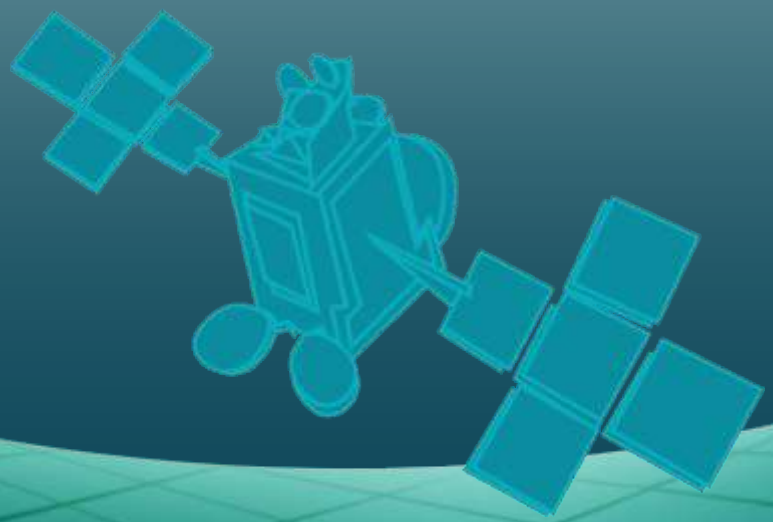
Communication Engineer

Satcom ABC series (4)



WU Boyang
APMT

Communication Payload

- Parameters
- Carrier Assignment
- Link Budget
- Frequency Resource and RF Equipments

Payload Management

- Spectrum Assignment
- Carrier Management

Technical Support

- Marketing Support Costumer Support
- Sun Outage

Frequency Coordination

Transponder Parameters

CHINA APMT

- Transponder
  - Combination of receiver, frequency converter and transmitter
  - Main parameters
    - ⇨ G/T, SFD and EIRP
    - ⇨ relative to antenna pattern (geographical location)
    - ⇨ relative to operation frequency (transponder number)
    - ⇨ city tables and isograms
  - G/T and SFD
    - ⇨ showing transponder Rx performance at its service area
    - ⇨ depending on antenna Rx gain pattern
  - EIRP
    - ⇨ showing transponder Tx power at its service area
    - ⇨ depending on antenna Tx gain pattern

G/T

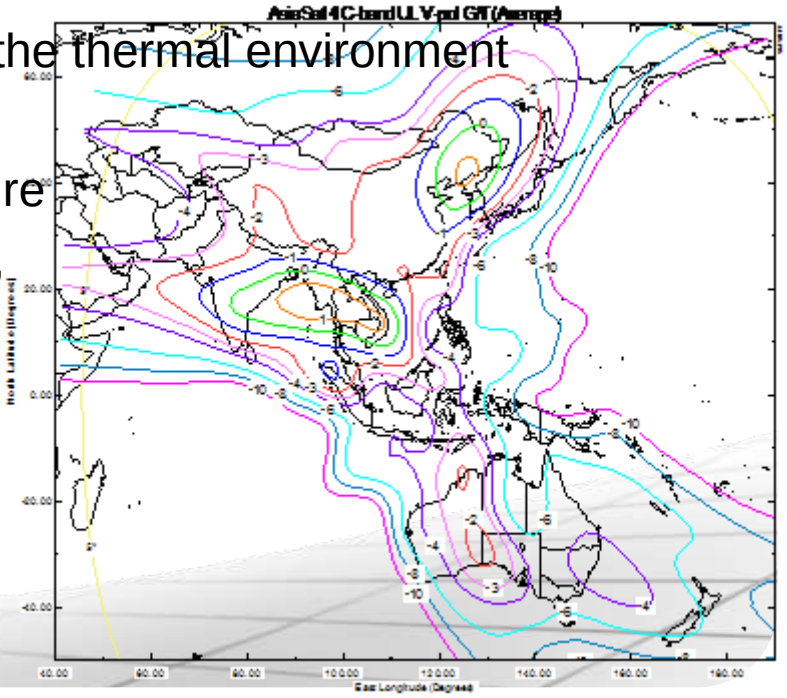
CHINA APMT

- figure of merit
  - Characterization of receive system performance

    G/T (dB/k) = G (dBi) – T_{SYS} (dBk)

    where, G is antenna gain and T_{SYS} is equivalent noise temperature of receiving system

    $T_{SYS} = T_{ANT} + T_{RCV}$
  - T_{ANT}: antenna noise temperature
    - ⇨ depends on its gain pattern with the thermal environment
    - ⇨ night sky: roughly 4 Kelvin
    - ⇨ earth ground: physical temperature
    - ⇨ sun surface: when in sun outage, too high to interrupt transmission
  - T_{RCV}: receiver noise temperature
  - G/T at beam peak
    - ⇨ C-band: about 1 dB/k
    - ⇨ Ku-band: about 7dB/k



SFD

CHINA APMT

- Saturated Flux Density
  - Flux density at receive antenna required to saturate HPA

    SFD = C + Attn - G/T (dBW/m^2)

    where C is a constant (-90 to -100), Attn is corresponding channel gain step (0 to 20 even to 30)

    ⇨ normal range: -70 to -100 dBW/m^2

    ⇨ normally selected value: -85 to -93 dBW/m^2
  - More sensitive SFD, less uplink power required

    ⇨ less C/N and C/I
  - SFD listed in data table is usually relative to a specified Attn

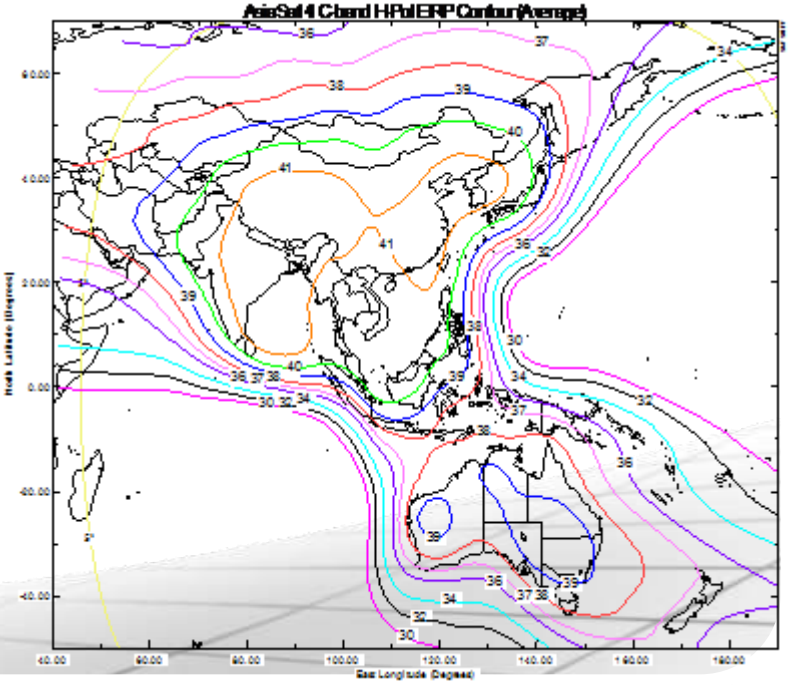
    ⇨ 0dB Attn (most sensitive SFD) or 8dB Attn (normally used SFD)

EIRP

- EIRP
  - Effective Isotropic Radiated Power
  - The power radiated by a directional antenna with an antenna gain relative to an isotropic antenna

    EIRP (dBW) = P (dBW) - Loss (dB) + G (dBi)

    where, P is HPA output power, Loss is wave guide loss between HPA and antenna feed, G is antenna gain
  - EIRP at beam peak
    - ⇨ C-band: about 41 dBW
    - ⇨ Ku-band: about 56 dBW



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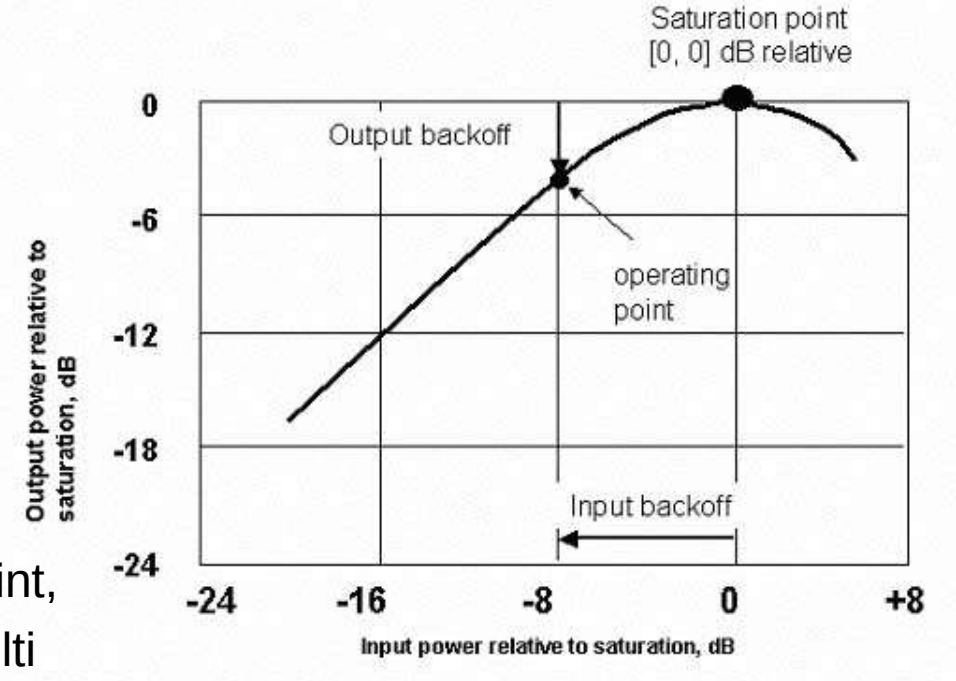
Gain transfer

