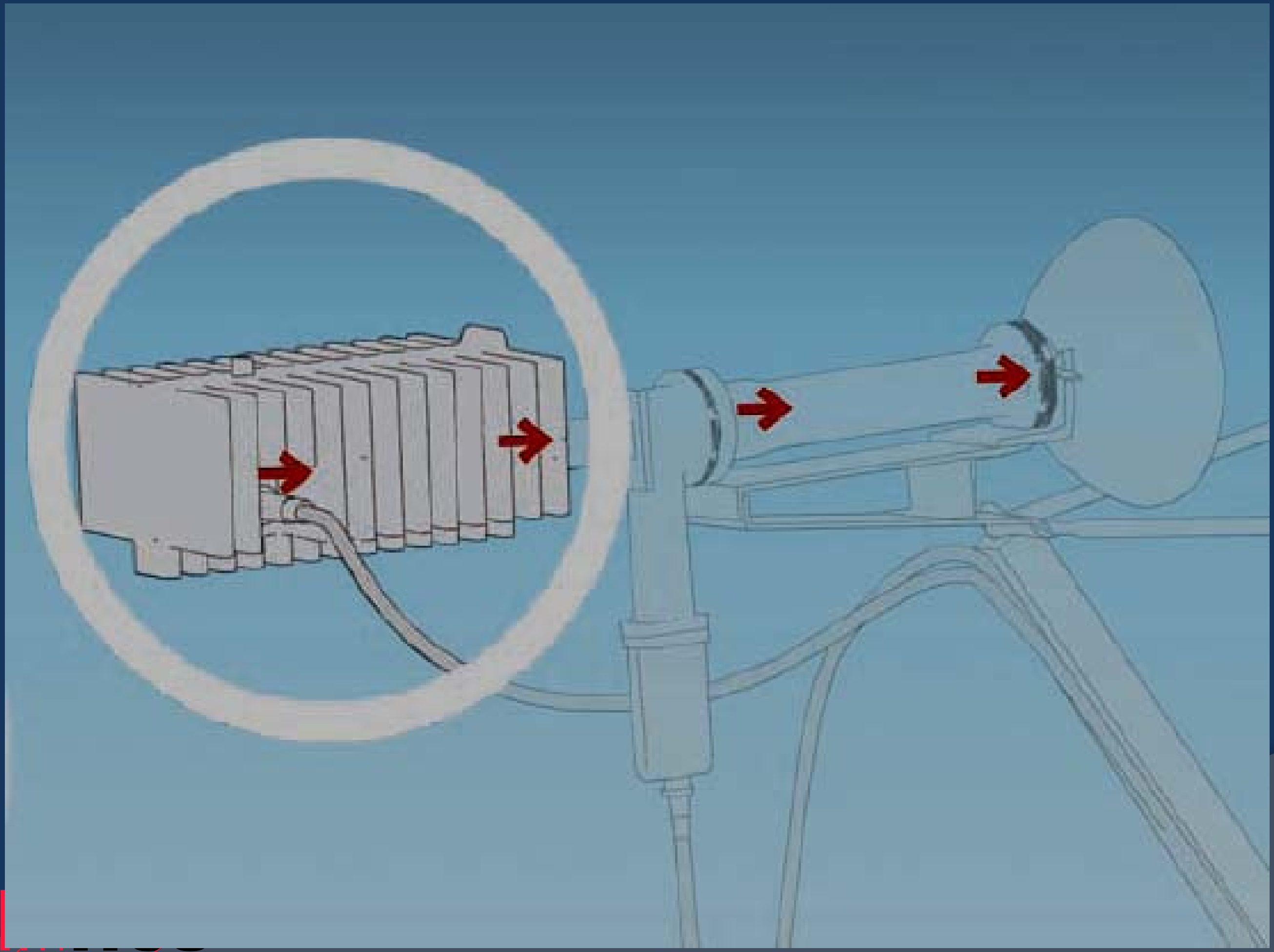
- BUC-Block up converter
- SSPA – Solid state power amplifier
- LNA(B)-Low noise amplifier (block converter)
- Down converter
- Couplers, Combiners,Dividers,circulators,switch ,power divider
- Filters, waveguide,coaxial etc
- Beacon receiver

RF equipments
transceiver, filters, waveguides and coaxial

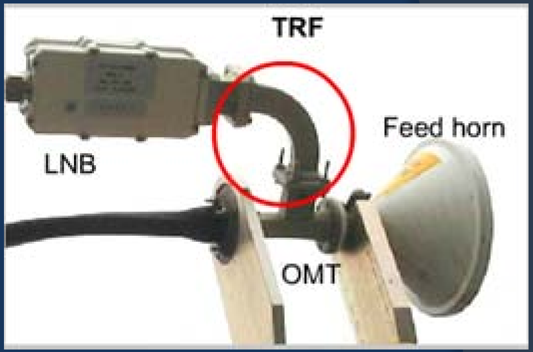


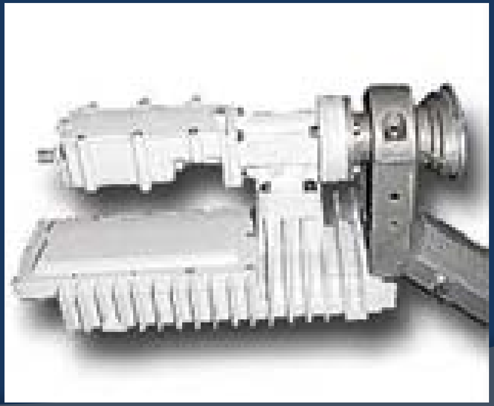
transceiver

RF Equipments
transceiver - BUC



RF Equipments
transceiver - BUC

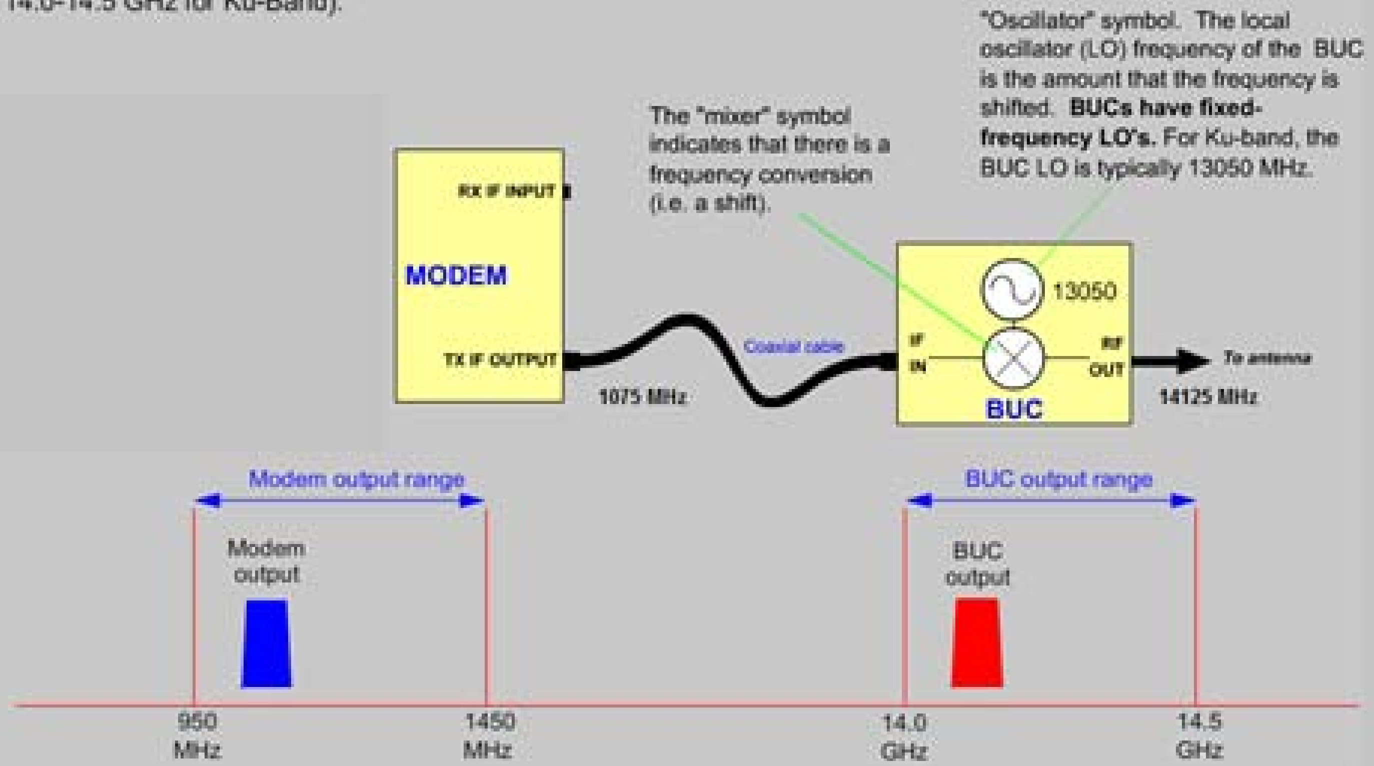




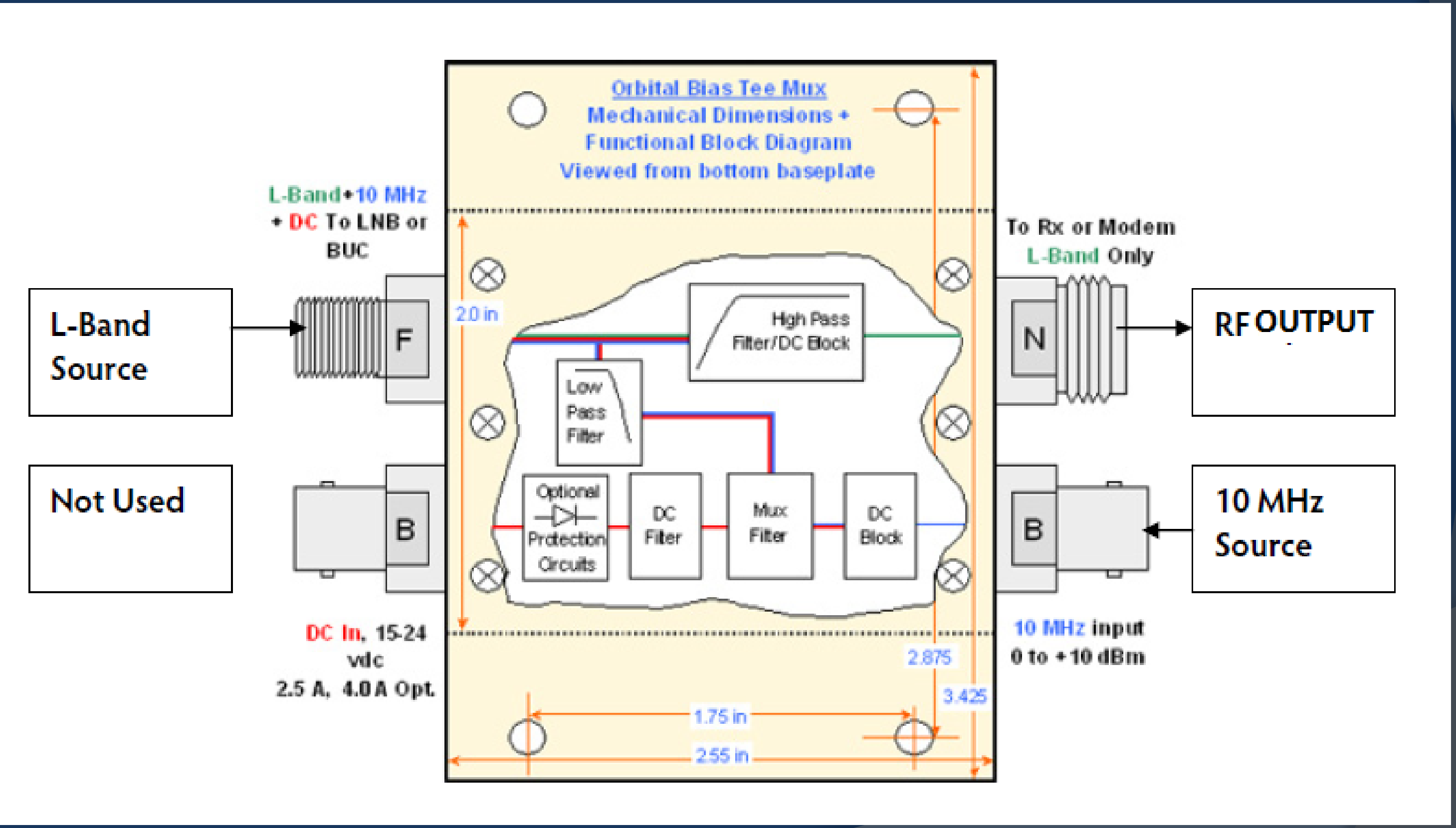
RF Equipments
transceiver - BUC

What does the BUC do?

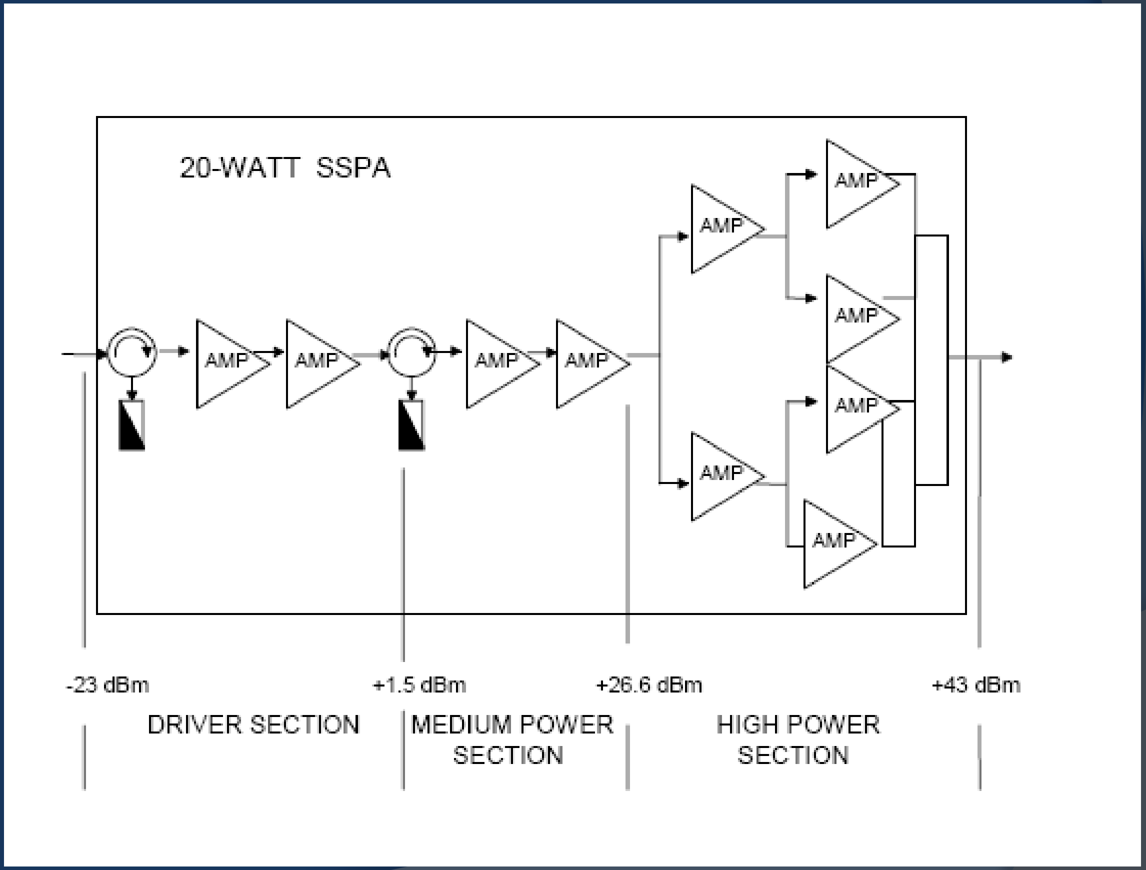
The BUC converts the IF frequency (typically 950-1450MHz) to the transmit frequency (typically 14.0-14.5 GHz for Ku-Band).



RF equipments transceiver - BUC



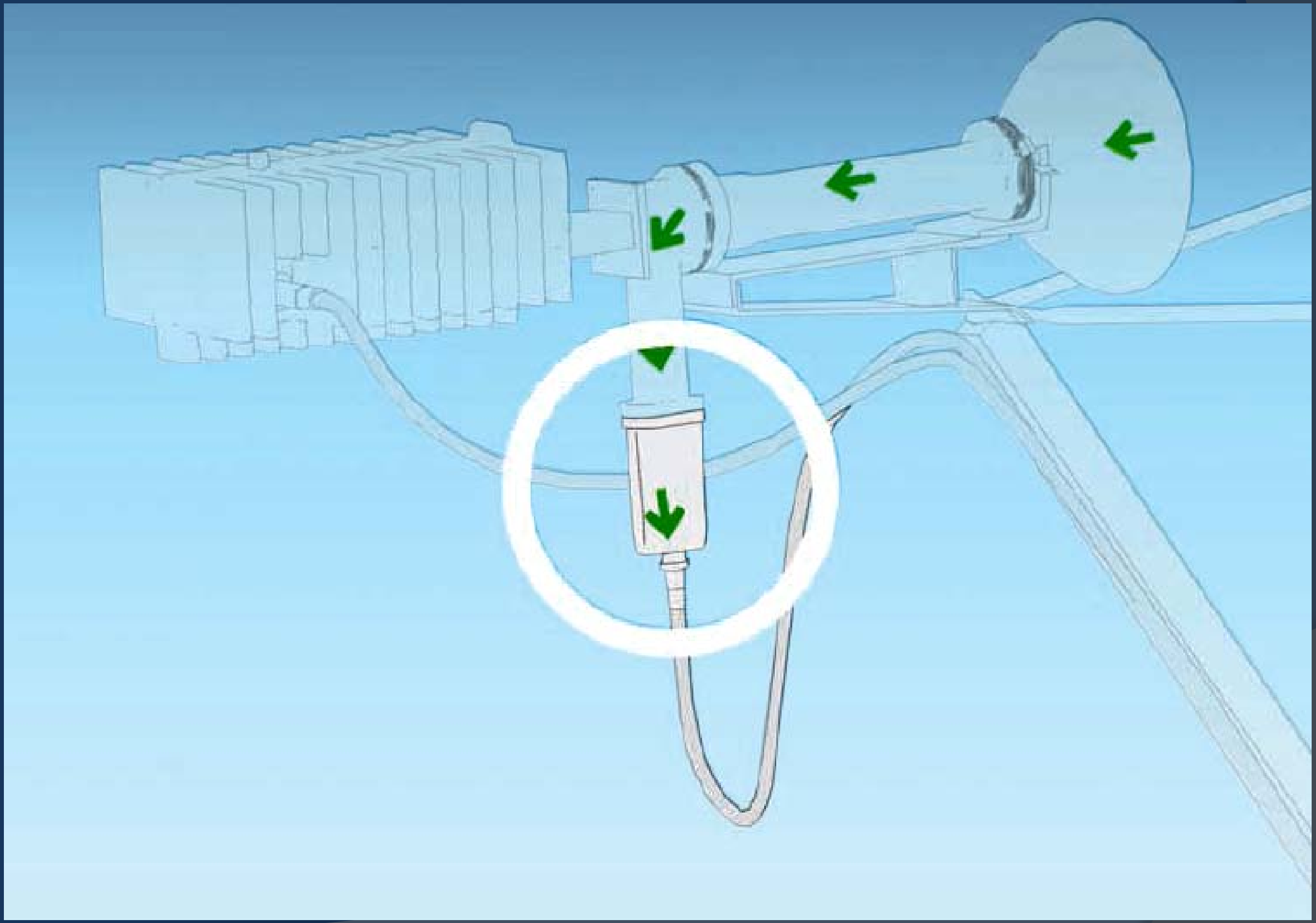
RF Equipments
transceiver - BUC (SSPA)



RF Equipments
transceiver - BUC

Item	Spec
IF frequency	70 or 140 MHz
IF bandwith	40 MHz minimum
RF freq range	C band (Ku band)
Freq stability	+/- 2 x 10-8 per month and 5x 10-8 per day (T ranges from 0º to 45ºC)
Output level	Adjustable over a range of +10 dB to -20 dB around the SSPA saturation drive level
Phase noise	Consistent with INTELSAT document IESS 308
Amplitude response	± 0.5 dB at ±36 MHz.
Frequency synthesizer step size	1 MHz
Gain stability	better than ± 0.5 dB per day over temperature ranges of 25 C ± 10 C.