CHINA APMT

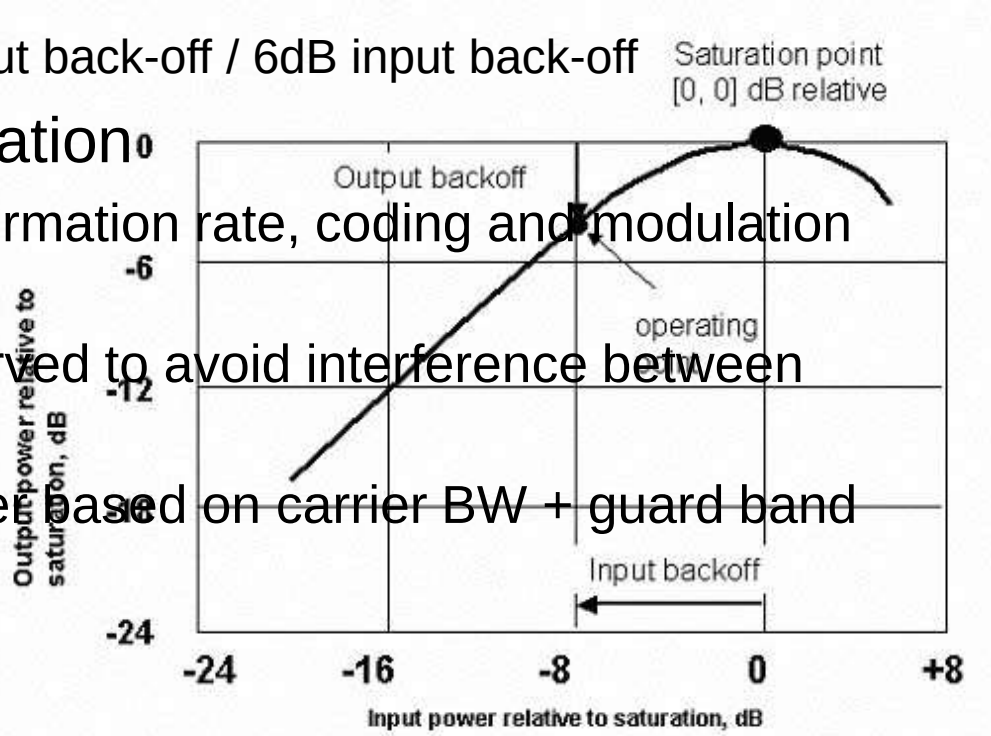
- TWTA
  - HPA of satellite transponder: non-linear amplifier
  - Output/Input relationship: gain transfer curve
    - ⇨ relationship between output power level and input power level
- Gain transfer curve
  - Y-axis: output power
  - X-axis: input power
  - Saturation point
    - ⇨ vertex of the curve
    - ⇨ reference point
  - Linearity range
    - ⇨ closer to saturation point, higher efficiency at multi carrier usage



Back-off and Bandwidth Allocation

CHINA APMT

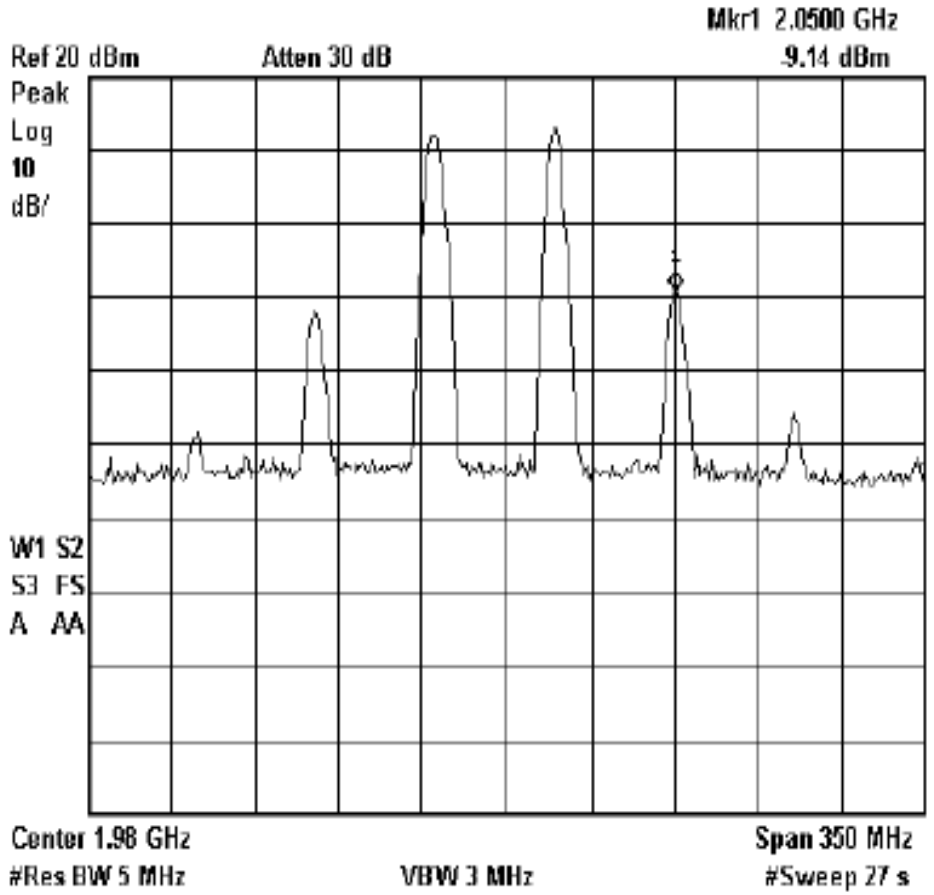
- Back-off
  - Input back-off: difference of input power level between operating point and saturation point
  - output back-off: difference of output power level between operating point and saturation point
  - Linear back-off: Operation point at highest linearity range to avoid IM
    - ⇨for LCTWTA: 3dB output back-off / 6dB input back-off
- Carrier bandwidth allocation
  - Calculated by signal information rate, coding and modulation type
  - Proper guard band reserved to avoid interference between adjacent carriers
  - Rental for the user carrier based on carrier BW + guard band



Intermodulation

CHINA APMT

- Intermodulation component
- Occurred at multi carrier operation
  - Interfered to other carriers



Power Allocation

CHINA APMT

- Transponder operation point
  - Reserving sufficient output back-off
  - To keep transponder power limited in linear range
- Carrier power allocation
  - Transponder resource: power and bandwidth
  - When power balanced with bandwidth

    $EIRP_C = EIRP_{Xpd} - OPBO_C$

    where, $EIRP_C$ and $EIRP_{Xpd}$ means EIRP for carrier and transponder, and $OPBO_C$ means carrier output back-off
  - Downlink carrier power allocated as

    $OPBO_C = OPBO_{Xpd} + 10\ lg(BW_{Xpd}/BW_C)$

    where, $OPBO_C$ and $OPBO_{Xpd}$ means output back-off of carrier and transponder respectively, and BW_{Xpd} and BW_C means bandwidth of transponder and carrier
  - If customer deserves higher carrier power than average power of the transponder, the payment should be more than average

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- **Link Budget**
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Payload Management

- Spectrum Assignment
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Technical Support

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Frequency Coordination

Link Budget

- Target
  - To calculate antenna elevation and azimuth angle
  - To calculate carrier power and bandwidth
  - To estimate up-link C/N, down-link C/N and total C/N (interference involved or not), and link margin
- Input data
  - Transponder parameters
    - G/T at up-link site
    - SFD at up-link site (corrected by gain step setting)
    - EIRP at down-link site
    - Up-link frequency of the carrier (down-link frequency may be auto-calculated by preset transfer frequency)
    - Output back-off (input back-off may be auto-calculated by preset gain transfer data)

Link Budget (cont.)

CHINA APMT

- Input data (cont.)
  - Carrier information
    - information rate
    - modulation type
    - coding rate
    - required E_b/N_0 (energy per bit to noise power density ratio, relative to modulation type, coding rate and bit error rate)
  - Parameters for up-link and down-link earth stations
    - location with longitude and latitude
    - antenna size, antenna efficiency, and system noise temperature
  - Parameters for fade and interference
    - pointing error, atmospheric absorption, troposphere fading, rain attenuation
    - C/T (carrier to noise temperature ratio) about adjacent satellites, intermodulation, and cross polarization interference

Link Budget (cont.)

- Data correction
  - Estimated results need to be manually revised one or more times
  - Data need to be revised before calculation
    - ⇨ allocated bandwidth (auto-calculated occupied bandwidth + proper guard band)
    - ⇨ suggested HPA output power (> calculated up-link power + back-off value, and match product standard)
  - Data need to be revised after first round of calculation
    - ⇨ carrier back-off (if calculated system margin is too high or too low)
    - ⇨ modulation type and/or coding rate (if calculated system margin is too high or too low)
    - ⇨ U/L antenna size (if calculated HPA output power is too high)
    - ⇨ D/L antenna size (if calculated system margin is not enough)

Link Budget (cont.)

- Sequence for link budget calculation
  - Multi input, and multi output estimation
    - ⇨ all output data may be revised by any input data correction
    - ⇨ several calculation sequences could be used
  - Carrier priority: preset carrier with changeable Rx antenna
    - ⇨ according to desired carrier modulation type and coding rate, using balanced or augmented back-off, selecting proper receive antenna size, to meet the required margin
  - Aperture priority: preset Rx antenna with changeable carrier
    - ⇨ according to desired receive antenna size, using balanced or augmented back-off, selecting proper carrier modulation type and coding rate, to meet the required margin
  - Back-off adjustment
    - ⇨ bandwidth limited result: P% < BW%, usable power wasted
    - ⇨ power limited result: P% > BW%, should pay more for rent
    - ⇨ balanced result: P% = BW%, power and BW resource fully used

Data and Formulas for Link Budget

CHINA APMT

- Symbol rate

  symbol rate = data rate / m / CRv / CRs

  where,

  m (modulation index), 1 for BPSK, 2 for QPSK, 3 for 8PSK, and 4 for 16QAM;

  CRv (Viterbi coding rate), normally as 7/8, 5/6, 3/4, or 1/2;

  CRrs (Reed-Solomon coding rate), normally as 188/204

- Carrier bandwidth

  noise BW (3dB BW) = symbol rate x 1.2

  occupied BW (20BW) = symbol rate x 1.4

  40dB BW = noise BW x 1.4 = symbol rate x 1.7

  - Common value of roll-off factor is 1.3
    - ⇨ normally between 1.25 and 1.5

Data and Formula for Link Budget (cont.)

CHINA APMT

- Antenna gain
  - Calculated by aperture and frequency

    $G = 10 \lg (\eta (\pi D/\lambda)^2)$

    where,

    η (antenna efficiency), normally valued as 55 to 65 %;

    D, aperture of antenna;

    λ, wave length relative to carrier frequency
  - Estimated by beam width

    $G_{ANT} = 31000 / (\theta_{Az3dB}\, \theta_{El3dB})$

    where, θ_{Az3dB} and θ_{El3dB} are half power beam widths at azimuth and elevation respectively
  - Antenna beam width

    $beamwidth_{3dB} = 70\ \lambda/D$

Data and Formula for Link Budget (cont.)