RF Equipments
transceiver – LNB(C)



RF Equipments
transceiver - LNB

Standard LNB

8 output LNB

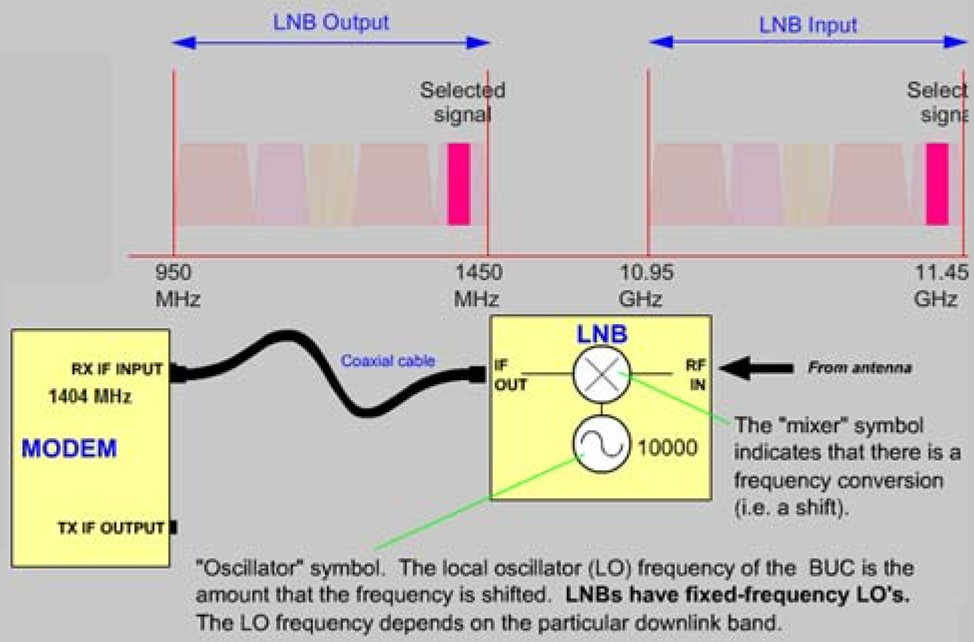
Twin output Monobloc LNB for sat. spaced close +/- 6º

RF Equipments transceiver - LNB

What does the LNB do?

The LNB amplifies the RF downlink frequency from the satellite (typically 10.95-11.45GHz or 12.25-12.75GHz for Ku-Band) and then converts it to the receive IF frequency of the modem (typically 950-1450 MHz).

Note that the LNB amplifies and converts the entire receive bandwidth. The demodulator in the modem must choose which signal to receive.

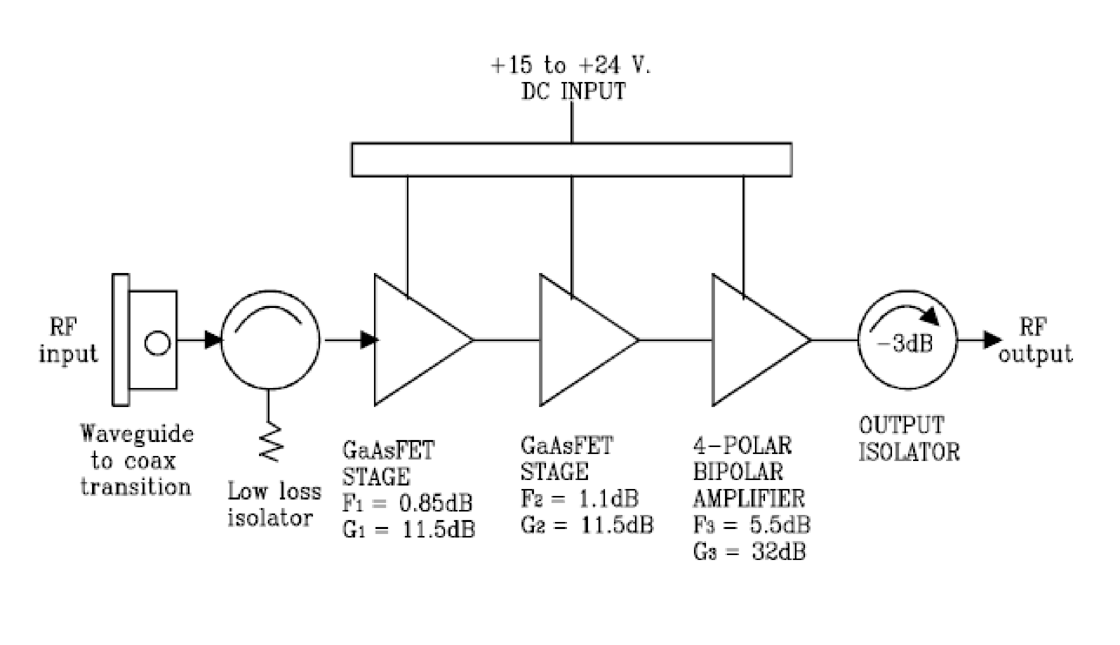


RF Equipments
transceiver - LNB

Item	Spec
Input freq band	12,25 to12,75 GHz
Input waveguide flange	WR 75
Noise figure (T1 – 25 ºC)	0,8 dB typ (1,3 dB mx)
Output freq band	950 to 1,450 MHz
Conversion gain	55 dB typ
Output power 1 dB compression	0 dBm min
Intermodulation products (3rd order)	31 dBc min
Local oscilator freq temp stability	11,2995 to 11,3005 GHz(11,300 +/- 500 KHz)
Power requirements	+ 12 to +24 Vdc

RF Equipments

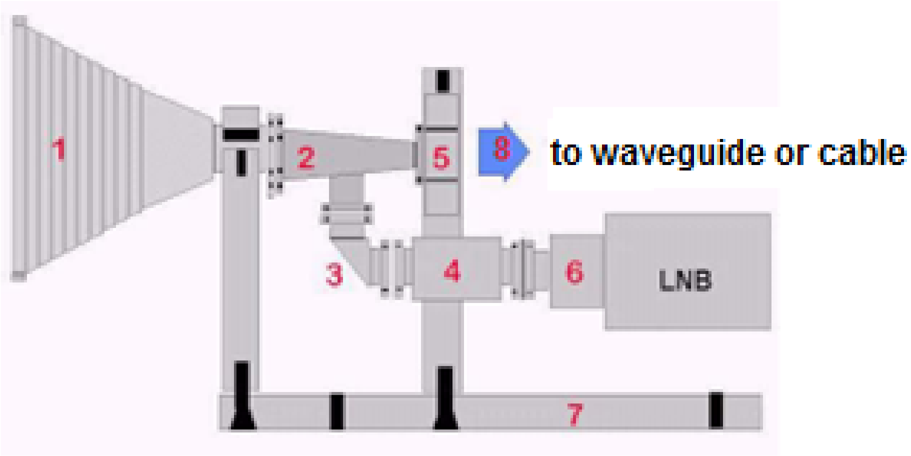
transceiver - LNA (SSPA)



An SSPA LNA FET typically uses 4 amp stages the 1st being thermo-electric cooled to -40º producing a a Ts 55 to 88 ºK for a Total gain of 60 dB

RF Equipments

Transceiver set



Standard feed installation in a offset antenna includes:

1 - Feed horn
2 - OMT also named diplexer
3 - 90º waveguide
4 - Transmission rejection filter
5 - Circular / rectangular adapter (donut)
6 - LNB (band L app) or LNC (IF band)
7 - Fixing bracket set
8 - Flexible waveguide / transmission line to IDU

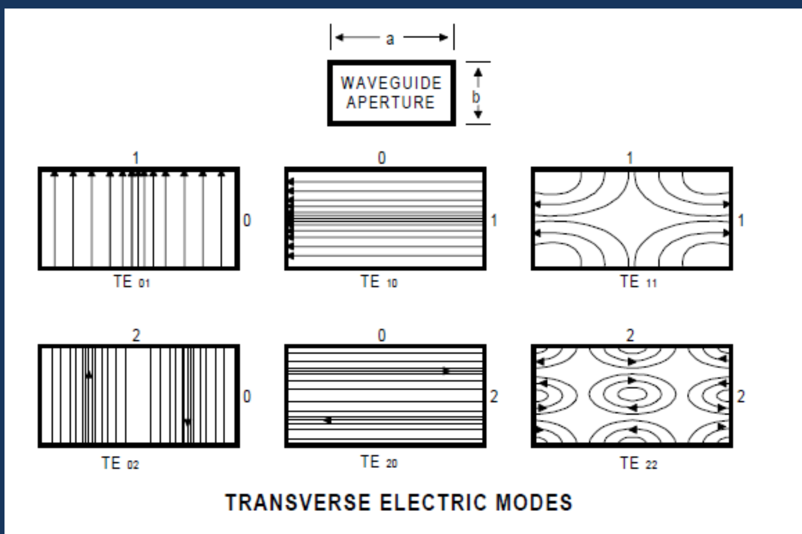
RF Equipments
Combiner / divider elements

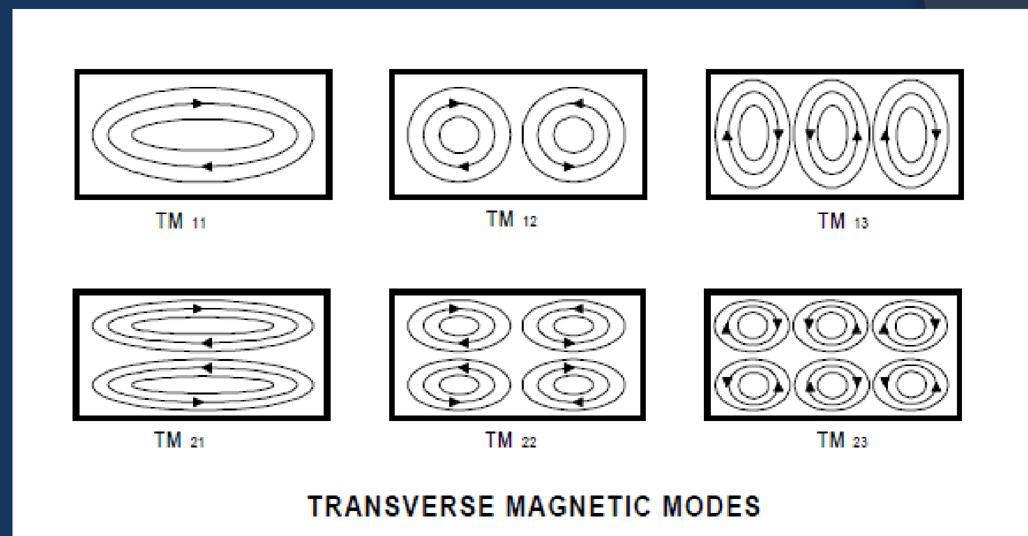
- The connection of transceiver to antenna shall be made to introduce low attenuation. For frequencies up to 2GHz it used coaxial cable because is cheap and has good characteristics and for frequencies above 2GHz (or bellow but with large IFL) it is used the waveguide (circular or rectangular) where the attenuation per meter is very low.
- For long distances (>20m) the waveguide are pressurized and the flanges shall be carefully choosen and in accordance with the IEC –International Electronics Commission Standards.

RF Equipments
Combiner / divider elements

- While a coaxial cable is a wideband transmission line, the waveguide can transmit only a determined low frequency called "cutoff“ frequency, which is the lowest frequency that can be transmitted, and depends on the waveguide sectional form and dimensions.
- At the higher frequency,other limits that have to be reached for the signal to be propagated along the waveguide.Transmission is made by modes(TE_{mn} and TH_{mn}) being dominant TE_{11} for the circular waveguide and the TE_{10} and TE_{11} for the rectangular waveguide

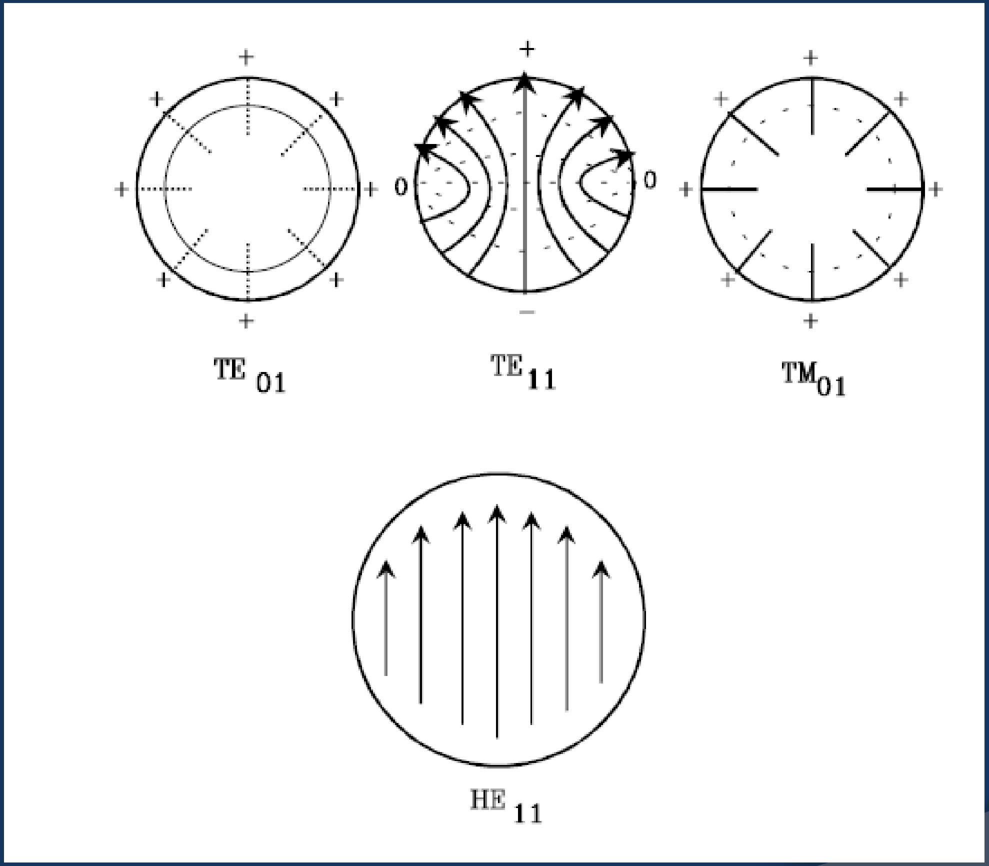
RF Equipments
Combiner / divider elements





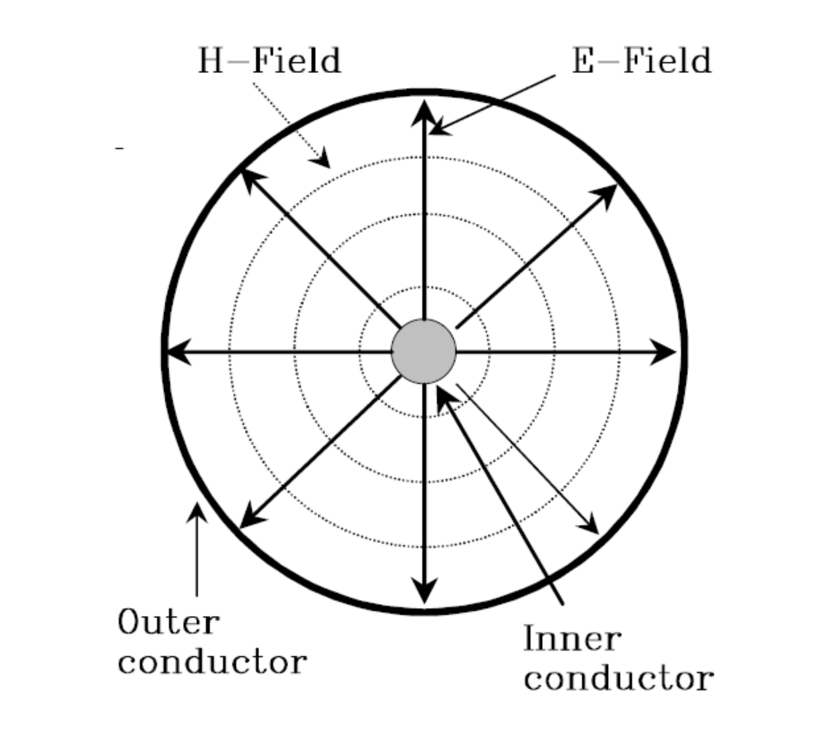
Some examples of rectangular waveguide modes are shown

RF Equipments
Combiner / divider elements



Some examples of circular waveguide modes are shown

RF Equipments
Combiner / divider elements



T_{mn} wave in a coaxial cable

RF Equipments
Combiner / divider elements

- In a typical Earth station there could be more than one power amplifier connected to the feed port of the antenna serving a particular polarization.
- Under these circumstances, it is necessary to combine the output of the amplifiers into a single signal path to the antenna feed.
- The output from the amplifier is usually in waveguide and is connected via one or more RF combiners
- An RF combiner can be one of three types, namely hybrids, circulators, and diplexers.