CHINA APMT

- Noise figure

  $N_F = 10 \lg(1 + T/290)$

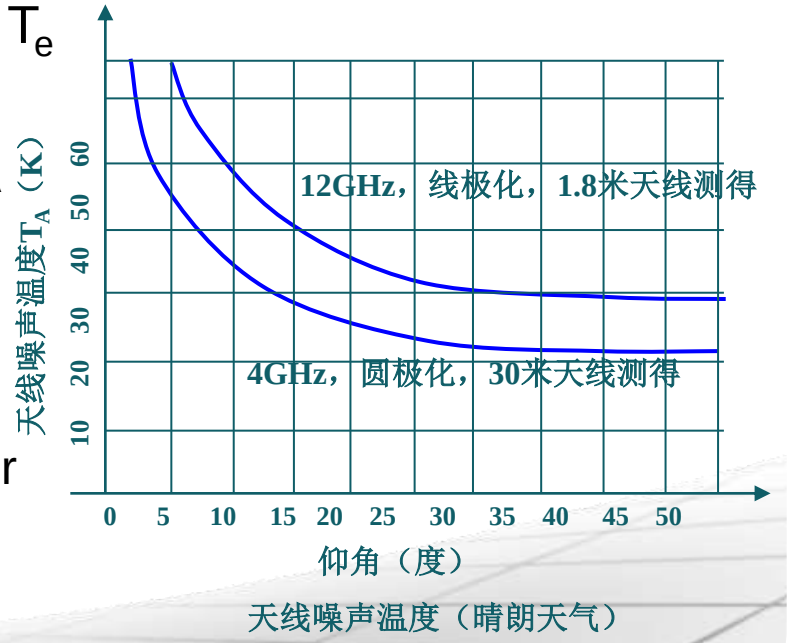
  where, T is noise temperature, and 290k is room temperature

  - Normally 0.4dB (25-30k) for C-band LNB
  - Normally 0.8dB (59k) for Ku-band LNB

- Receive system noise temperature

  T_S (dBk) = $T_a + (L_F - 1)\, T_1 + L_F \times T_e$

  where, T_a and T_e are noise temperatures of antenna and LNA respectively, L_F is insertion loss between antenna feed and LNA input, and T_1 is the environment temperature of feeder line



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- **Frequency Resource and RF Equipments**

Payload Management

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Technical Support

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Frequency Coordination

Orbit and Frequency Resource

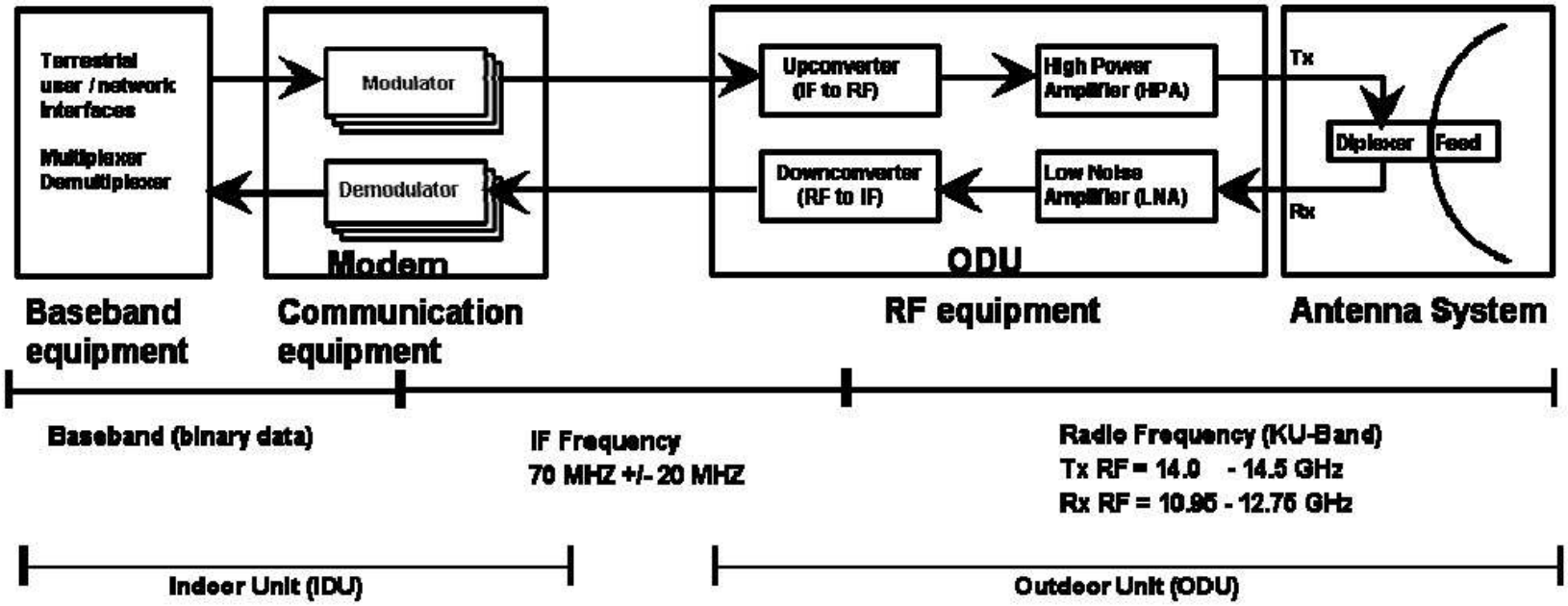
CHINA APMT

- Valuable resource
  - Expanding requirement against limited resource
  - 2 or 2.5 degrees orbital separation for C- and Ku-band
  - Early occupation, higher priority
  - AP30B resource reserved for developing countries at unpopular frequency
- Frequency band
  - Standard C-band
    - ⇨ 5925 to 6425 MHz / 3700 to 4200 MHz, Δf = 2225MHz
  - Standard Ku-band
    - ⇨ 14.0 to 14.5 GHz / 12.25 to 12.75 GHz, Δf = 1.75GHz

Block Diagram for Earth Station

CHINA APMT

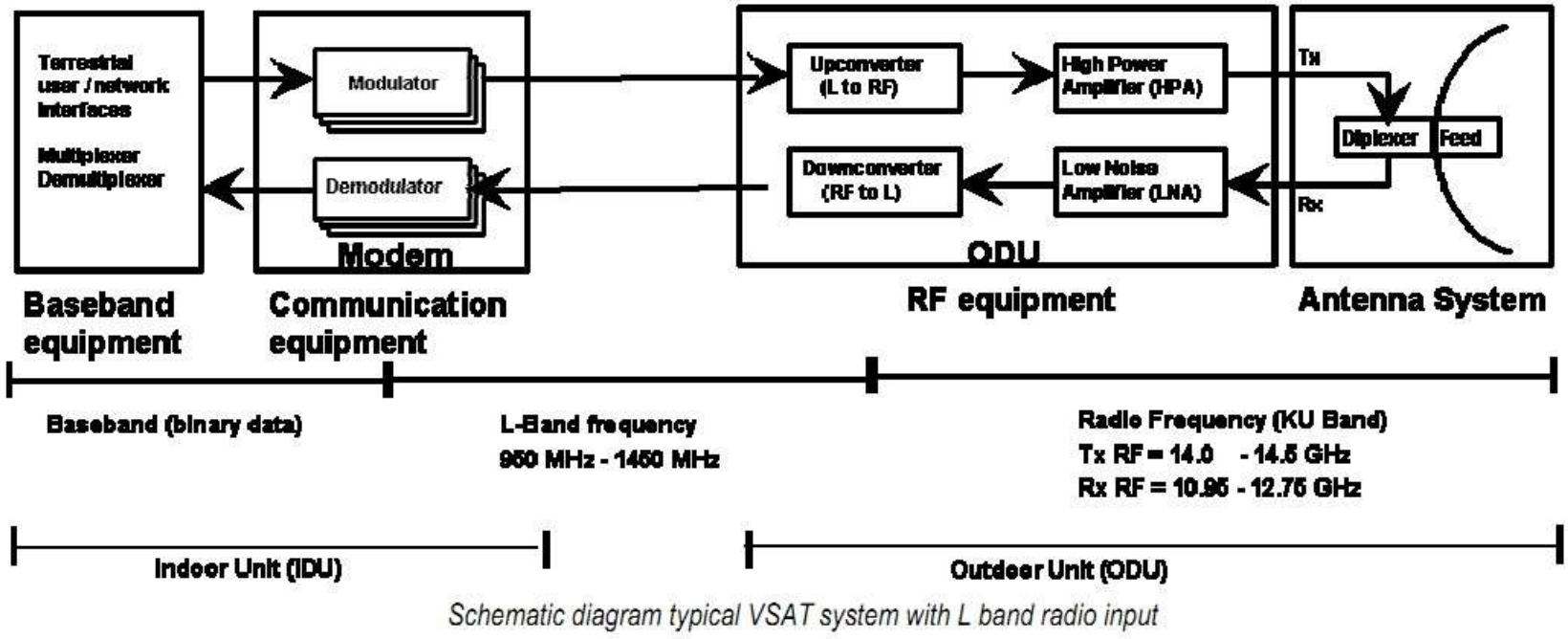
- IF connection
  - Cable between IDU and ODU at IF band (70MHz or 140MHz)
  - RF and Δf of U/C and D/C lied on frequency plan of designated satellite
  - Operation frequency band of antenna, HPA, LNA also lied on satellite frequency plan



Schematic diagram typical VSAT system with IF radio input

Block Diagram for Earth Station (cont.)