RF Equipments
Combiner / divider elements

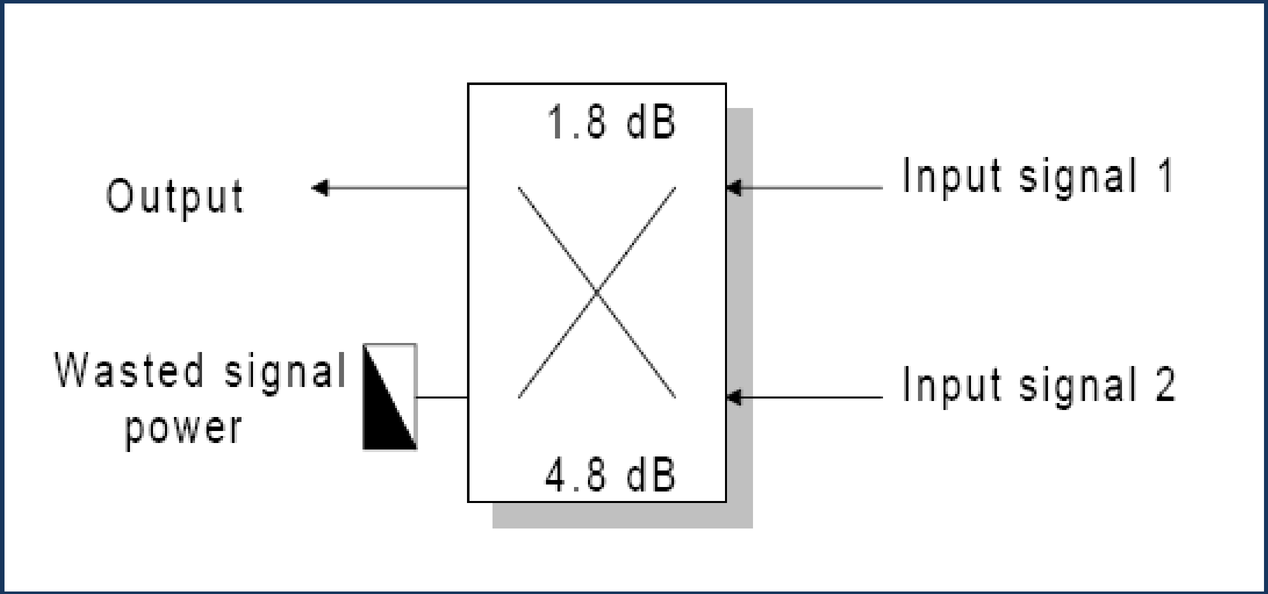
A 4-port splitter has four outputs.

The signal power is divided by 4, which is a **6 dB** loss. There is also typically an **extra 2 dB** of loss due to internal circuit losses. Therefore the loss from input to any output is about **8 dB**.

Tip:
You can remember how much loss a 4-port splitter has by thinking of it as dividing the signal by 2 (3 dB loss), then dividing by 2 again (another 3 dB loss).

So the total loss is simply 3 dB, plus 1 dB extra for each time the signal is split in two. The total loss is about:
3+1 + 3+1 = **8 dB**

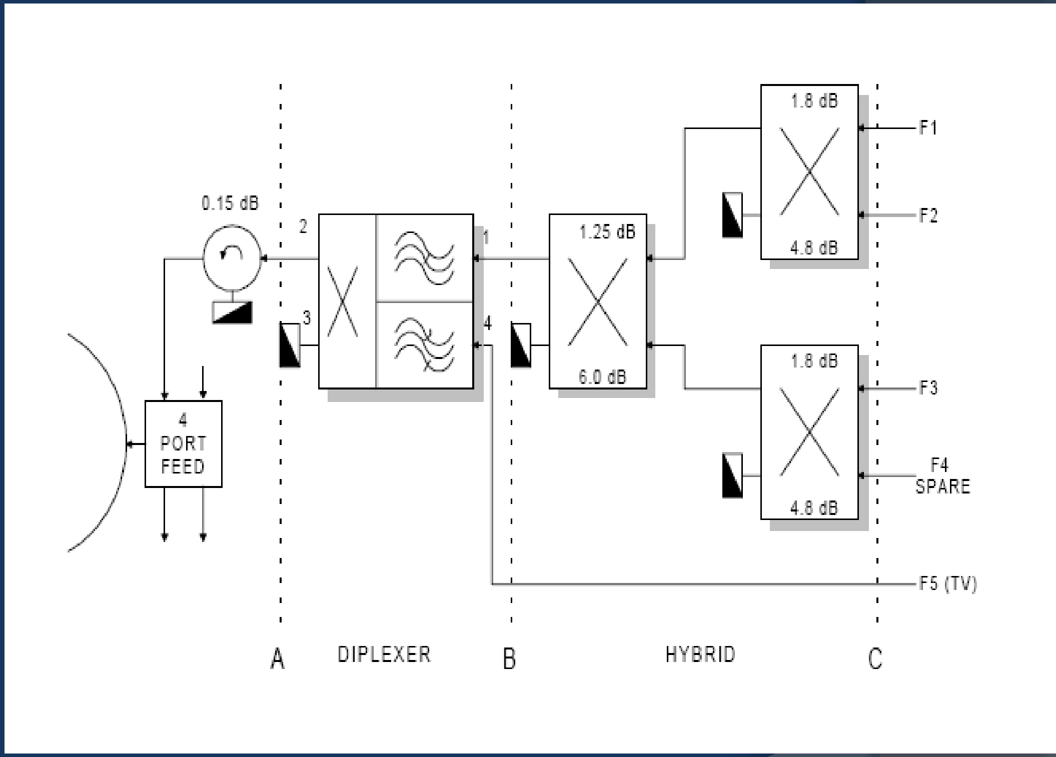
RF Equipments
Combiner / divider elements



Input	Loss in hybrid	Output 1	Output dummy
Input 1	1,8 dB (direct) 4,8 dB (cross)	66%	33%
input 2	same	33%	66%

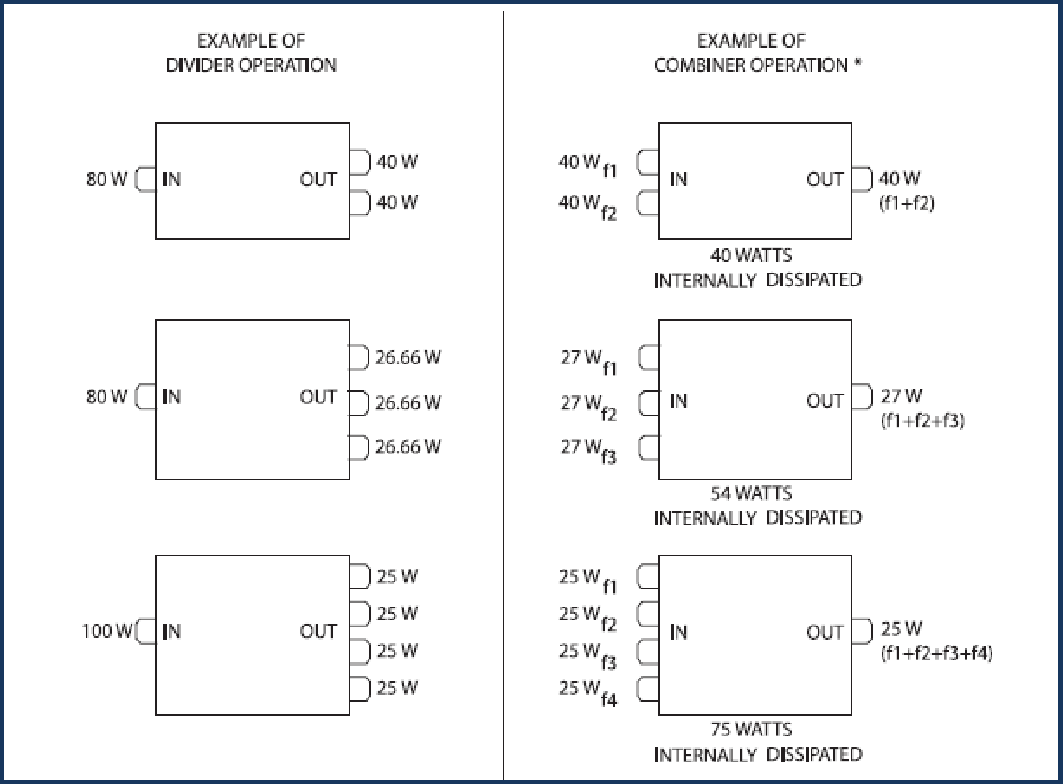
RF Equipments
Combiner / divider elements

Input	Hybrid loss (dB)	Diplexer loss (dB)	Total loss (dB)
F1	3	0,8	3,8
F2	6	0,8	6,8
F3	7,8	0,8	8,6
F4	10,8	0,8	11,6
F5	…..	1,8	



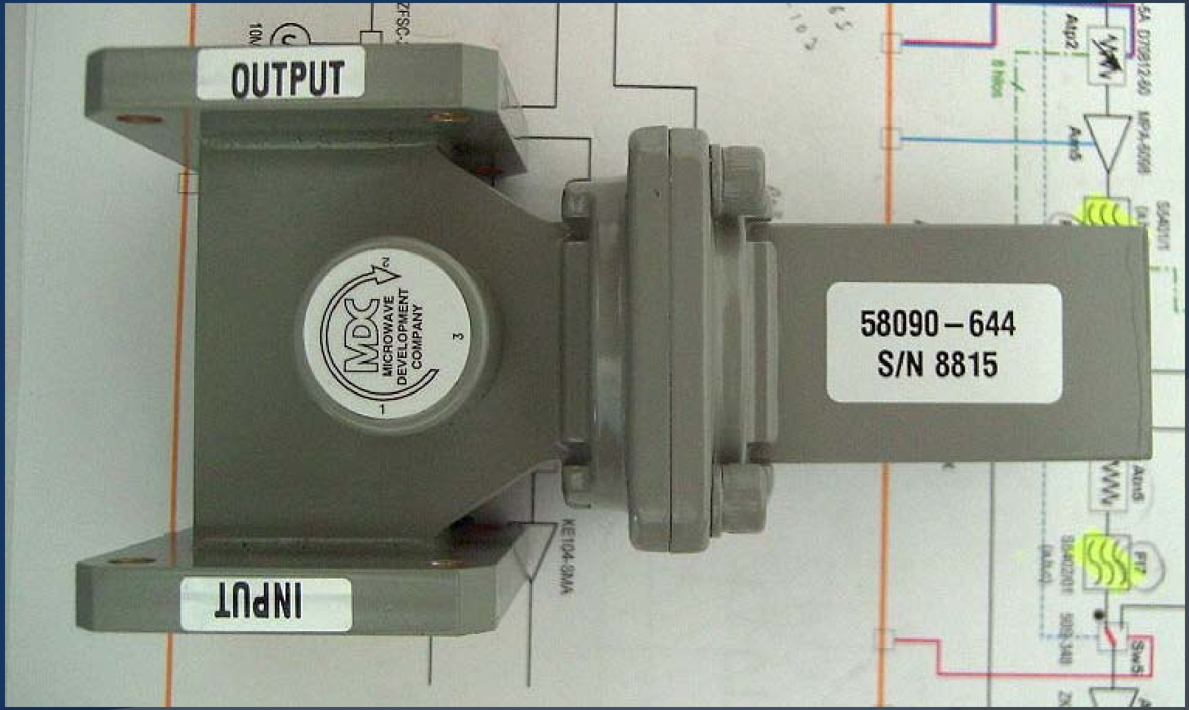
Low loss combination, although it is specific on the frequency diplexer

RF Equipments
Combiner / divider elements

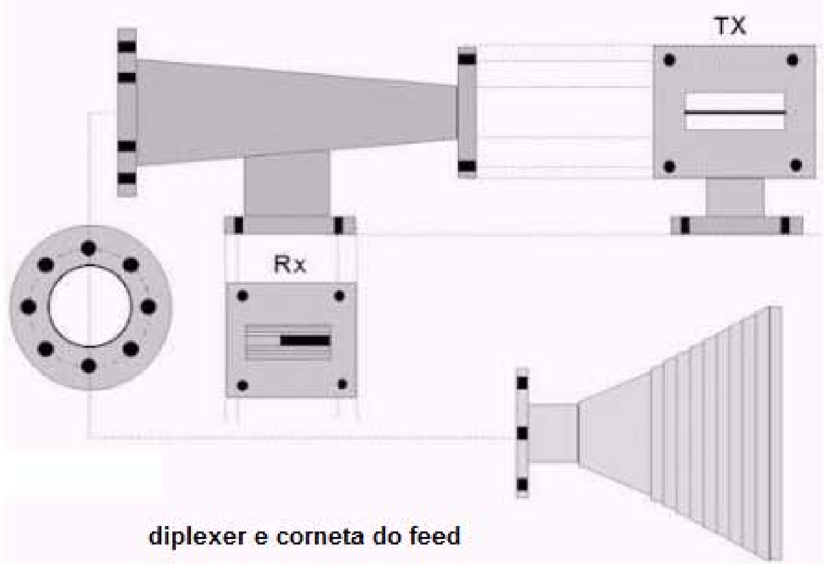


RF Equipments
Combiner / divider elements

Circulador (duplexer)



RF Equipments
Combiner / divider elements



diplexer e corneta do feed


exemplo tipico de diplexer

RF Equipments
Combiner / divider elements

- RF couplers are circuits that sample RF transmissions by combining (coupling) signals asymmetrically. There are three basic types of devices, unidirectional, bidirectional and dual directional.
  - Unidirectional RF couplers are four-port devices with a main input and output line, a coupled line with a coupled output, and an internal termination on the fourth port. The power passing from the input to the output is combined with the coupled output, but the coupled output is isolated from the main output. Any reflected power from the main line output is coupled to the termination.

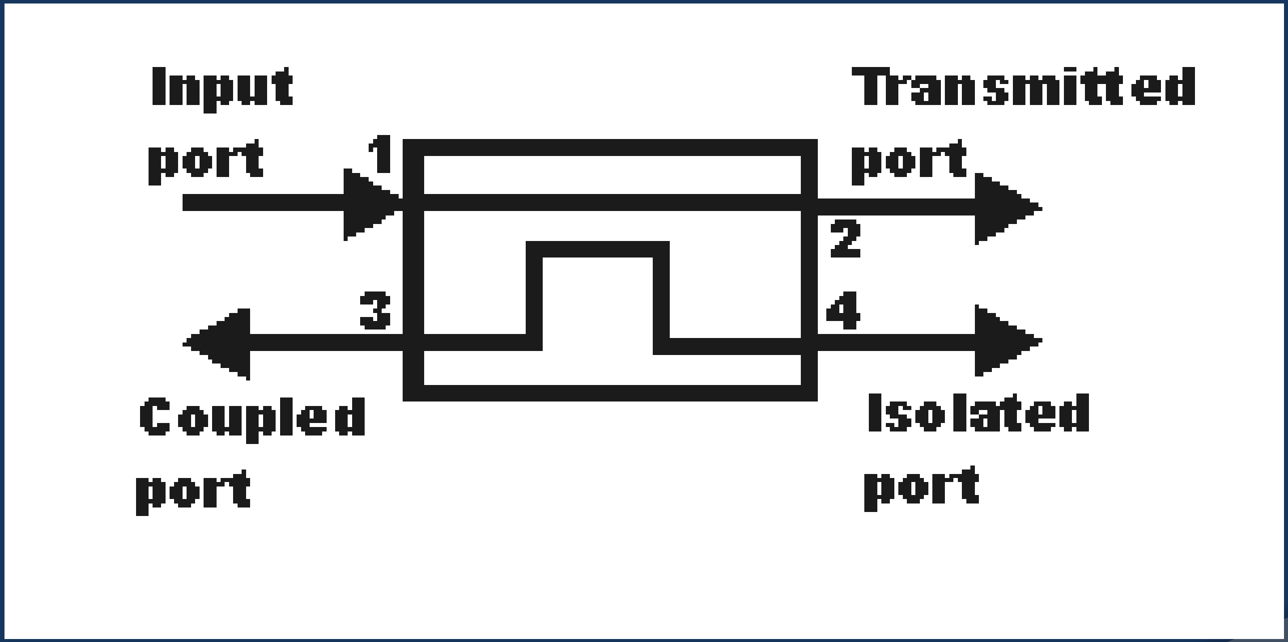
RF Equipments
Combiner / divider elements

- Bidirectional RF couplers are similar to unidirectional couplers, but do not provide termination on the fourth port. Main line power is coupled to the forward output of secondary line and reflected power is coupled to the reflected output. For isolation to be achieved, coupled outputs must be obtained through well-matched terminations at each port.

RF Equipments
Combiner / divider elements

- Dual directional RF couplers are four-port devices that consist of two unidirectional couplers. They can be connected back-to-back in series, with the main line output of the forward coupler connected to the output of the second coupler; or integrated into one device with a single main line and two secondary lines. Integration in a single device provides several advantages, including a shorter or more compact unit. In addition, because there is only one main line, insertion loss is reduced and high isolation is more easily attained.

RF Equipments
Combiner / divider elements



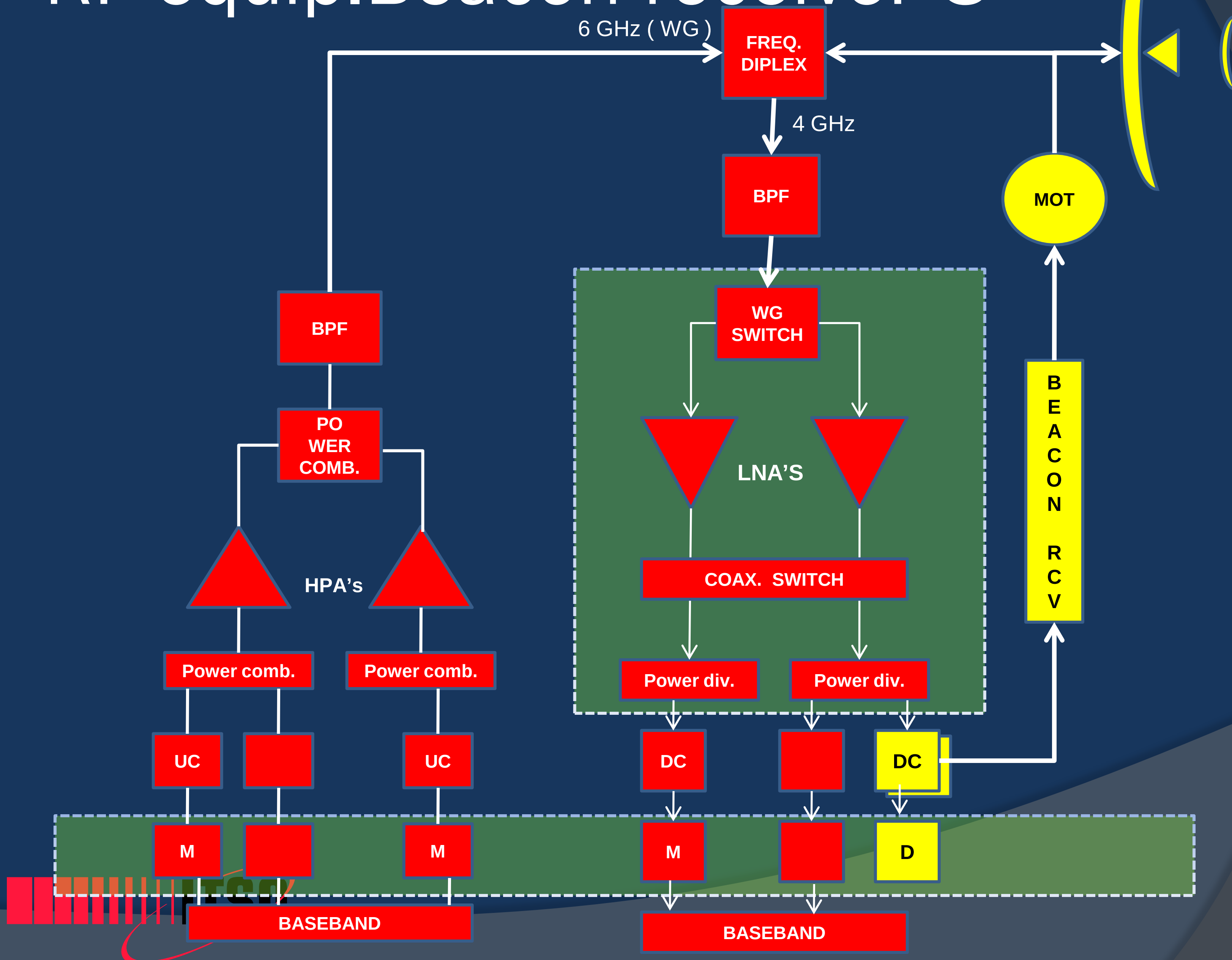
RF Equipments
Beacon receiver 1

- O beacon do satélite é um sinal muito fraco da ordem de 1,5 x 10-15 W (1,5 fW) ou seja menos118 dBm - normalmente não modulado - cuja finalidade é permitir o “tracking”, o “up-link power control” bem como acções de telemetria e pesquisa.
- O sinal é sucessivamente “shiftado” e amplificado em unidades conversoras de forma a colocar o beacon centrado na IF de 70 MHz no “beacon receiver” que seleciona um dos pilotos (cada satélite tem mais do que 1) e fornece um sinal DC à unidade de controlo da antena.

RF Equipments
Beacon receiver 2

- This unit is therefore responsible for signal optimization decisions of antenna towards the satellite research, generating the appropriate elevation and azimuth controls. "
- On the other hand transducers type "Synchros or variable potentiometers" in each one of the axes of the antenna provide feedback of position at each moment to a centralised control room display.

RF equip.Beacon receiver 3



Earth station measurements

- Spectrum Analyser
- Power meter & Power sensor
- Data analyser (*ber test*)
- Volt-ohmmeter
- .....
- dB, dBm, dBW
- EIRP
- C_0+N_0/C_0

Spectrum analyser

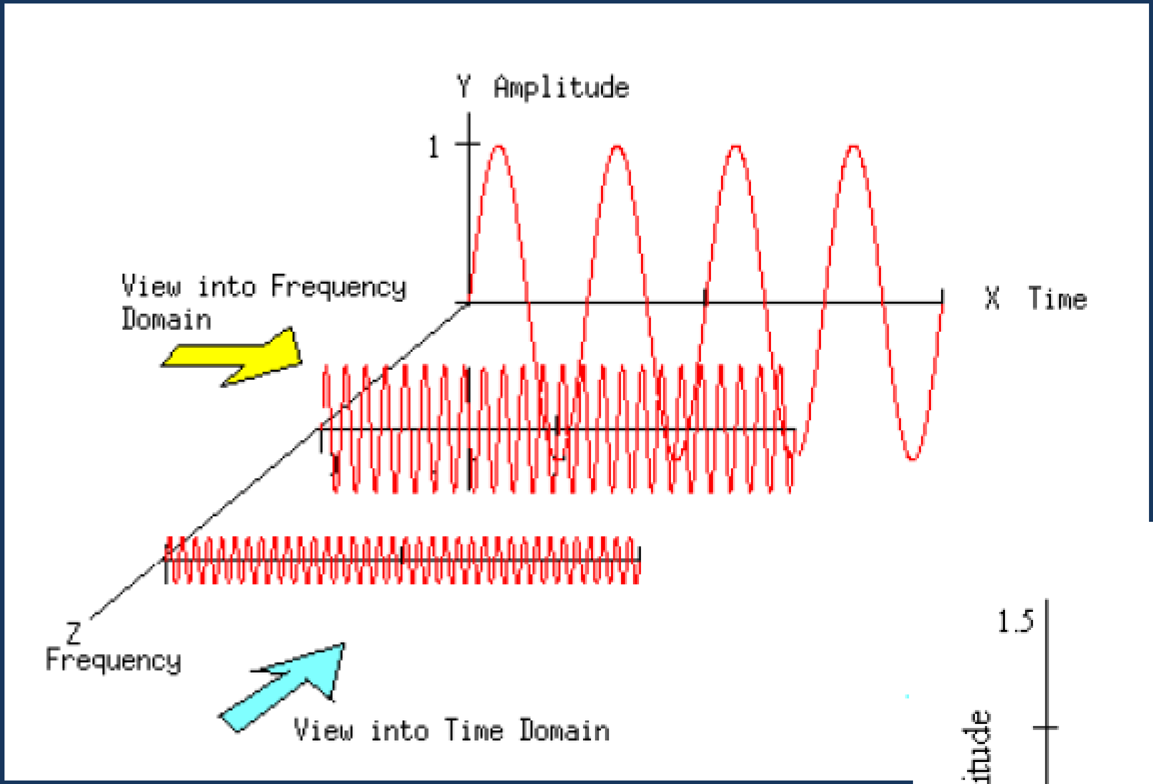
- The standard method for observing electric signals is to use an oscilloscope. The horizontal axis of a CRT oscilloscope increases by a unit of time. Oscilloscopes are sometimes referred to as time-domain instruments. Observation in time domain is useful to obtain signal timings and phases.

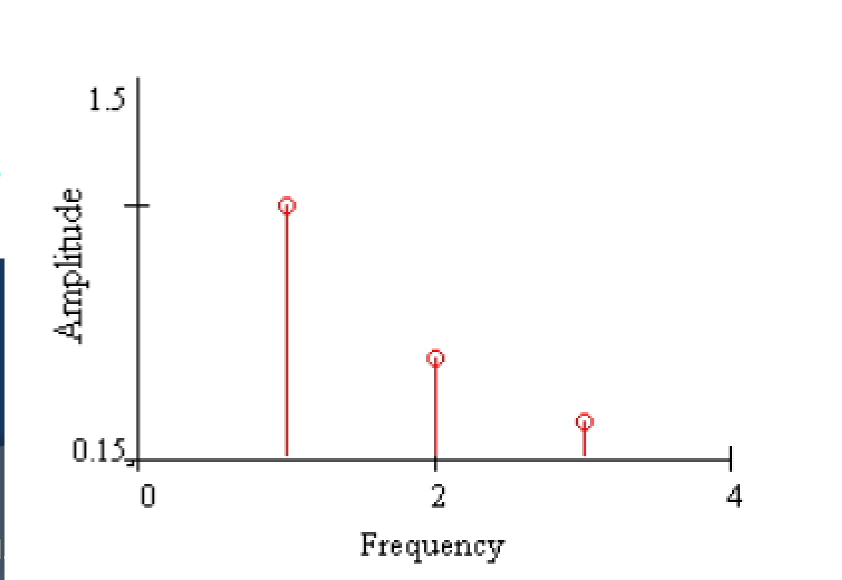
- But the performance of certain elements such as amplifiers, oscillators, mixers, modulators, filters, and others require the analysis of other characteristics (frequency response, harmonic distortion, intrinsic noise) and meaningful information is not attained until their frequency responses are obtained. Instruments that display levels of an electric signal as a function of the respective frequencies are called frequency domain instruments, called spectrum analyzer

Spectrum analyser

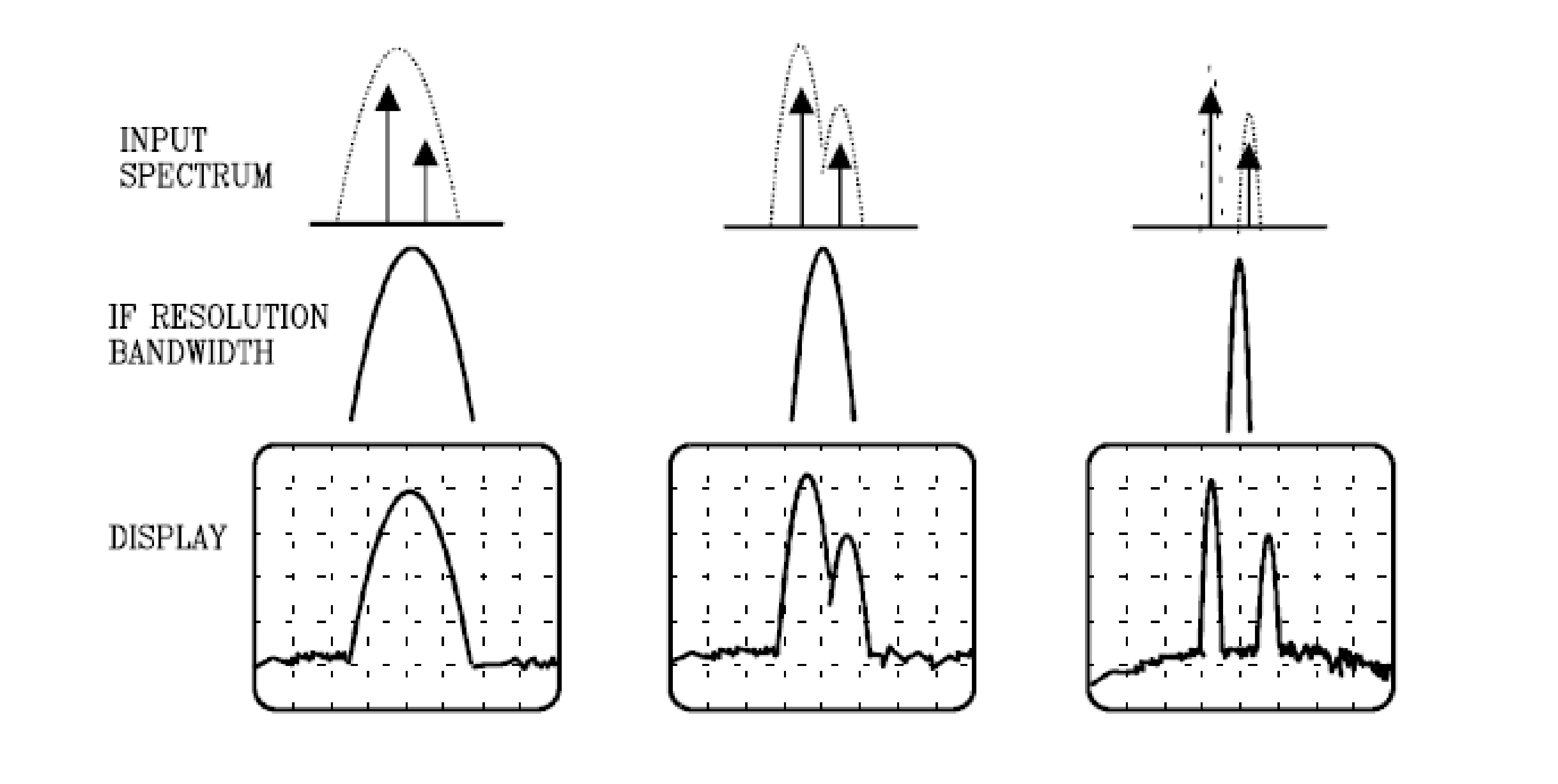
- Being basically one receiver with scanning capacity, they integrate one filter of variable tunning (mixer) to convert the input signal into several IF's as many as the components within the original signal, showing them according to resolution band filters used , and in way to become possible to visualize them.
- According to the RF band we wish to check, that there are specific types of spectrum analyser e.g. DC-8GHz, 10Hz-6,2GHz or 9GHz-20GHz

Spectrum analyser



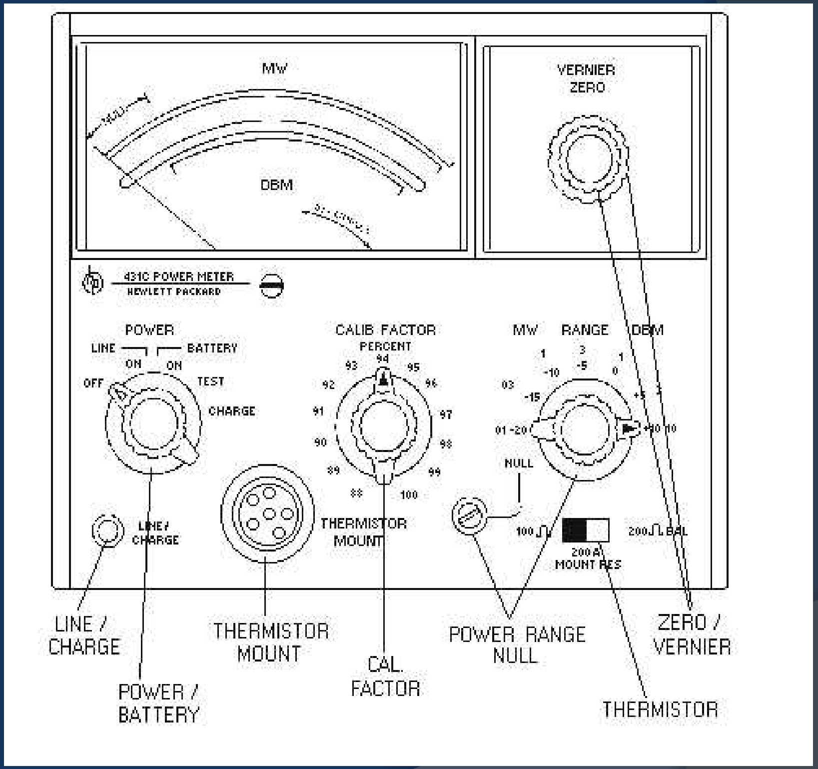


Spectrum analyser resolution filter



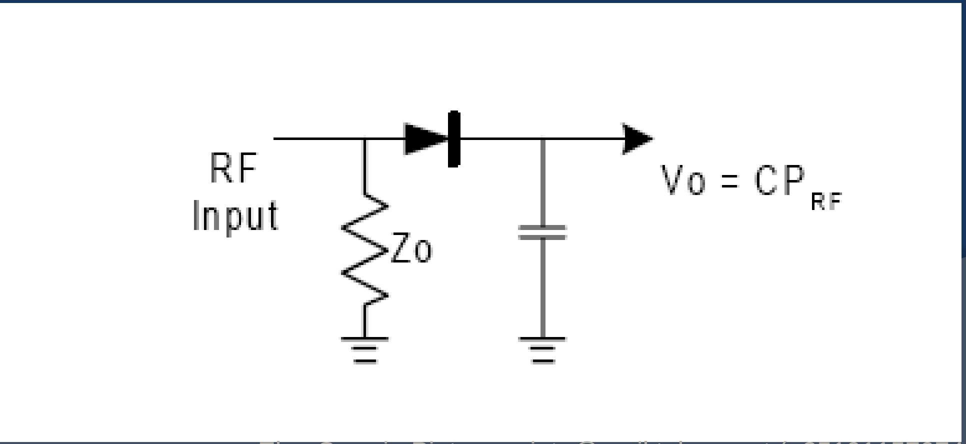
Power meter

A common technique for measuring power at high frequencies is to employ a sensing element that converts the RF power to a Measurable DC or low – frequency signal.The sensing element is often designed to form a termination that is matched to the characteristic impedance of the input transmission line.Various types of sensing elements are used……



Power sensor

Diode sensors, create a DC voltage (less than 10 mV), being the typical read range of 0.1 nW to 10 mW and maximum frequency of 18 GHz. Its operation uses the principle of Shottky barrier diode to detect if the RF signal. If RF voltage is less than 20mV the diode presents outside the square of the input voltage or DC voltage is proportional to the power of RF. To RF tensions higher, output rectified changes gradually to detection mode profile. Diode sensors have to be previously calibrated with accurate RF signals.



Data analyser

1. In digital communication, bit errors can be generated as a result of noise, jitter, or level variations. If such distortions occur, the transmitted information is received in a deformed condition, which means deterioration of the transmission quality.
2. Transmission quality is measured in terms of the degree of variation of bits (error rate). To measure the error rate accurately, a sequence of bits simulating the real data is transmitted at a rate equal to the transmission rate…..

Data analyser

3. This pattern, called Pseudo-Random Bit Sequence (PRBS), is then compared with the one generated at the receiver, and the ratio of detected mismatched bits to the total number of bits is calculated as the bit error rate.
4. The pseudo-random bit sequence must adhere to ITU-T Recommendations O.151 and O.152 to ensure compatibility between equipment. The length of test patterns is selected according to the transmission rate of the system being tested.

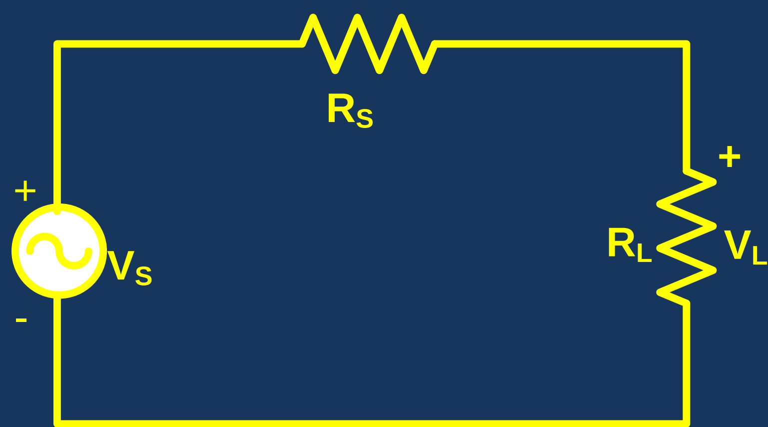
Measurement units

Decibel (dB) definition

- The decibel (dB) is a subunit of the bell (B) and represents the ratio between two powers such as:
  - dB = 10 log 10 (P_0 / Pi) where
  - Log 10 is the logarithm in the base 10
  - Po is the output power in a amplifier
  - P_i is the input power in the previous amplifier
- The result will be an amount representing the power gain of the amplifier. The dB can not be used by itself to represent a magnitude unless a reference quantity is specified. The abbreviation for decibel is dB and it is often modified to suggest the reference value, as following:
  - dBm is used to express power related to 1 milliwat
  - dBi is used to express the gain of an antenna relative to the isotropic one

Measurements unit - dBW

CASE STUDY



We can say

$P_L = P_S . R_L / R_T$

Where

$R_T = R_L + R_S$

$V_L = V_S . R_L / (R_L + R_S)$

$P_L = P_S . R_L / (R_L + R_S)$

$10 \log_{10} (P_L / P_S) = 10 \log_{10} (R_L / R_T)$

$10 \log_{10} (P_L) - 10 \log_{10} (P_S) = 10 \log_{10} (R_L / R_T)$

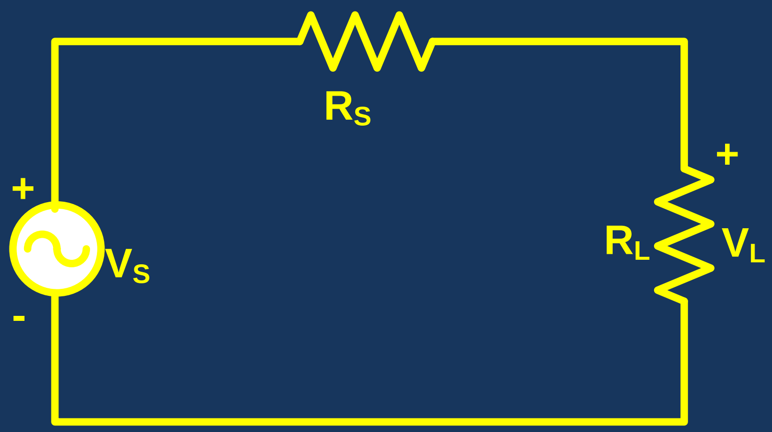
Or dividing all by 1W (meaning express power Watt)