- L-band connection
  - Cable between IDU and ODU at L-band
  - RF and Δf of U/C and D/C lied on frequency plan of designated satellite
  - Operation frequency band of antenna, HPA, LNA also lied on satellite frequency plan

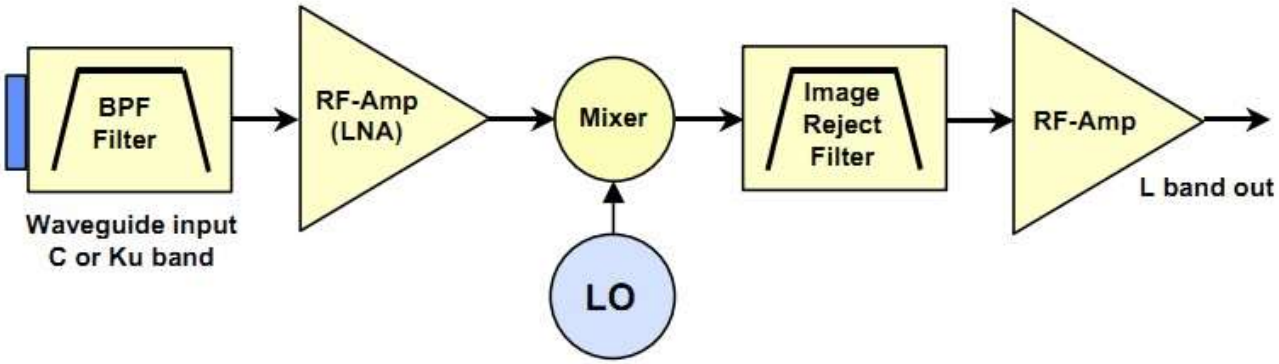


Schematic diagram typical VSAT system with L band radio input

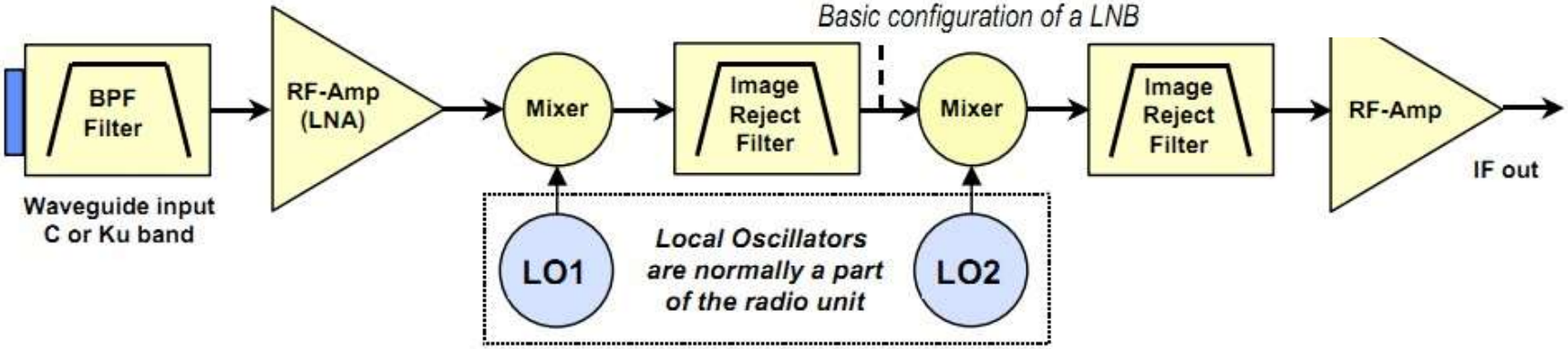
Low Noise Amplifiers

CHINA APMT

- LNA: only amplifier (50 to 100 dB gain)
- LNB: amplifier with D/C, output at L-band
- LNC: amplifier with D/Cs, output at IF, (80-100 dB)



Basic configuration of a LNB

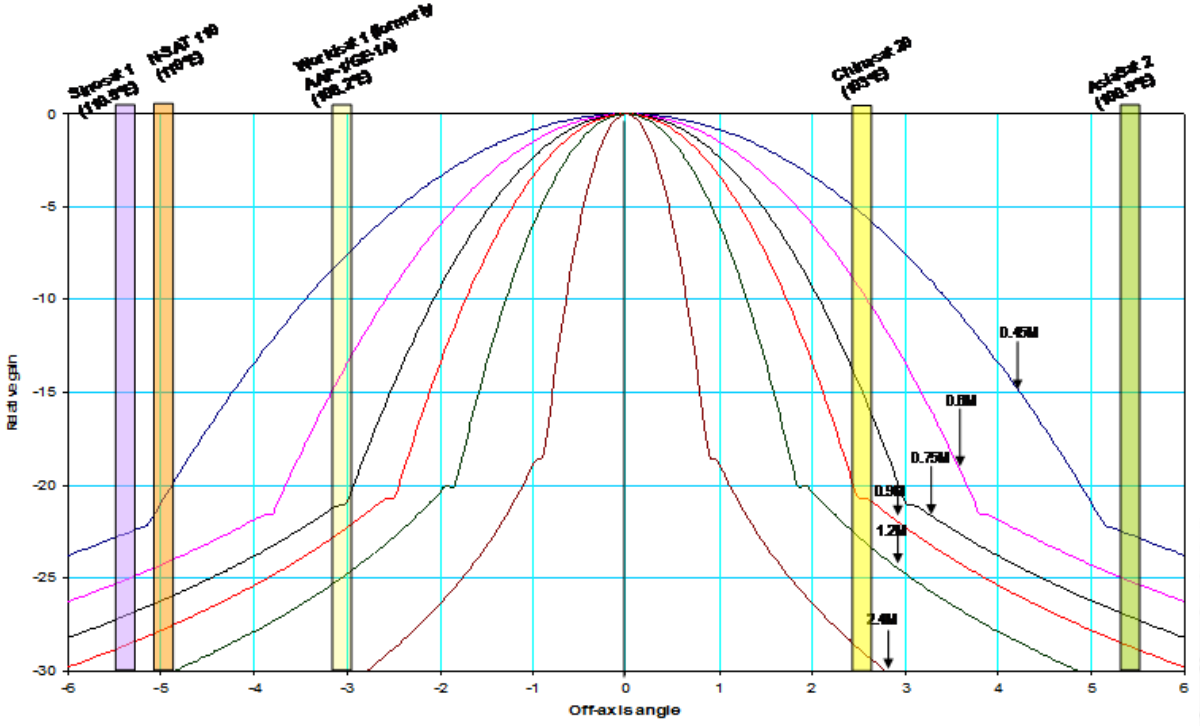


Basic configuration of a LNC

Adjacent Satellites

CHINA APMT

- Adjacent satellite interference
  - Interfered by adjacent satellite operating of co-frequency band and co-service coverage
  - Larger antenna, narrower beam width, lower interference
  - Figure shows antenna size relative to Ku D/L interference
    - ⇨ beam width for 0.45, 0.6, 0.75, 0.9, 1.2 and 2.4 m antennas



Discussion for LaoSat-1

CHINA APMT

- Not good at marketing
  - Uncommon frequency band, rarer and more expensive antennas and RF equipments
    - ⇨ allowance often used for customer carriers' migration
  - More difficult in transponder rent and sell
    - ⇨ more competitive rent fee often offered
- Good at adjacent satellite interference
  - Uncommon frequency band, rarer and less interference from adjacent satellite
    - ⇨ easier for frequency coordination
    - ⇨ smaller antenna may be used for market development

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Payload Management

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Technical Support

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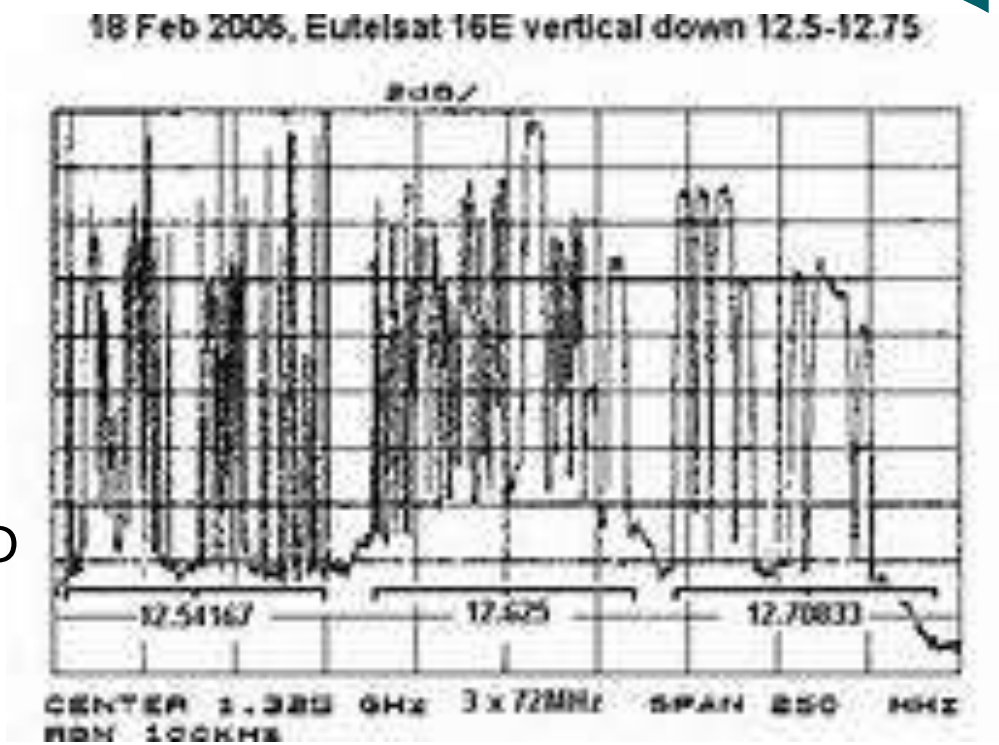
Frequency Coordination

Transponder Resource

CHINA APMT

- Transponder resource
  - Power resource
    - ⇨EIRP, linear EIRP
  - Frequency resource
    - ⇨bandwidth
  - Resource allocation
    - ⇨sharing EIRP and B/W
- Transponder spectrum
  - Noise floor showing SFD sensitivity
  - Y-axis: EIRP density, dBW/Hz
  - X-axis: bandwidth, Hz
  - Area: EIRP

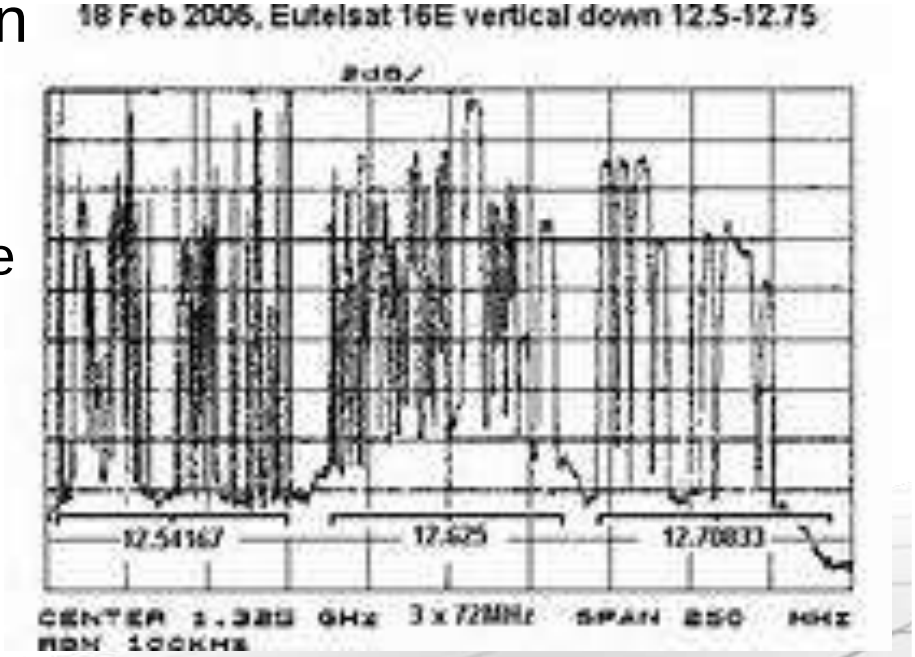


EIRP (dBW) = EIRP density (dBW/Hz) x bandwidth (Hz)

Transponder Spectrum

CHINA APMT

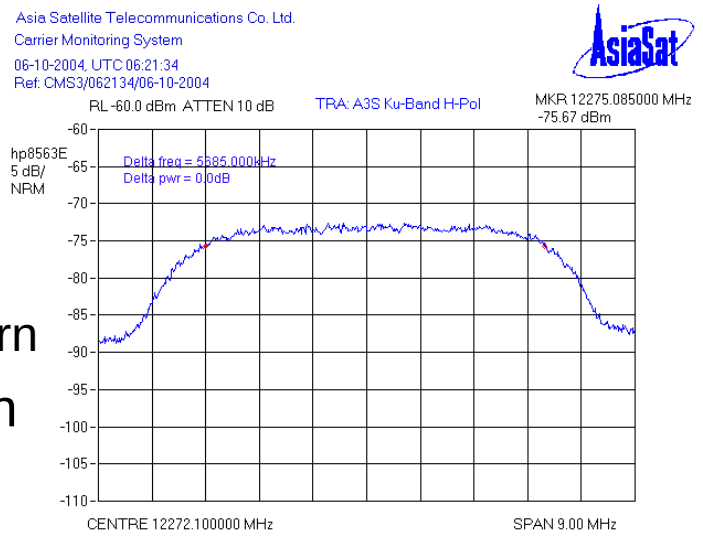
- Carriers in transponders
  - Higher in Y-axis, higher power density occupied
  - Wider in X-axis, more frequency bandwidth occupied
  - Larger in area, more power occupied
  - Total area of carriers or carrier areas' integral: transponder power occupied by all carriers
- Rule of resource allocation
  - Keeping carriers as same power density as possible
  - More power occupied, more expense offered

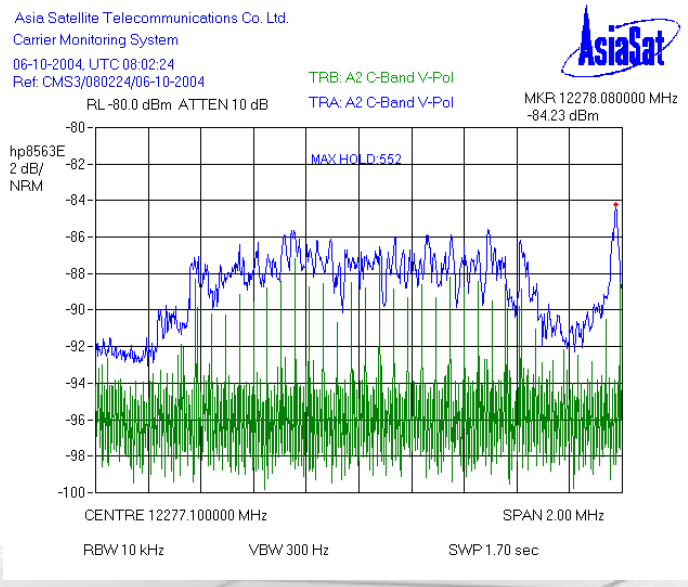


Carrier Spectrum

CHINA APMT

- Carriers at spectrum analyzer
  - SCPC carrier by phase modulation
    - ⇨spectrum line at rectangular shape
  - TDMA carrier by phase modulation
    - ⇨spectrum lines as rectangular pattern
  - Analog TV carrier by FM modulation
    - ⇨spectrum lines as pyramid pattern
- Carrier resource allocation
  - Enough frequency bandwidth including guard band
  - Average power (density) with clear and flat noise floor

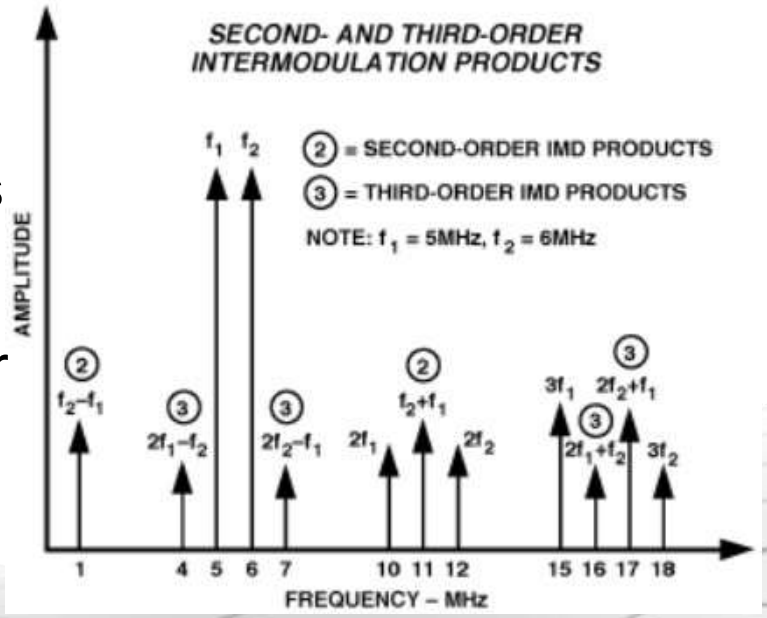




Other Parameters

CHINA APMT

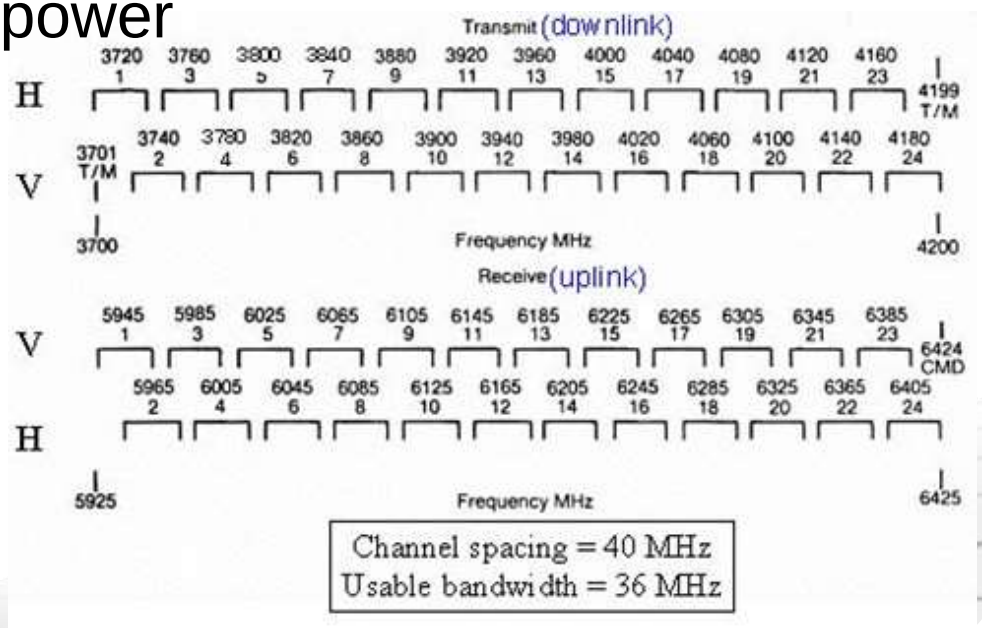
- Linearity requirement
  - 3rd intermoduration product, noise power ratio, phase shift, and AM/PM transfer
  - Better specification at the band around center of transponder
- Frequency response
  - frequency response, gain slope, and group delay
  - Better specification at the band around center of transponder
- Cross polarization
  - Occurred by polarization adjustment for transmit antennas
- Frequency and power stability
- Center in transponder is better



Carrier Allocation

CHINA APMT

- Multi carrier used transponder
  - Center bandwidth properly reserved for pure carrier test
    - ⇨causing corsspol interference to the transponder at crosspol
  - Interleaving frequency plan is better
- Center frequency band allocation
  - Center is better for carriers easily influenced by non-linearity or phase noise (TDMA and others)
- Carriers needed more power
  - Asides is better to let IM products going out of band