$10 \log_{10} (P_L/1W) - 10 \log_{10} (P_S/1W) = 10 \log_{10} (R_L / R_T)$

$P_L (dBW) - P_S (dBW) = 10 \log_{10} (R_L / R_T)$

Measurements unit - dBm

IF WE EXPRESS POWER IN mW



We can say that

$P_L = P_S . R_L / R_T$

Where

$R_T = R_L + R_S$

$V_L = V_S . R_L / (R_L + R_S)$

$P_L = P_S . R_L / (R_L + R_S)$

$10 \log_{10} (P_L / P_S) = 10 \log_{10} (R_L / R_T)$

$10 \log_{10} (P_L) - 10 \log_{10} (P_S) = 10 \log_{10} (R_L / R_T)$

Or dividing all by 1mW(express power in mWatt)

$10 \log_{10} (P_L/1mW) - 10 \log_{10} (P_S/1mW) = 10 \log_{10} (R_L / R_T)$

$P_L (dBm) - P_S (dBm) = 10 \log_{10} (R_L / R_T)$

Measurements unit dBr, dBm0,dBm0p

- We can express one ratio referred to a determined point and in such case will be dBr.
- For instance if we consider in a monitoring point the nominal level of one carrier as 10 dBm and in another we measure +8,7dBm, we can say that in the measurement point we have -1,3dBr.
- Same way we define dBm0 and dBm0p as the power referred to a transmission point of level zero, or to a point of level zero noise power respectively

Designation	Reference	Conversion tabl
dBm	1 mW	dBm = dBW + 30
dbW	1 W	dBW = dBm - 30

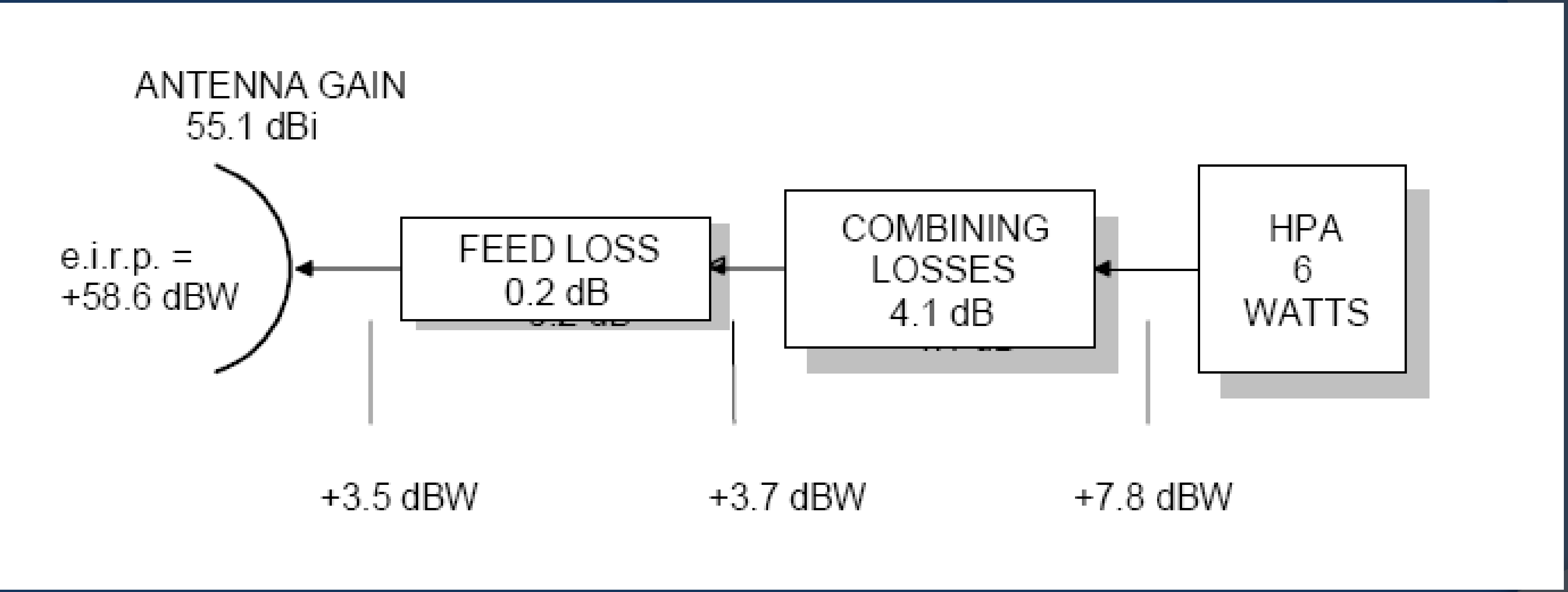
Measurements unit general concept

- The decibel concept is extended allowing the ratio of any two similar quantities to be expressed in decibel units. For example two temperatures T_1 and T_2 may be expressed as 10 $\log_{10} (T_1 / T_2)$ and if the temperature T_2 is referred to 1ºK, the temperature Kelvin expressed in decibels would be given as dBk. For instance T_1 = 290º K can be expressed by 10 $\log_{10}(290 / 1)$ dBk or 24,64 dBk
- Another example that occurs widely in practice is bandwith referred to 1Hertz. Thus a bandwith of 36 MHz, is equivalent to 10 $\log_{10}36000000$ =75,56 dBHz …….

Measurements unit general concept

- Decibel units can be added directly even if diferent units are used. If a power of 34 dBW is transmitted through a circuit that has a loss of 20 dB, the received power P_R = 34 dBW - 20 dB = 14 dBW
- Sometimes diferent types of ratio are related. A good example is the ratio G / T in a receiving system. Expressed in decibels G / T dBK^{-1} = G dBi - T dBK
- Or the ratio E_B / N_0 called Energy per bit / Noise Spectral density ratio:
  - E_B / N_0dB = C / N0 dB / Hz - 10log10(data rate) dB / Hz, where
  - E_B dBW / Hz – Energy per bit referred to data rate
  - N_0dB / Hz – Noise spectral density
  - C dbW – Carrier power

Measurements unit - example



EIRP = HPA output - feed loss - combiner loss + antenna gain

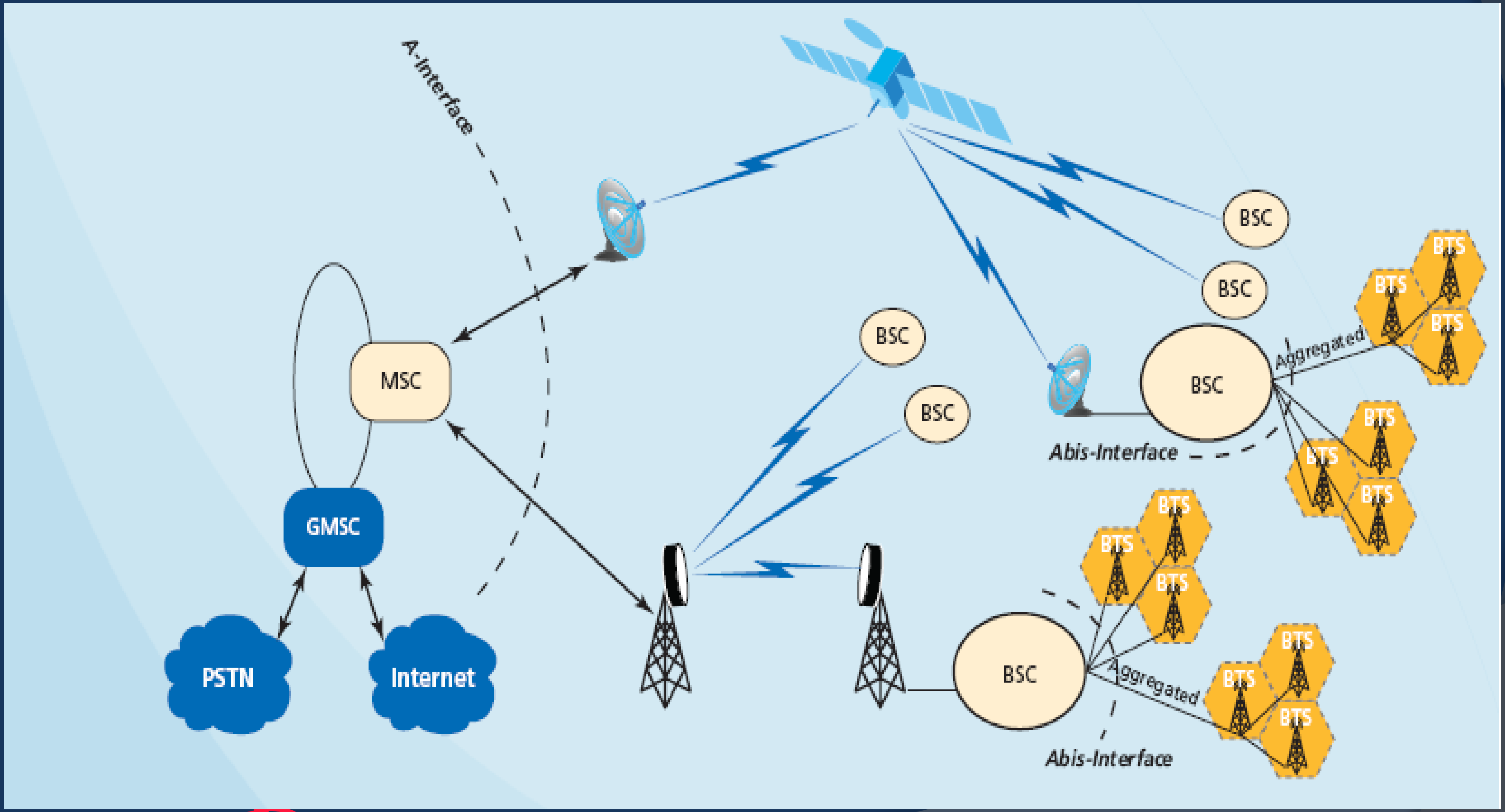
Basic services

- Voice
  - Mobile Backbone, cells connection
  - Private line
  - Trunking IP
  - SCPC
  - Maritime broadband
  - VoIP (Digital Divide)
- Vídeo
  - IPTV (corporate TV)
  - Multicast
  - Broadcast (DVB-S)
  - SNG
- Data
  - Internet
  - B2B, B2C, C2C

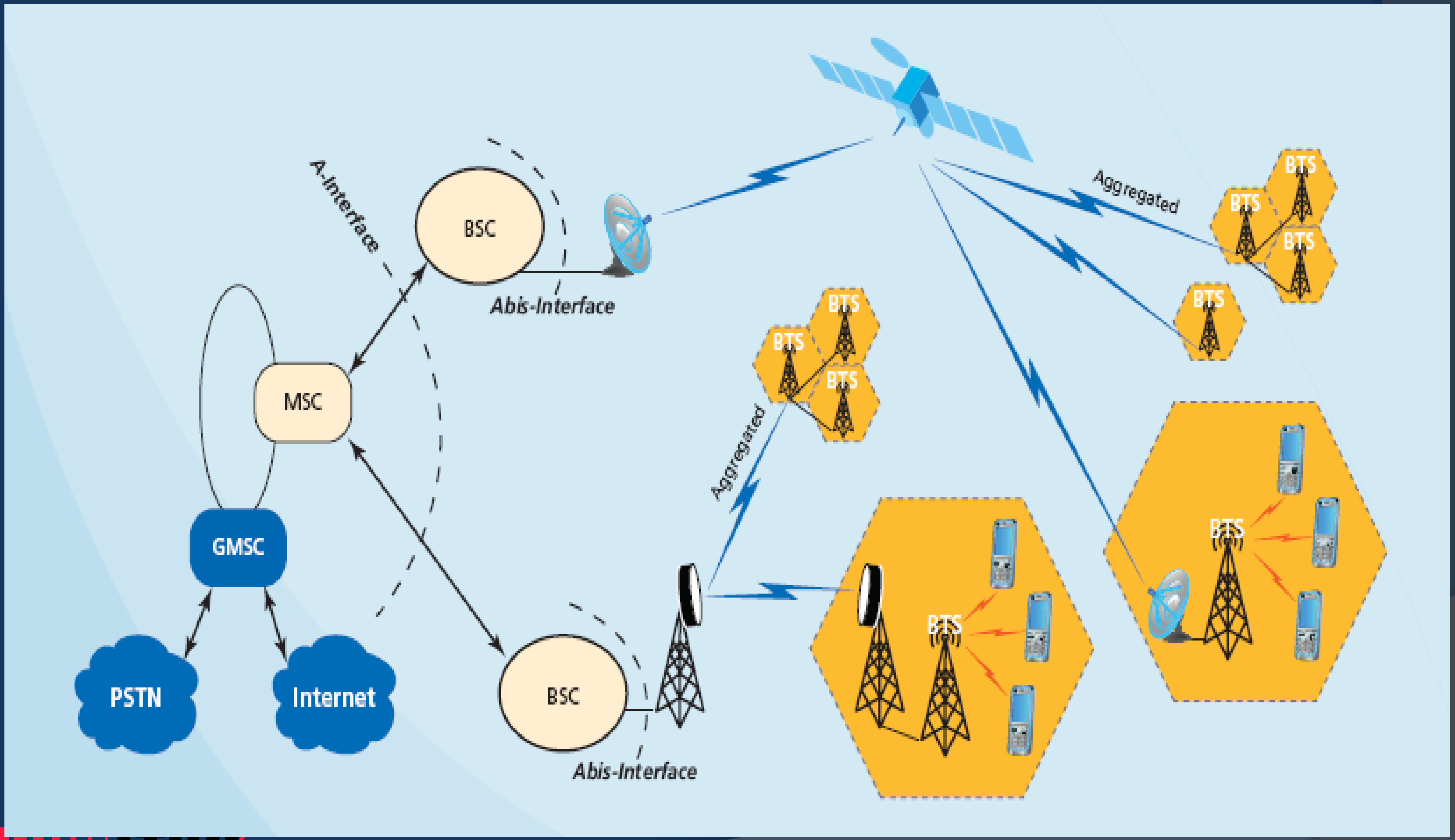
Cellular backhaul

- Cellular companies are developing strategies to economically extend the reach of mobile services to population ”islands” not readily accessible by traditional network infrastructure. The economic challenge is particularly evident in reaching relatively remote areas where the low volume of user traffic requires tight control of capital and operational costs of providing connectivity from the remote cell towers back into the mobile network.
- Developing regions are also benefiting from the economics of mass - produced mobile technology, making it viable to provide telecommunications services in areas with minimal infrastructure
- This network shall be flexible (pontual bandwith increase, traffic balance, emergencies) cost-efective versus the alternative (e.g fiber), minimize point of fail (compared hop in terrestrial link) etc

Mobile services MSC - BSC



Mobile services BTS - BSC

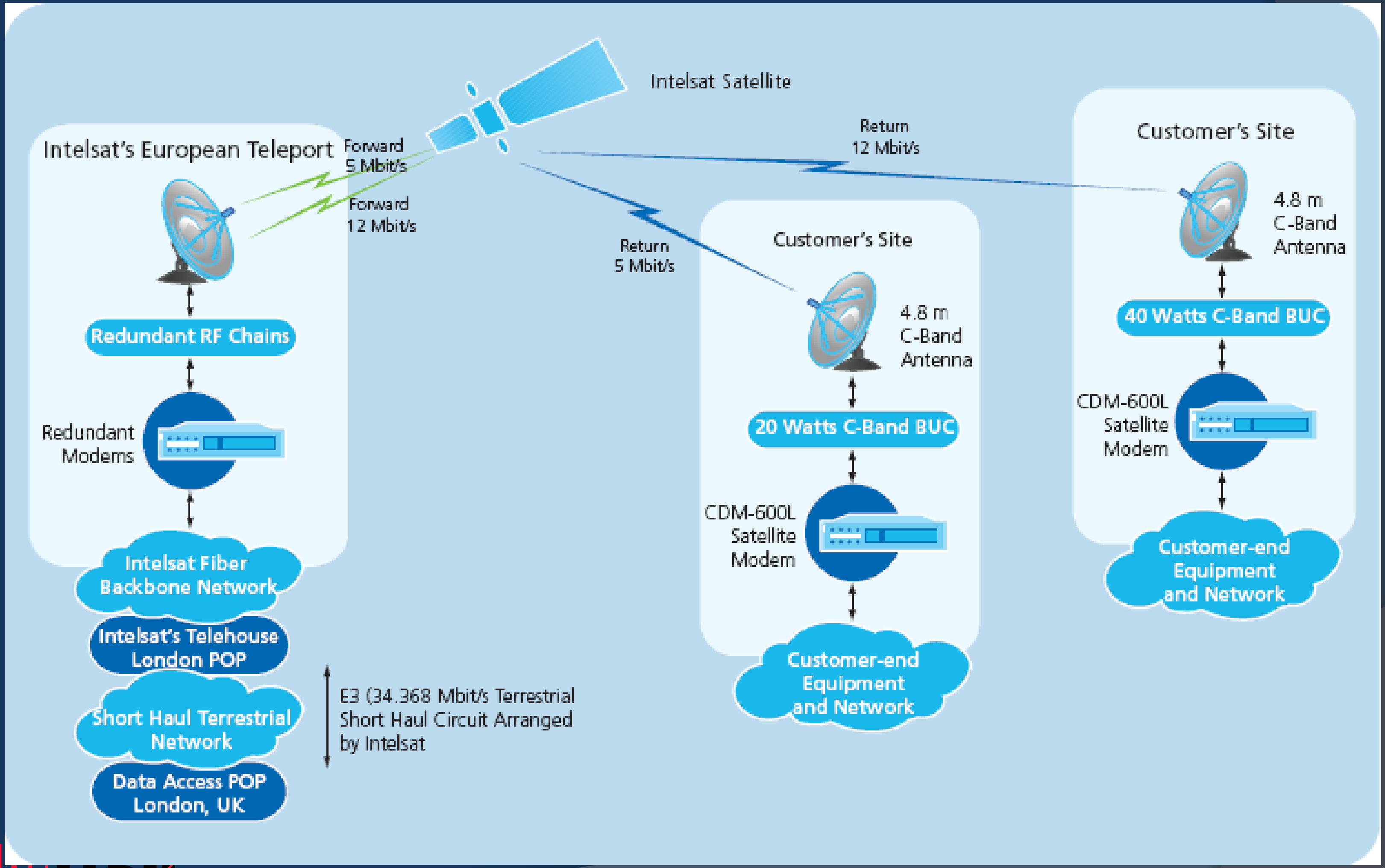


Private line 1

We are talking about PTP dedicated connections to supply global communications to “*Service Providers”, corporations, OI’s* , final users namely at:

- LAN to LAN connectivity between remote locations
- Bulk data transfer
- Remote database access
- Videoconferencing
- Backup *(Disaster recovery)*
- *CSS-Customer service and support*
- VoIP

Private line 2



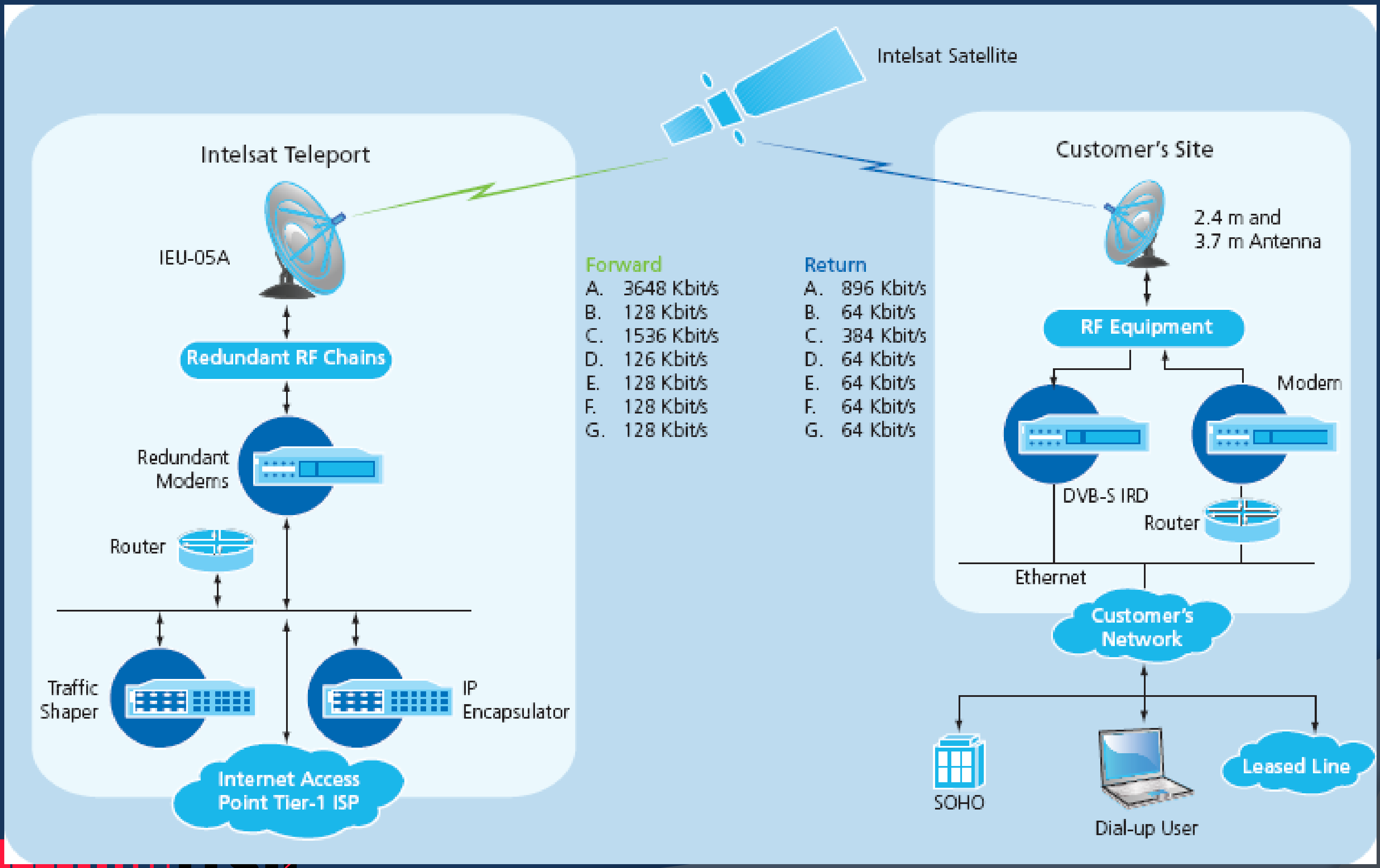
Trunking IP 1

It is a wholesale, end-to-end service aiming expand customers' infrastructure and resources. Intelsat provides telecommunications carriers, ISPs and corporate network providers with direct, high - speed Internet backbone access in terrestrially-challenged service areas, needing medium and high speed data rate, under 2 alternatives …..

Trunking IP 2

- **Shared access solutions** with the cost-effective DVB is designed for lower data rates, providing customers with a shared forward and dedicated return carrier (using SCPC) for accessing the Internet. Sharing the forward carrier, customers are allowed to more effectively use capacity between multiple locations while maintaining CIR on the return carrier
- **Dedicated access solutions** for large bandwidth requirements, a dedicated forward and return carrier is recommended, to provide high-speed access to the Internet using Committed Information Rates; supporting customers requiring connections up to STM-1 (155 MBs) for single or multiple locations.

Trunking IP 3



SCPC – Single Channel per Carrier 1

As we will see later in with more detail, systems of multiple access as FDMA because they use more than one carrier on the transponder, there is potential interference, and this has been minimized through the use of output back off, although it doesn't overcome the problem completely. That difficulty - in access with frequency sharing - was mitigated with the implementation of one channel per carrier - SCPC - to very specific applications, namely

- Pre Assignement commonly voice activated allowing digital signals usually associated to channel multipliers whatever, be DSI - Digital Speach Interpollation and DCME - Digital Circuit Multiplication equipment , and
- Demand Assignement (also known by DAMA - Demand Assignement Multiple Access or bandwirth on demand)

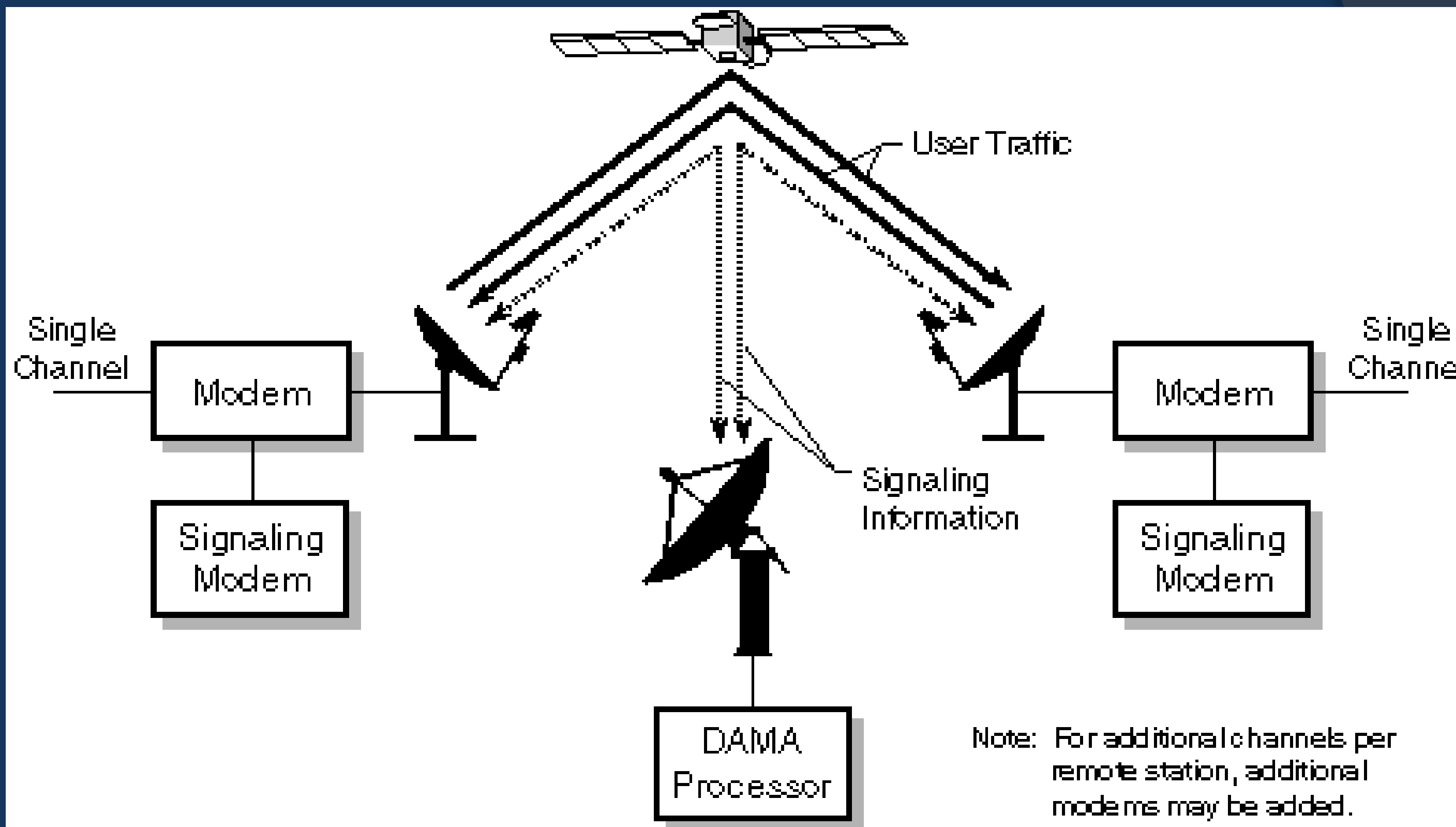
SCPC - Single Channel per Carrier 2

- Each remote access to common but temporally individually, without contention:
  - There is no sharing between remote
  - There is no frame to packaging with restraint
- It is not necessary to access control i.e.
  - There is no *overhead*
  - All *burst* match traffic
- Each remote has its share of band permanently assigned (DA) or not (FA)

SCPC - Single Channel per Carrier 3

- The type of traffic – small or medium – oriniginally made through analogue systems FDM/FM, is migrated for SCPC, and supporting direct connectivity among users communities decreasing or eliminating costs associated with transit taxes. There are the following possibilities of service:
  - Low and medium traffic telephonic service through gateways for PSTN
  - Rural telephony through VSAT
  - 64 Kbs data applications (or higher rates) on request

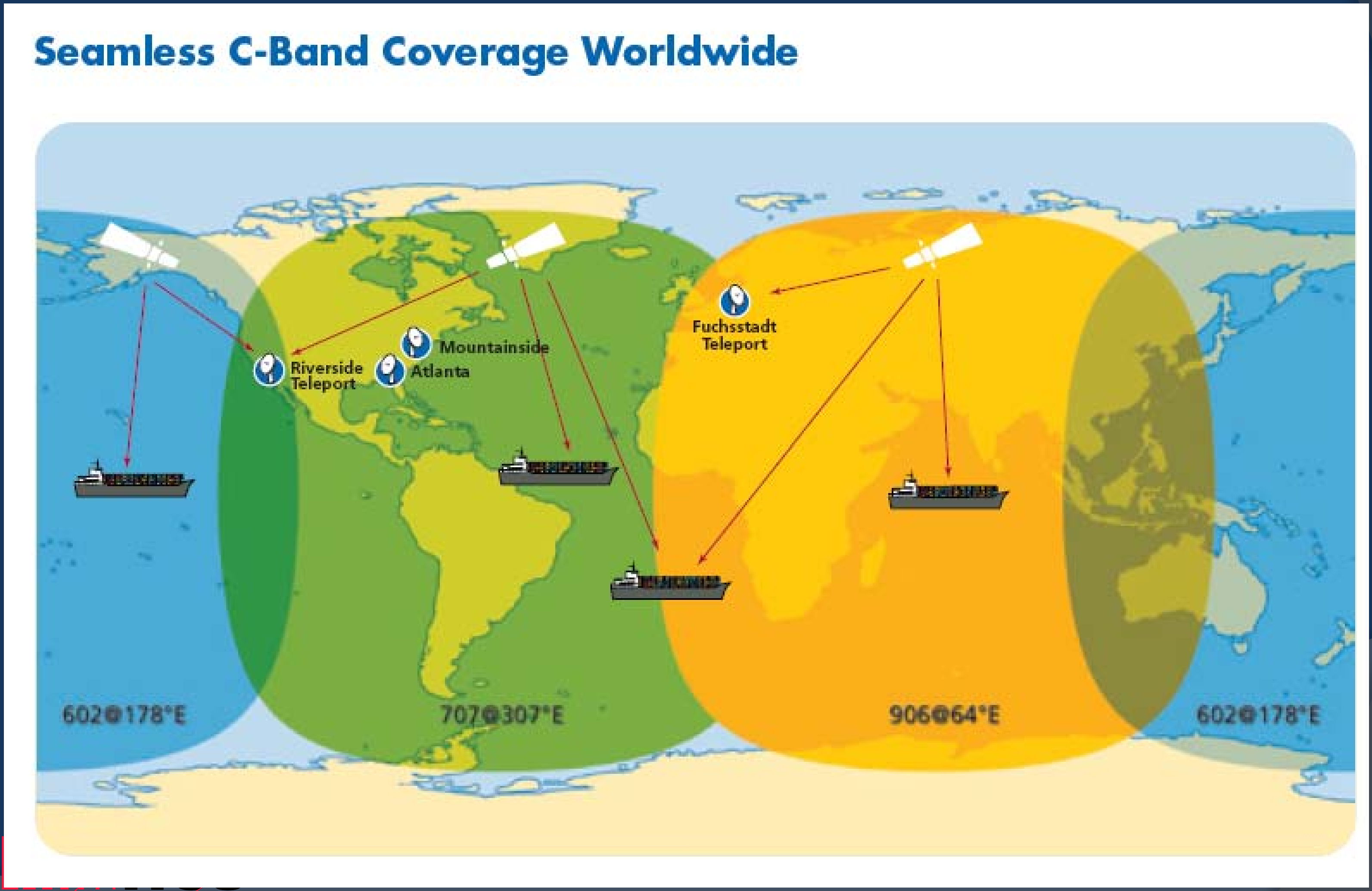
SCPC - DAMA generic



Maritime broadband 1

- Maritime market demands robust, secure, ubiquitous broadband connectivity traditionally delivered by terrestrial networks, but now satellite platforms offer the performance and reliability of land-based VSAT networks, where Intelsat ONE SM Global Maritime product offers a unique always - on, true broadband access service worldwide
- In general terms - always on, broadband access global coverage - can be assured with integrated management (GNMS - *Global Network Management System)* and automatic beam switching (ABS - Automatic beam Switch) at effective costs
- Intelsat offers global services at IS-602, IS-707 and IS-906, through dedicated hubs at Fuchsstadt and Riverside Teleports

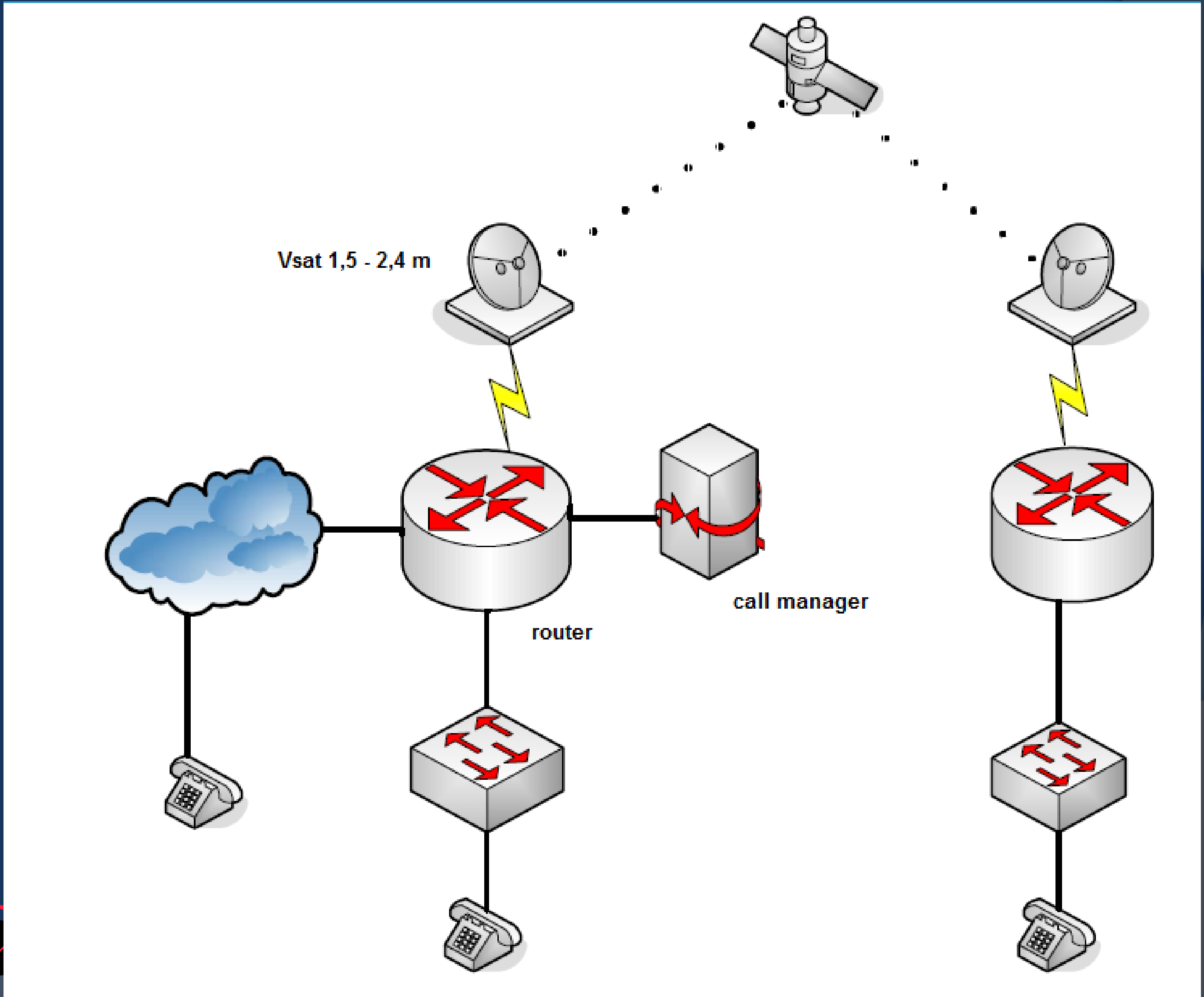
Maritime broadband 2



VoIP

- Integration of a pure IP environment, on satellite, or more sophisticated clients (e.g., videoconferencing), in:
  - VoIP
  - Broadband connections in extensive areas
- Equipment already and much striped (off the shelf)
- FDM or TDM access
- but with Qos mechanisms