C-band and Ku-band

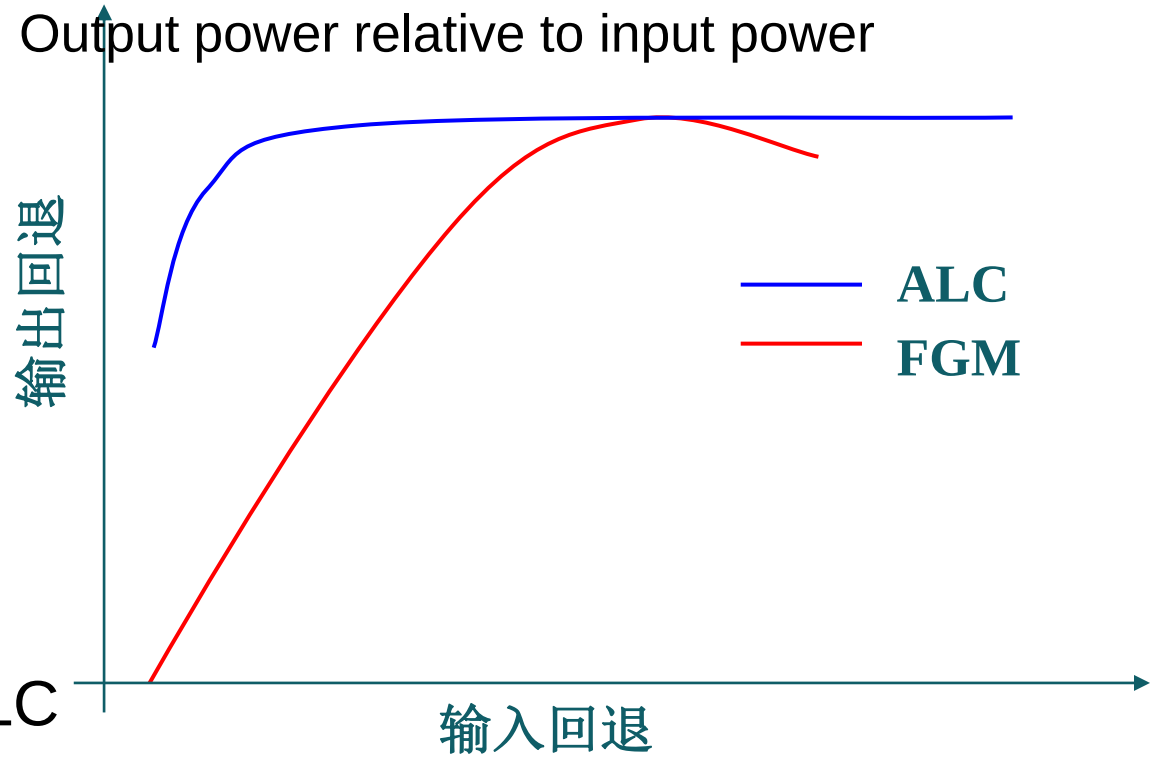
CHINA APMT

- C-band
  - Larger service area
  - EIRP at 36 to 42 dBW, and G/T at -5 to +1 dB/k
  - 1.8m or larger antenna for VSAT terminal
  - Less climatic influence
  - Compliant for high reliability as well as inter continent service
- Ku-band
  - Smaller coverage
  - EIRP at 44 to 56 dBW, and G/T at -2 to +8 dB/k
  - 1m or smaller antenna for TVRO and internet access
  - Rain fade and other climatic influence
  - Compliant for domestic network of numerous terminals

FGM and ALC

CHINA APMT

- FGM
  - Fixed Gain Mode
  - Output power relative to input power



- ALC
  - Automatic Level Control
  - Fixed output power at proper input power range
  - Suit for broadcast carrier uplinked by single E/S

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Frequency Coordination

Carrier Filing

CHINA APMT

- Link budget
  - One link budget table covering whole transponder bandwidth
  - Carriers or carrier groups listed one by one
  - Carrier's center-frequency/bandwidth and carrier group's start/stop-frequency/bandwidth with their power level
  - Two down-link C/N, one for user's E/S and the other for carrier monitoring at SCC
- Carrier spectrum archive
  - New plotted spectrum and its noise floor at line-up test
  - Regular profiling and comparing
- Carrier information and spectrum plots
  - Information about carrier and user
  - Spectrum plots of the carrier, including neighbouring carriers, and whole transponder

Regular Monitoring

CHINA APMT

- Daily monitoring
  - Raised noise pulse or noise floor
    - ⇨ checking transponder and carrier spectrum by wide band and narrow span
  - Raised carrier power or intrusive carrier
  - Anomaly recording and analyzing
    - ⇨ informing the user and resolving the problem

Interfering Measures

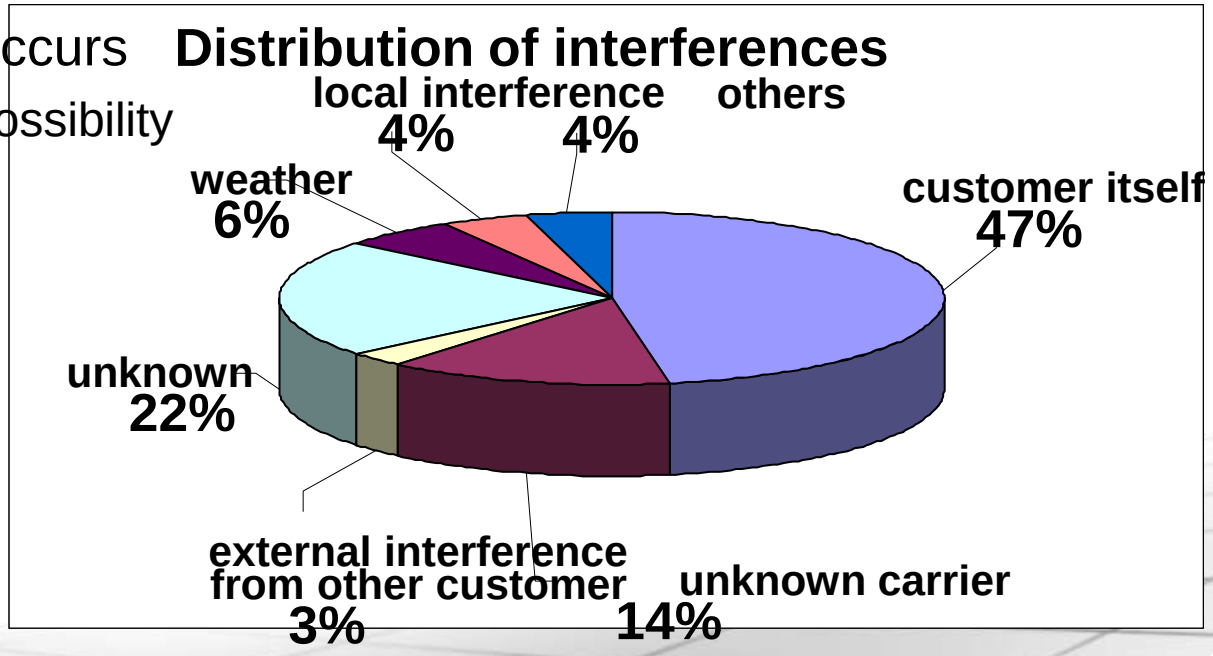
CHINA APMT

- Interferences in satellite networks
  - Often happened
  - Hard to find the source
    - ⇨ because of wide coverage, open access, lots of uplinkers, stealers and intruders
- Interfering source
  - Technical caused
    - ⇨ equipment problem and incorrect operation, accounted for 90%
  - Unauthorized uplink
  - Intentional intrusion
    - ⇨ economical or political reason

Interfering Measures (cont.)

CHINA APMT

- Classification statistics
  - Most of the interferences are caused by improper operation
- Measures
  - Power level decreased
    - ⇨ U/L problem? Rain fade? Antenna mispointing?
  - Noise floor risen
    - ⇨ Intermodulation? Crosspol interference?
  - Interference occurs
    - ⇨ too much possibility



Preventative Measures

CHINA APMT

- Measures of operator's
  - Rigorous network management
    - ⇨ equipment verification test
    - ⇨ carrier line-up test
    - ⇨ carrier monitoring system
  - Completed interfering coordination
  - Enough margin remained at link budget
- Measures of user's
  - Notice operator before network changed
  - Carrier test plan prearrangement with operator

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Frequency Coordination

Pre-sale

CHINA APMT

- For potential customers
  - Analyzing user's requirement
  - Offering link budget based link or network suggestion
    - ⇨ frequency band
    - ⇨ antenna size and HPA power
  - Coordination
    - ⇨ user asked antenna size vs. interference coordination requirements
    - ⇨ user asked power vs. power/bandwidth balance
    - ⇨ user asked carrier bandwidth vs. physical truth + guard band

Pre-sale (cont.)

CHINA APMT

- For potential migration customers
  - Introducing the advantage of space segment
    - ⇨ less adjacent satellite inference at unique frequency band
    - ⇨ local service, quick response and omnibearing support
  - Measuring the difficulty of migration
    - ⇨ unique frequency band for antenna and RF equipments, etc.
  - Discussing the process of migration
    - ⇨ working quantity evaluation and migration schedule drafting
  - Cooperation
    - ⇨ antenna pointing and pol-angle adjustment
    - ⇨ line-up test for uplink carriers
    - ⇨ other cooperation works

Post-Sale

CHINA APMT

- Annual session
  - Cooperation with marketing department
  - Invitation to all customers
  - Transponder resource introduction
  - Operating condition introduction
  - Common concern discussion
  - Technical training
- Other technical support
  - Cooperation with marketing department

Communication Payload

- Parameters
- Carrier Assignment
- Link Budget
- Frequency Resource and RF Equipments

Payload Management

- Spectrum Assignment
- Carrier Management

Technical Support

- Marketing Support
- Costumer Support
- Sun Outage

Frequency Coordination

Regular Tests

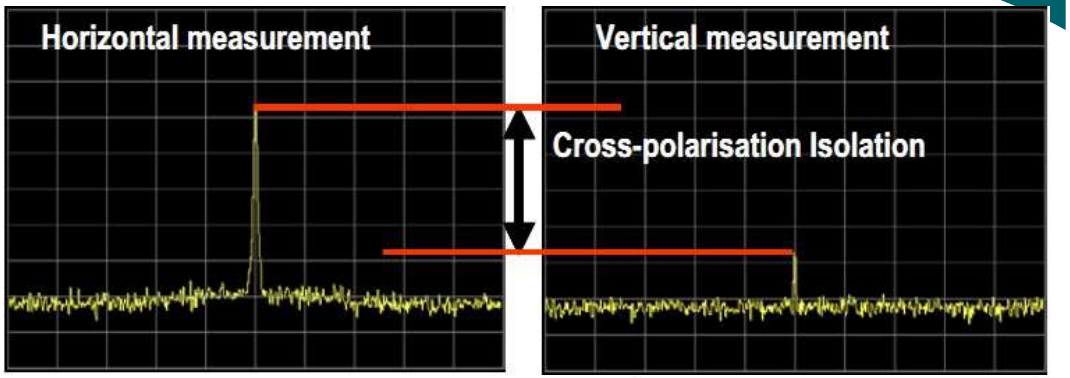
CHINA APMT

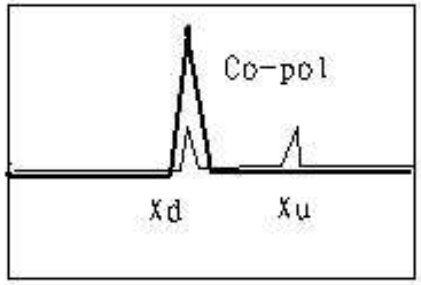
- Verification test
  - Antenna
    - side lobe test
    - crosspol isolation test
  - RF equipments
    - spurious, modulation and intermodulation characteristics
    - power and frequency stability
- Line-up test
  - Antenna
    - pointing and pol-angle adjustment
  - Carrier
    - frequency and power calibration