VoIP - architecture



IPTV and Corporate TV

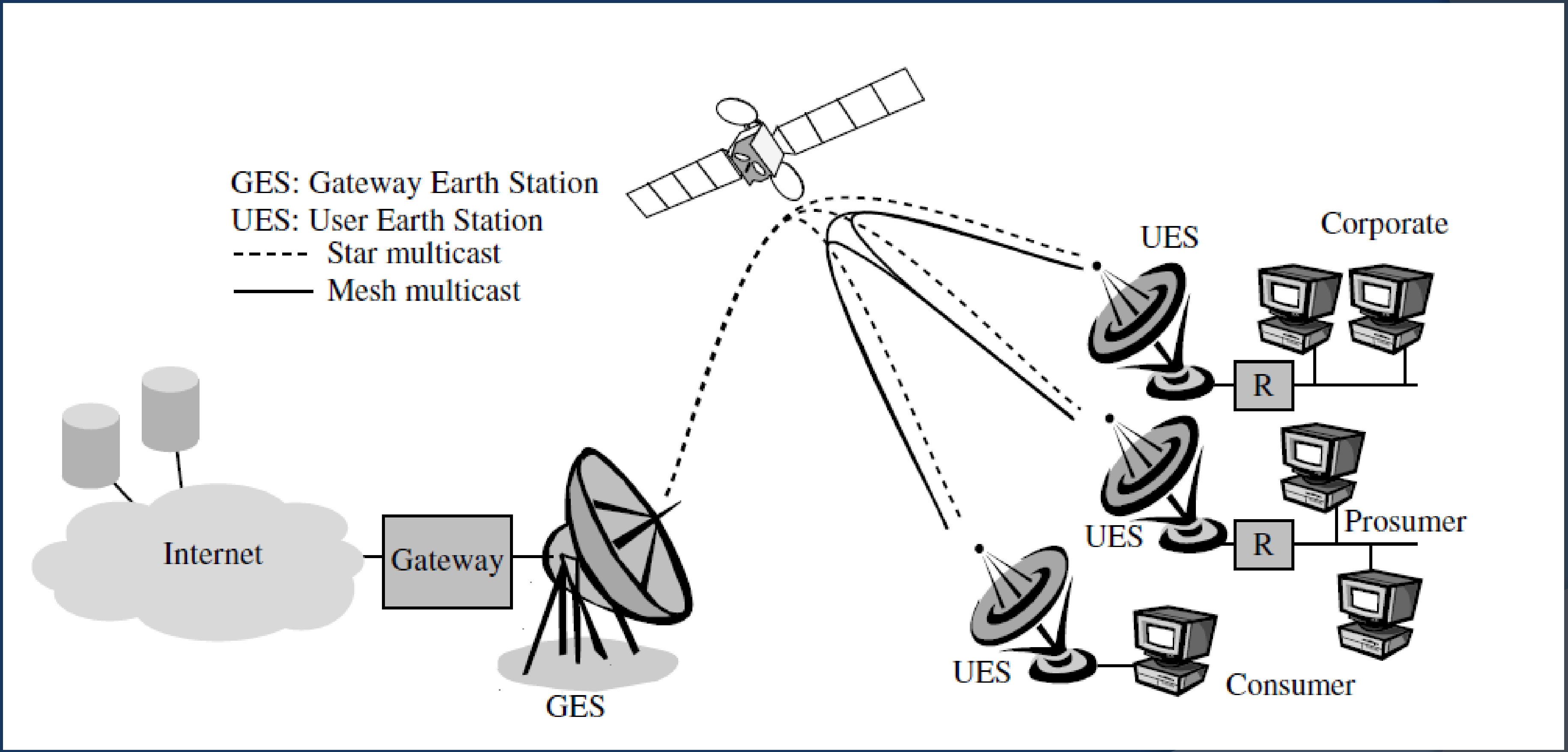
- Potent means of communication for businesses, based on contents mutimédia supported on LCD or plasma TV or similar.
- Dynamic communication for marketing actions implemented in indoor or outdoor, to:
  - Shopping centres
  - Places standby (doctors, banks etc)
  - International congresses, fairs

IPTV and Corporate TV

Multicast 1

- Multicast allows a communications network source to send data to multiple destinations simultaneously while transmitting only a single copy of the data to the network. The network then replicates the data and fans it out to recipients as necessary. Multicast can be considered as part of a spectrum of three types of communications:
  - **Unicast**: transmitting data from a single source to a single destination (for example, downloading a web page from a server to a user's browser, or copying a file from one server to another).
  - **Multicast**: transmitting data from a single source to multiple destinations. The definition also encompasses communications where there may be more than one source (i.e. multipoint-to-multipoint). Videoconferences provide an example of the latter, where each participant can be regarded as a single source multicasting to the other participants in the videoconference.
  - **Broadcast:** transmitting data from a single source to all receivers within a domain (e.g. within a LAN, or from a satellite to all receivers within a satellite spot beam).

Multicast 2

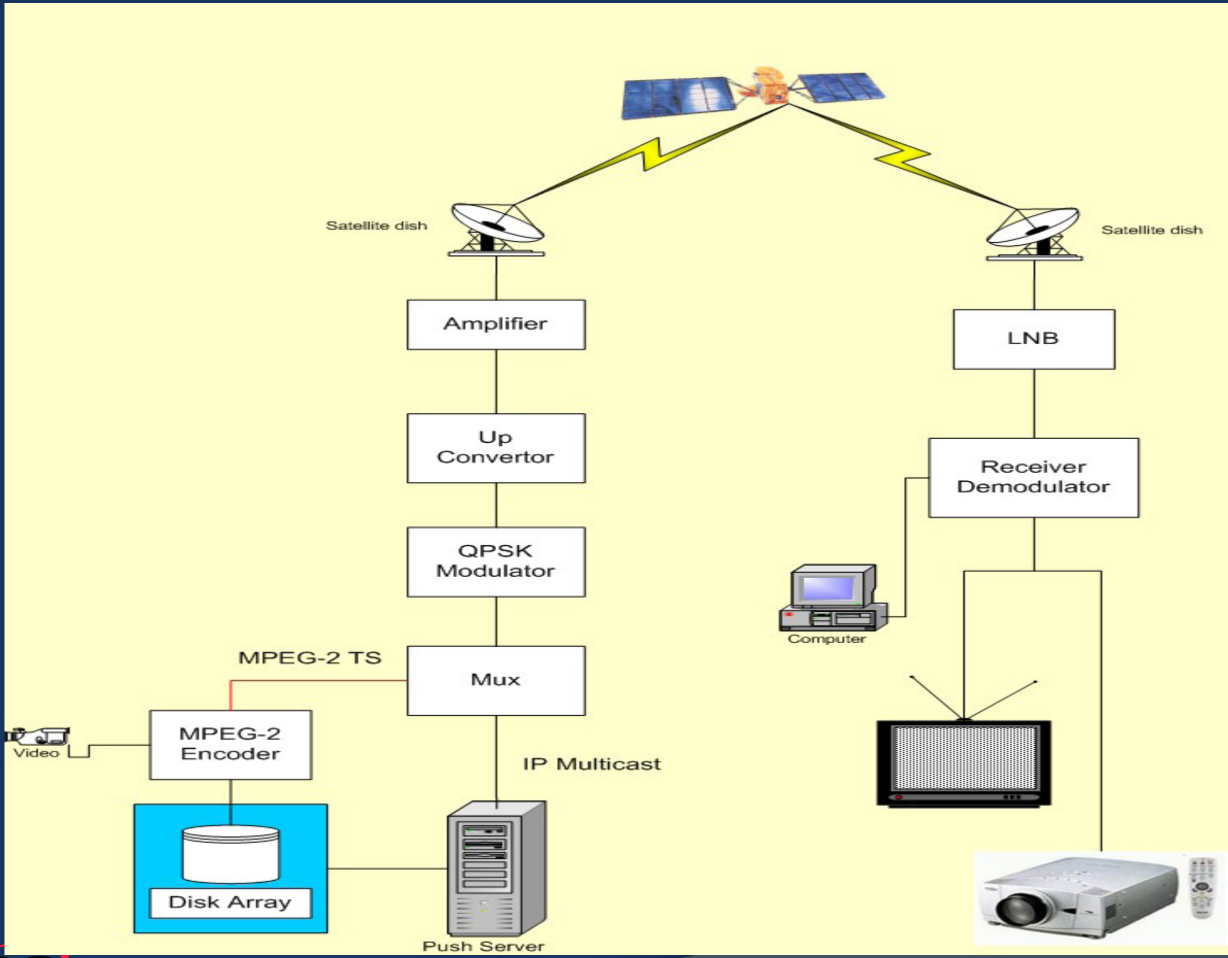


GES: Gateway Earth Station
UES: User Earth Station
Star multicast
Mesh multicast
Internet
Gateway
GES
UES
Corporate
R
UES
Prosumer
R
UES
Consumer

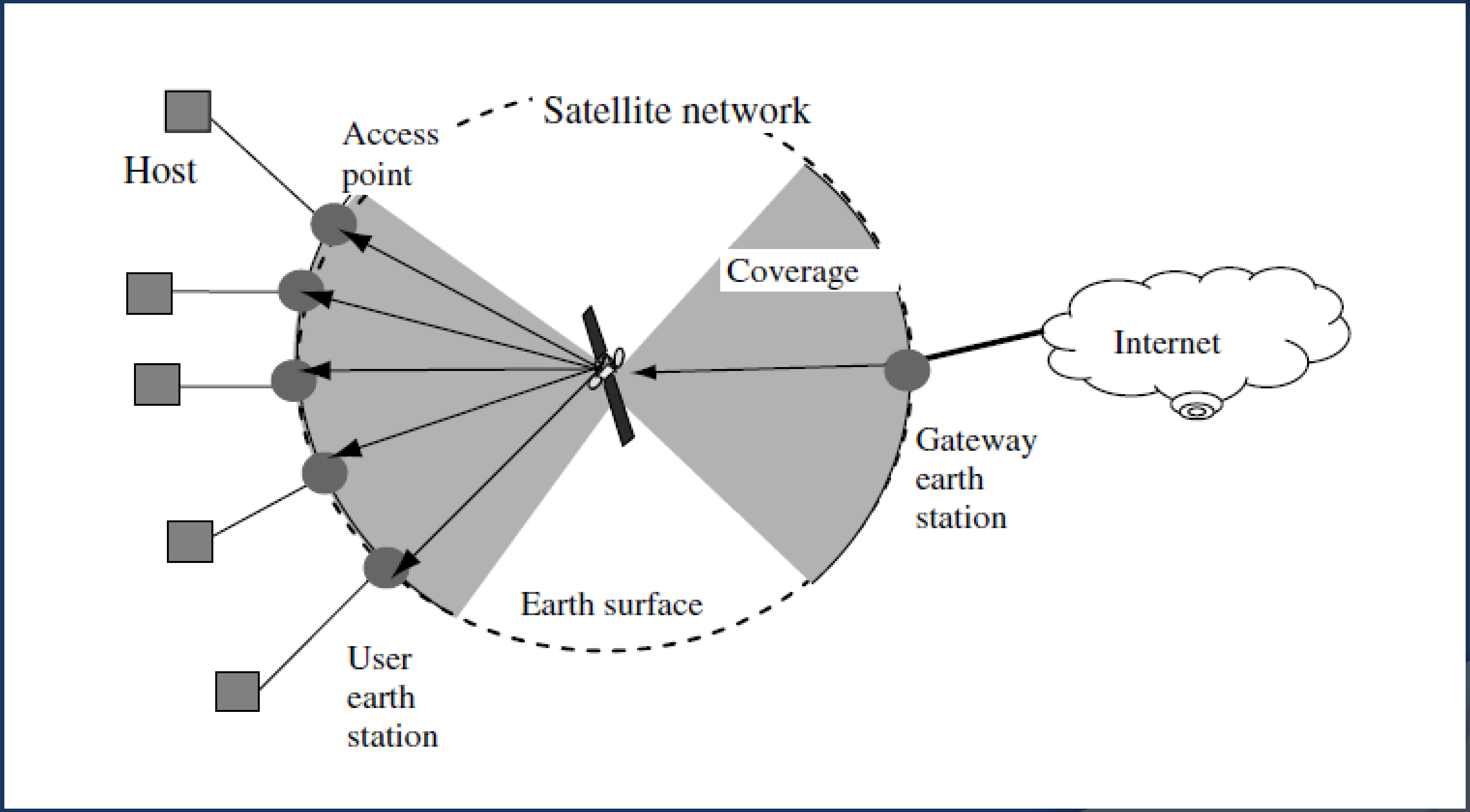
DVB - Digital Video Broadcasting 1

- Standard for Digital Video Broadcasting involves today several manufacters and vendors in a consortium started 1993
- It comprises of 3 sub-standards according to the main transmission medium,e.g:
    - Satellite (DVB-S QPSK modulation)
    - Terrestrial (DVB-T QAM modulation) and
    - Cable (DVB-C OFDM modulation)
- Uses MPEG 2 modified (transmission standards, modulation systems, error correction, integrated receiver_decoder and service information) to codify and transport data.
- Assure HDTV distribution (DTH-Direct to Home) and all broadband interactive services.

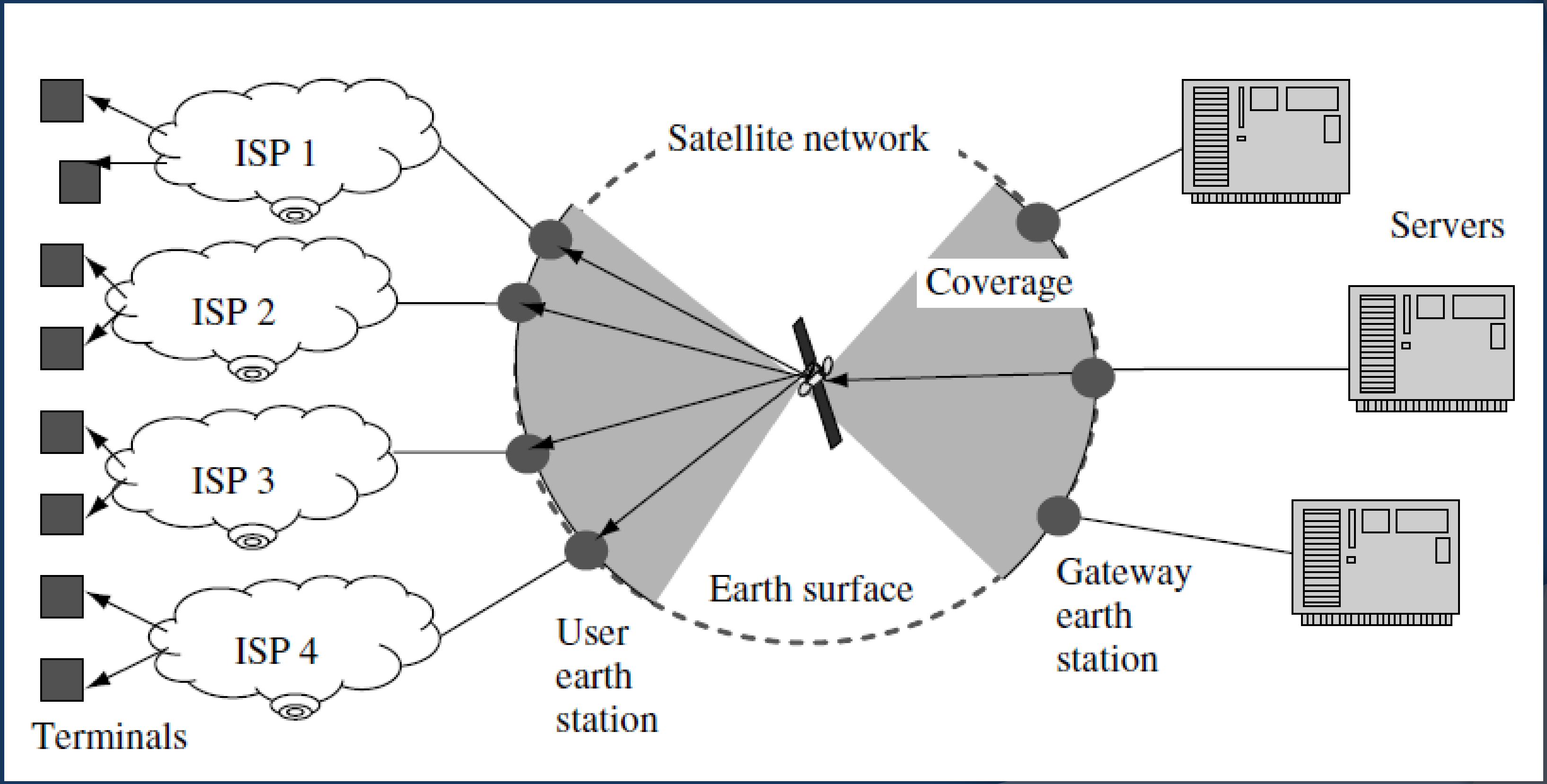
DVB - Link


Satellite dish
Satellite dish
Amplifier
LNB
Up
Convertor
Receiver
Demodulator
QPSK
Modulator
Computer
MPEG-2 TS
Mux
MPEG-2
Encoder
Video
IP Multicast
Disk Array
Push Server