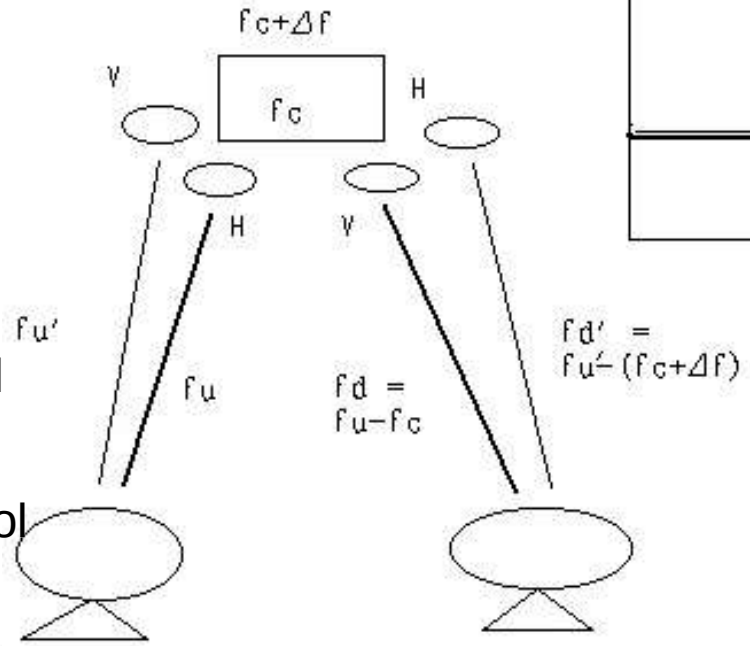
Crosspol Isolation Test

CHINA APMT

- Crosspol isolation
  - Power difference at co-pol and X-pol
  - Intrinsic specification of antennas
  - Better or worse by adjustment
- Method
  - Change at Tx side
    - ⇨ transmitting at both polarization
    - ⇨ monitoring at co-pol
  - Change at Rx side
    - ⇨ transmitting at co-pol
    - ⇨ monitoring at both polarization







Clients Service

CHINA APMT

- Regular customer visiting
  - Operating condition review for user equipments
  - User claim and requirement listening
  - User's future plan discussion
  - Service and interference problem suggestion
- Customer test cooperation
  - Offering idle space segment
  - Witness and cooperation for the test
  - To avoid unnecessary intrusion, test resource about short term and limited band may be offered for non-user

Adjacent Satellite Interference

CHINA APMT

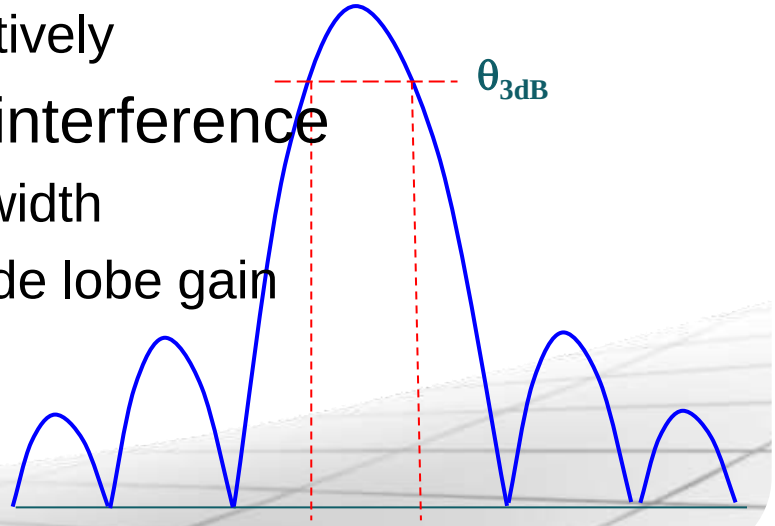
- Half power antenna beam width
  - Beam width at antenna main lobe where -3dB roll off from peak

    $\theta_{3dB} = 70\ \lambda/D$

    where, D is antenna aperture, and λ is the wave length relative to carrier frequency
  - Antenna could be estimated by beam width

    $G_{ANT} = 31000 / (\theta_{Az3dB}\ \theta_{El3dB})$

    where, θ_{Az3dB} and θ_{El3dB} are half power beam widths at azimuth and elevation respectively
- To decrease adjacent satellite interference
  - Larger antenna, narrower beam width
  - Wider orbital separation, lower side lobe gain



Adjacent Satellite Interference (cont.)

- Down-link interference
  - Emission from adjacent satellite received by side lobe of local antenna

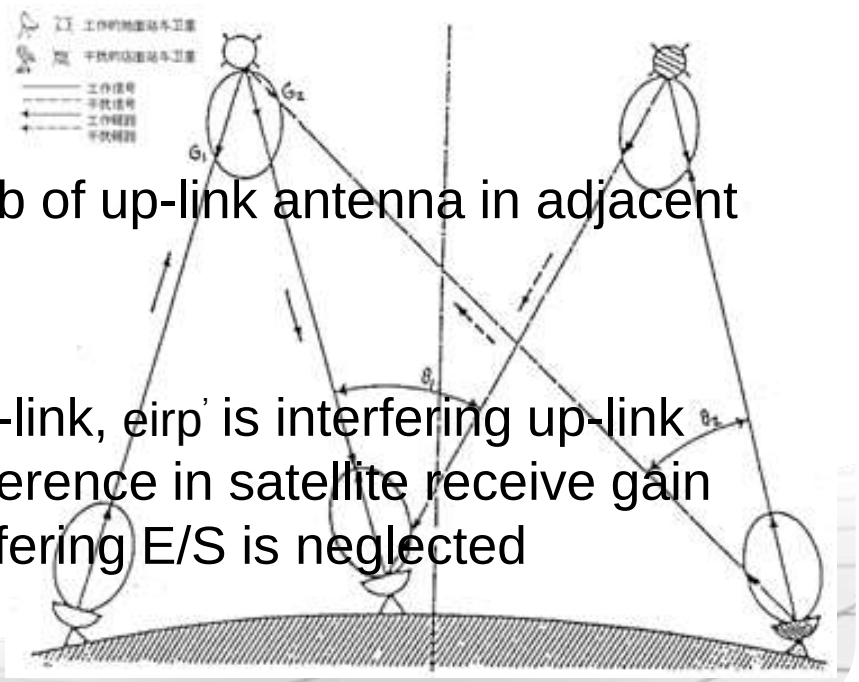
    $C/I = (EIRP + G_{Rx}) - (eirp + G')$

    where, C/I is carrier to interference power ratio, EIRP and eirp is wanted and interfering satellite EIRP, G_{Rx} and G' is peak antenna gain pointing to wanted satellite and off-axis gain to interfering satellite

- Up-link interference
  - Off-axis emission from side lob of up-link antenna in adjacent satellite network

    $C/I = EIRP - eirp'$

    where, EIRP is wanted up-link, $eirp'$ is interfering up-link through side lobe, and difference in satellite receive gain between wanted and interfering E/S is neglected



Interference Caused by X-pol and IM

CHINA APMT

- Cross-polarization
  - Closer to beam center, better crosspol isolation
    - ⇨ antenna mispointing causing worse X-pol isolation
  - Gain variation by pol-angle changing is more sensitive at X-pol than co-pol
    - ⇨ monitoring X-pol when polarization angle adjustment
- Intermodulation
  - Unauthorized carrier power increasement
    - ⇨ carrier uplink power may be increased by one user after another, when some of them without regard to allocated power level
  - Up-link power losing lock at RF equipment
  - Less margin in power allocation

Interference from Earth Station

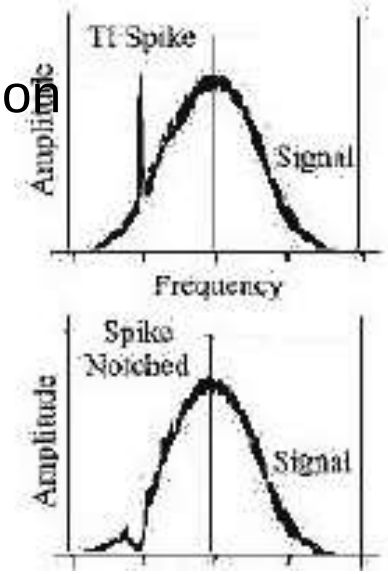
CHINA APMT

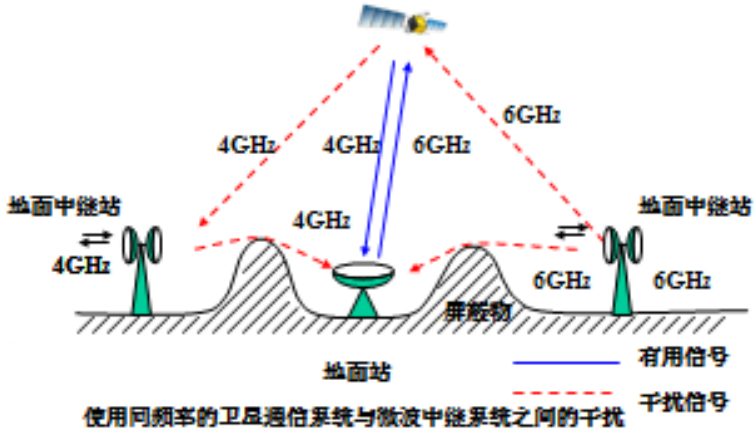
- Unwanted loop formed at RF or IF segment
  - Retransmission raising noise floor
    - ⇨ wide band noise floor raised
    - ⇨ switching off suspects' HPA one by one
  - RF equipment
    - ⇨ down-link signal into up-link
  - Cable coupling
    - ⇨ paralleling IF or L-band cable, especially under ground

Interference from Microwave and Intrusion

CHINA APMT

- Micro-wave relay
  - C-band shared by satellite and terrestrial
  - Low elevation angle, parallel to terrestrial emission
- Stealing
  - Normally for testing in short term
  - Improper X-pol adjustment
- Intrusion
  - Attitude bias for uplink site exploration
  - Negotiation with relative administration