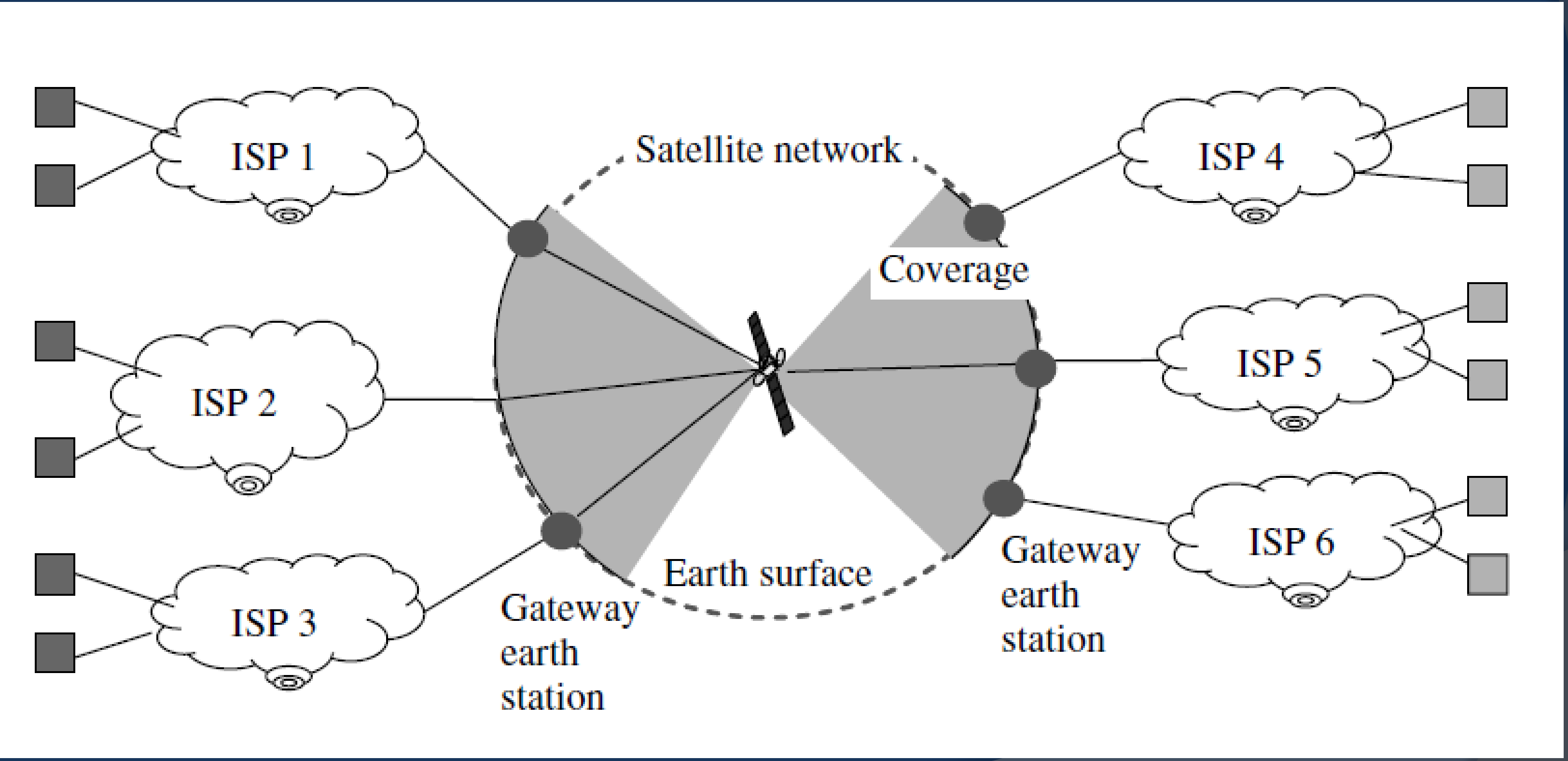
Internet vsat last mile connections



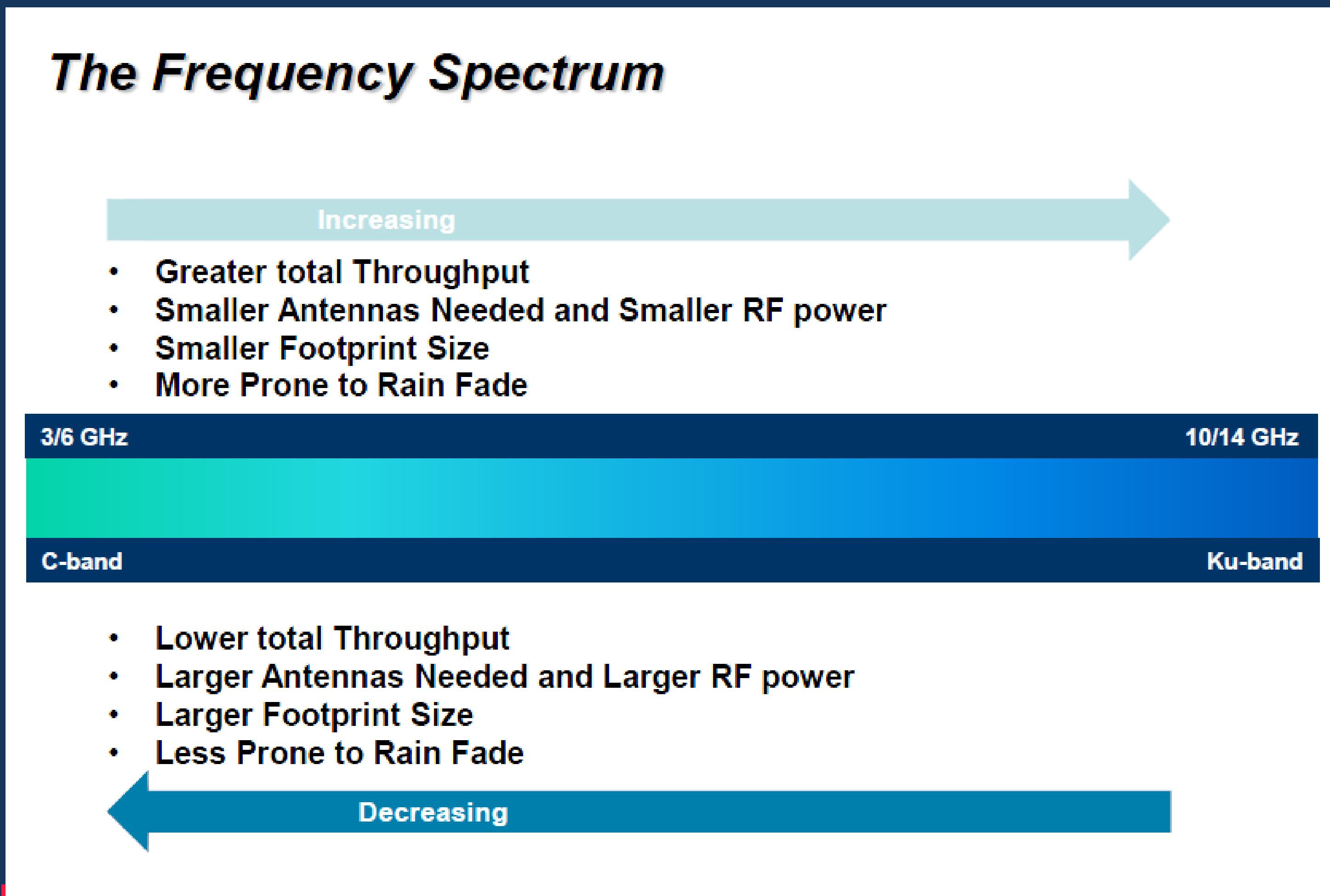
Internet vsat first mile connections



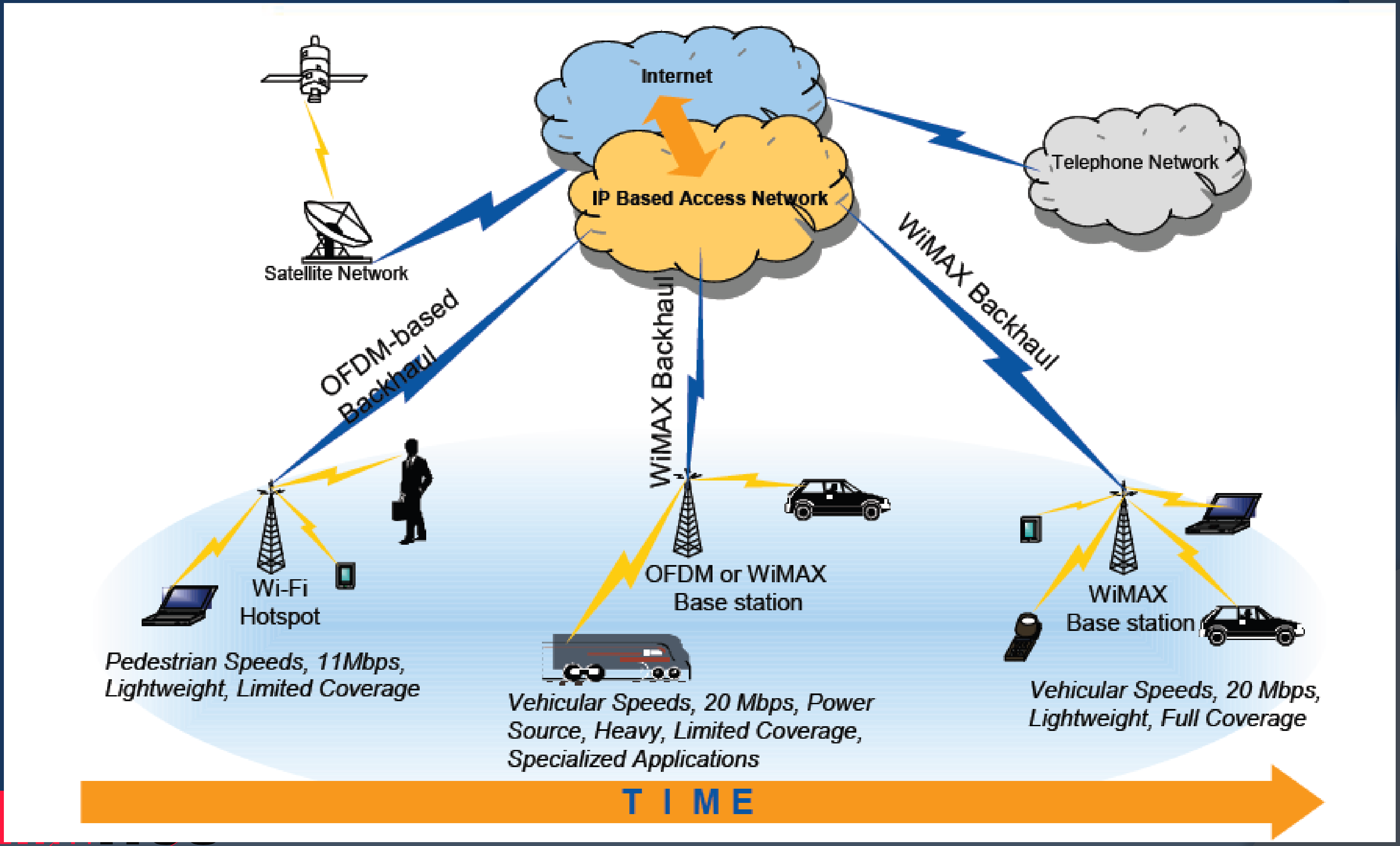
Internet transit connections



C band, Ku band, tendency



Present – future or the future present?



service & technology trends

50´s

Artificial radio Repeaters

Mainly fixed com

Telephone
TV
signals

80's

Mobile Com

Ship's
Aircrafts
Space vehicle
Forest guard
Dolphin..
Human in motion

Thelephone
Broadcast
Data rx and distribution,
Weather monitoring,
GPS

00´s

Mobile personnal com
Voice, data, video, image
AnyoneAnytimeAnywhere

Overhall sat system design
Improving G / T to miniaturize earth terminals

Greater tx power and complexity sat antennas
Efficient signal processors and switching equipment

Direct communications between satellites
High frequency bands
Electronics miniaturization
Small satellite uses

Speciallization in inaccesible places, thin routes , data collection and distribution

20…'s

Information vs transmission satellites

Reconfigurable antennas
multirange receivers
BB & RF switching matrix
new modulation and access techniques
Sensors on board for EO warning for atmosphere, water, forest monitoring..

N / S Geo synchronous orbit satellite

Small Satellites improvement
(mini.micro,nano,pico, femto)
E O constelations to improve spatial and temporal sampling
Altimetry constellations

Year (decade)

Technology trends summary

- As the demand for AAA communications increases, IP based network - centric architectures enabling the fusion of technologies including, digital video broadband Internet and mobile communications - is the groung platform.
- Emerging mobile services e.g aeronautical, maritme, fast trains and vheicular app.
- DVB-S / S2 / RCS-NG / SH developments
- Hybrid and integrated satellite – terrestrial system architectures for mobile app to achieve a seamless integration.
- Next generation earth observation satellite systems, as follow

Technology trends summary
Terrestrial observation

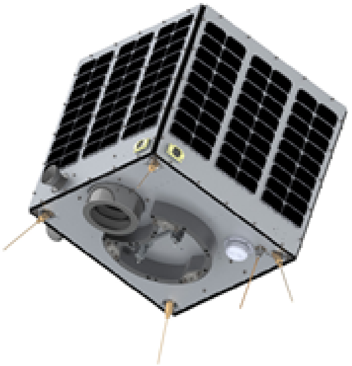
Sensor	• High resolution panchreomatic optical sensor with target resolution 1m • Multispectral optical sensor to detect flooded areas . • Synthetic aperture radar for night observation and bad weather
Swath width	• Target swath width 50 Km or more (40-70 to earth quakes , 30-50 windstorms, and flood damages)
Observation frequency	• Within 3 hours after event (the optical sensor and the synthetic apperture radar are carried by diferent satellites . A 4 satellite system consisting of 2 optical and 2 radar satellites shall is under study)

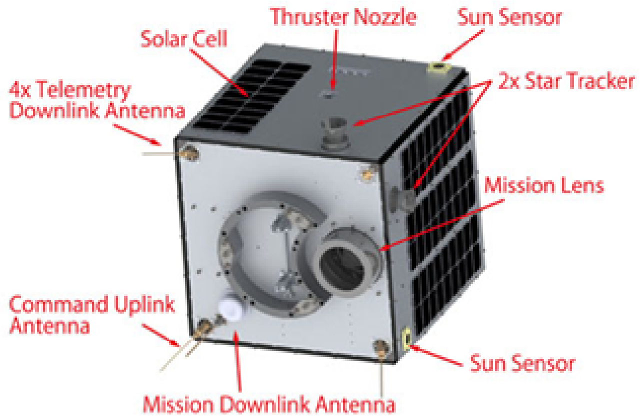
Technology & services trends summary

Cluster of four satellites will be launched by Russian Dnepr rocket at the end of 2012, arranged by University of Tokyo

—Micro-satellite "HODOYOSHI-1" will also be launched—

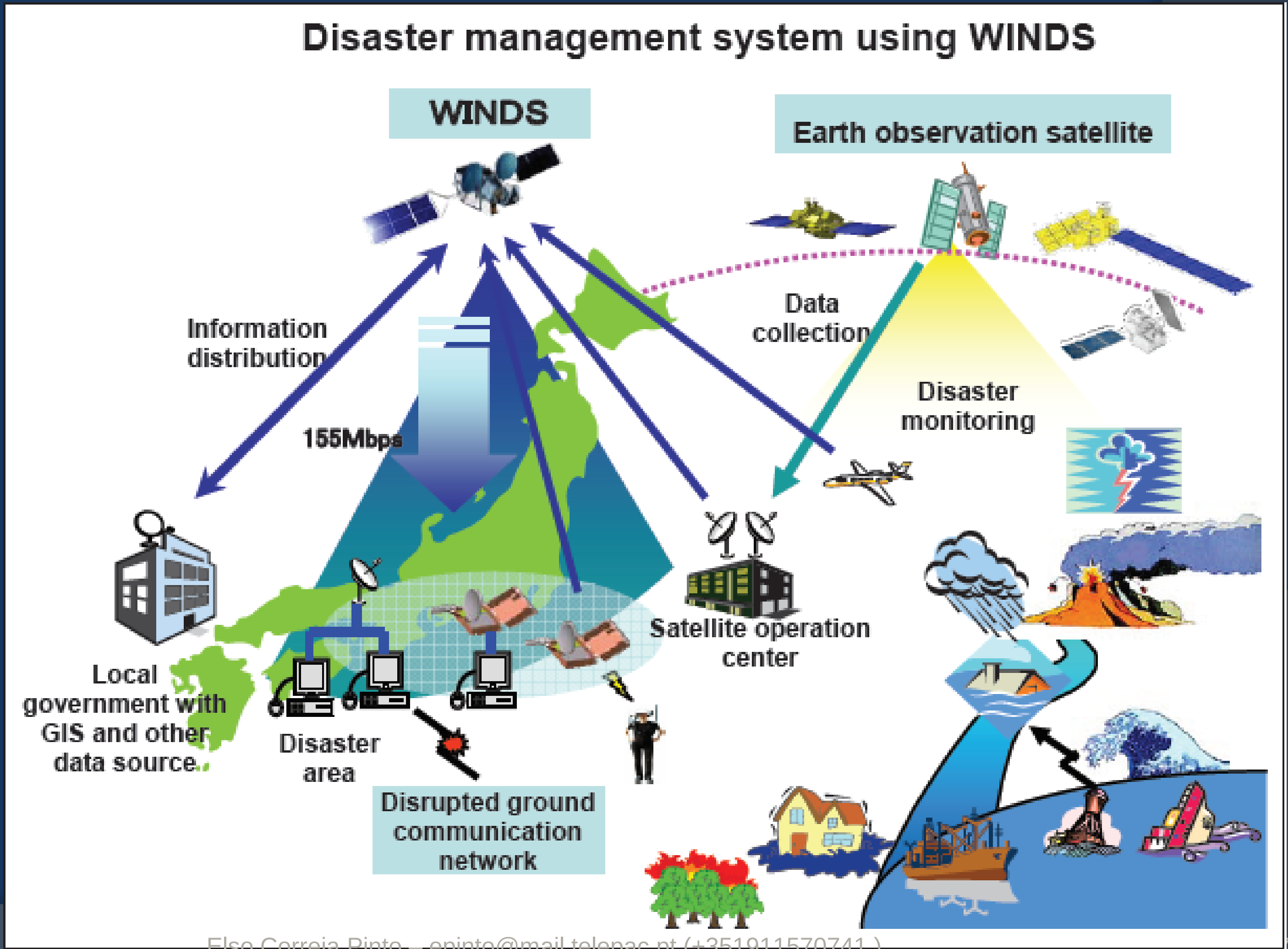
Professor Shinichi Nakasuka's laboratory of Department of Aeronautics and Astronautics, Graduate School of Engineering, University of Tokyo and Next Generation Space System Technology Association (NESTRA) decided launching Japanese four micro-satellites using Russian Dnepr launch vehicle from Yasny launch base in Russia at the end of 2012. These four satellites are being developed by the following universities with primary objectives of technology demonstration of Earth remote sensing. University of Tokyo's micro-satellite "HODOYOSHI-1," which is 6.8 m ground resolution Earth remote sensing satellite, will also be launched.



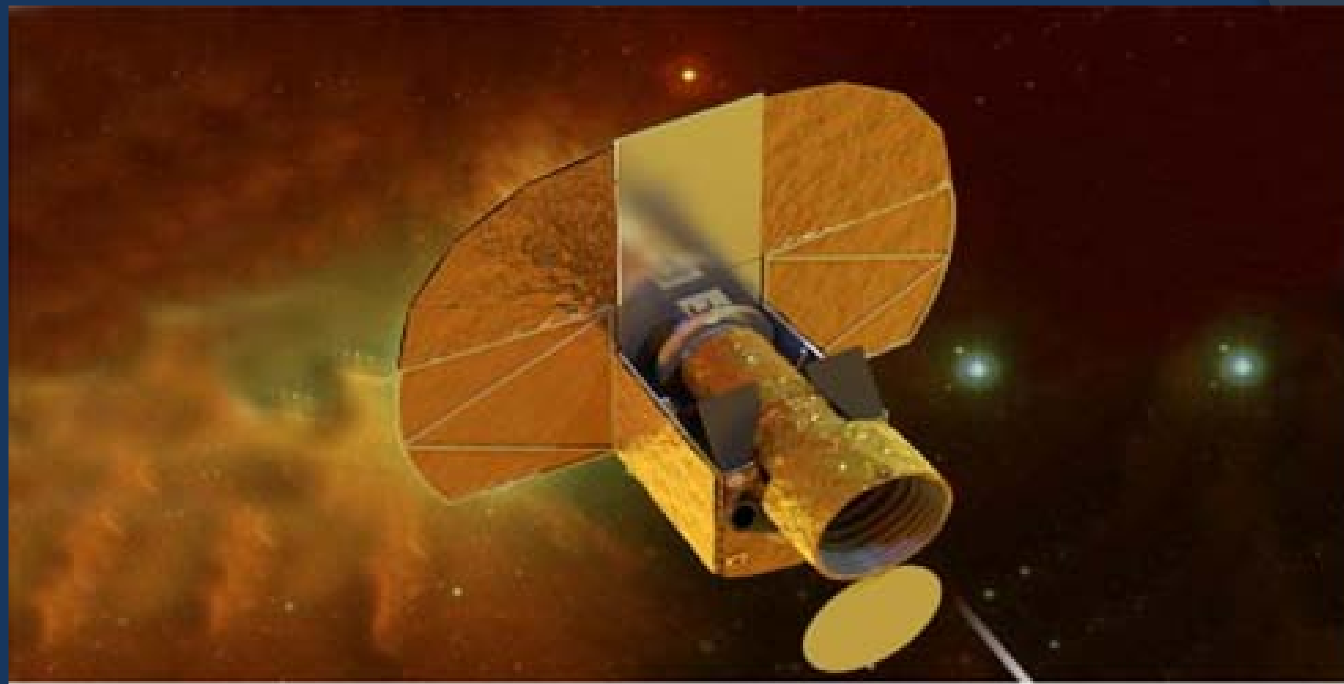


Ground resolution 6.8m remote sensing satellite "Hodoyoshi-1"

technology trends
natural disasters



Technology trends space observation



cheops.unibe.ch

It is planned for 2017 to put in orbit the space lab telescope Cheops (CHaracterizing EXoplanets Satellite) whose objective will be searching and study planets simillar to earth, in the neighborhoods to shining star of the solar system

Technology and services trends palm of your hand