Rain Fade

- Absorption of microwave signals by rain
  - Ku-band, up- and down-link
  - 5dB or more attenuation
    - ⇨with raising noise floor and worse X-pol isolation
  - Insufficient even minus C/N margin
- Up-link rain fade
  - Uplink power increasing
  - ALC mode presetting for mono uplink transponder
- Down-link rain fade
  - More margin obligated

Communication Payload

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Payload Management

- Spectrum Assignment
- Carrier Management

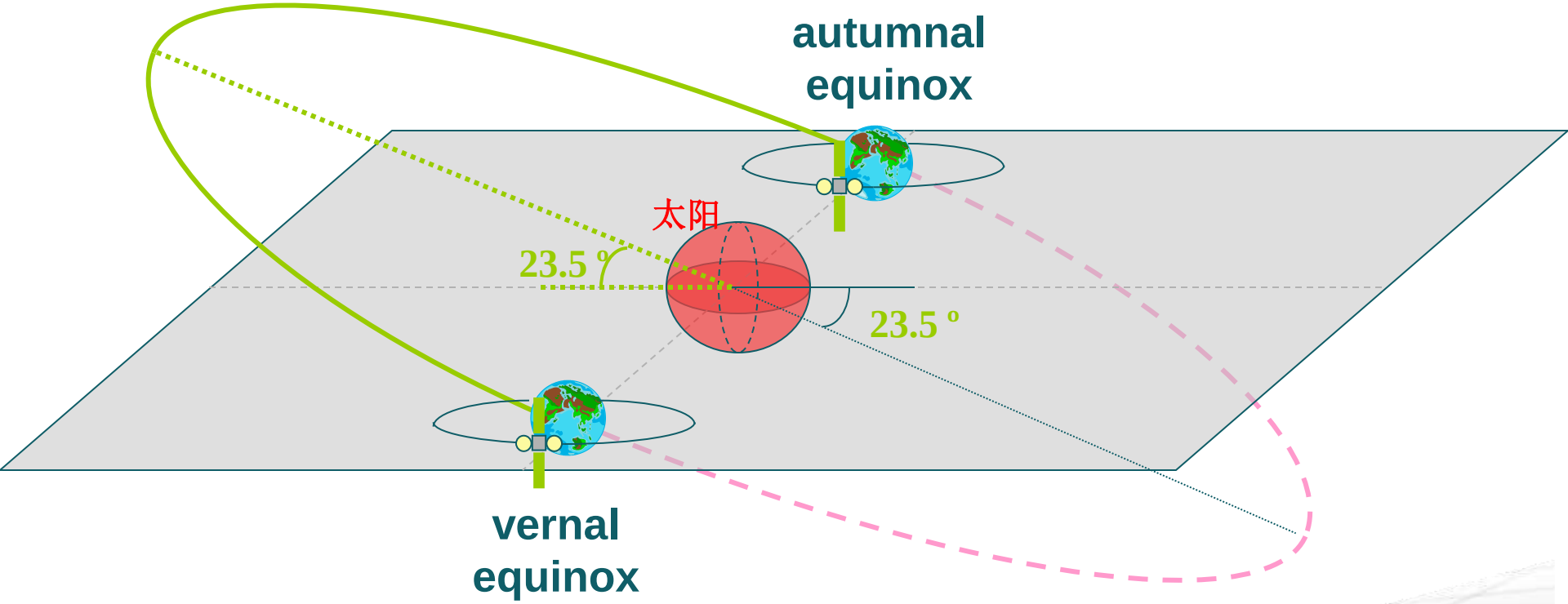
Technical Support

- Marketing Support
- Costumer Support
- Sun Outage

Frequency Coordination

Earth Orbit

- Earth orbit is inclined to equatorial plane and GEO
- During spring and fall equinoxes, the sun passes through the equatorial plane



Sun Outage

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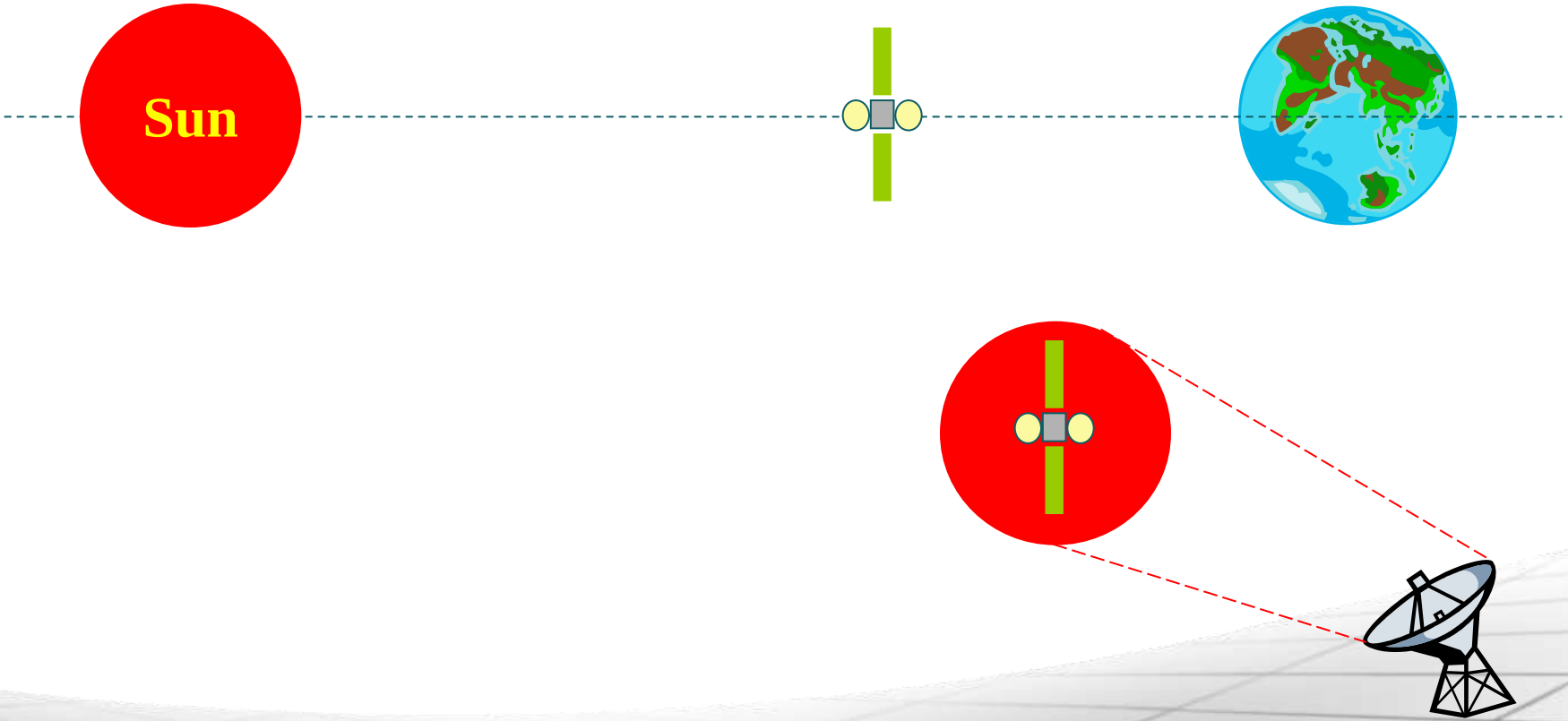
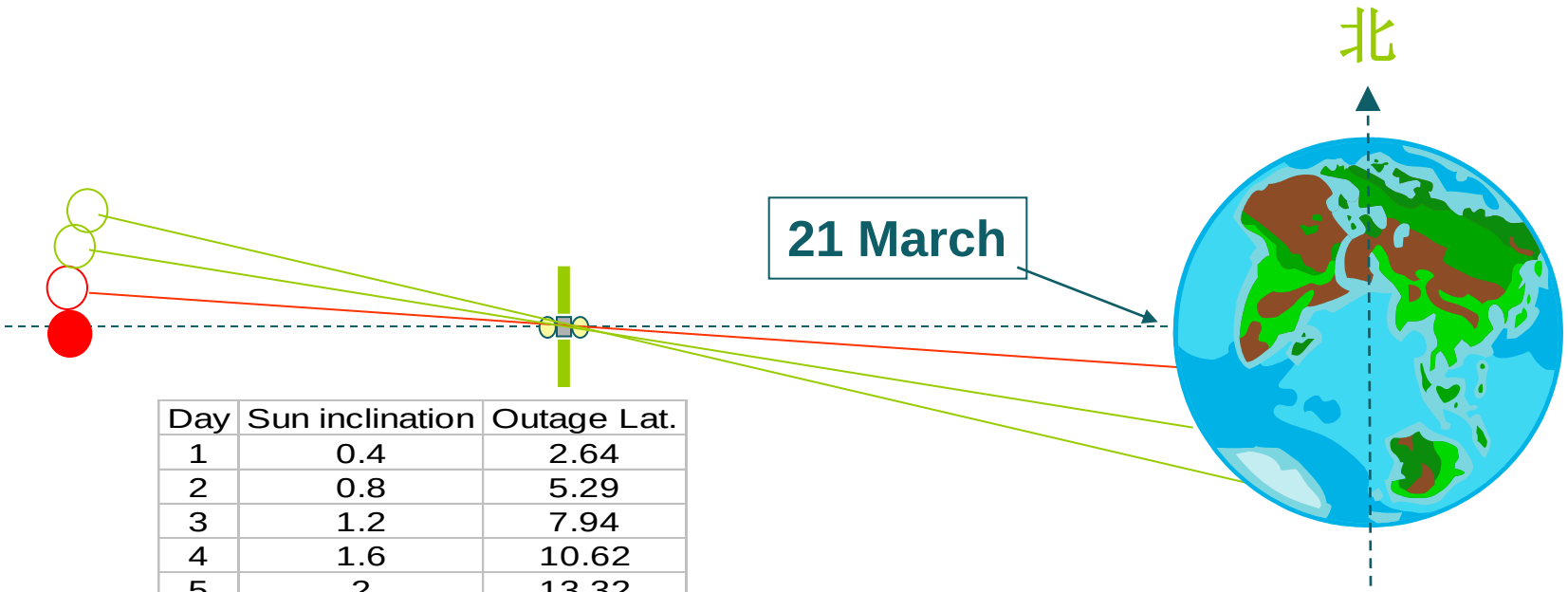
- When the sun appearing behind the satellite around noon
- D/L signals from the satellite are overpowered by the RF energy from the sun



Outage date

CHINA APMT

- Solar orbit's daily shift in south/north is 0.4 degrees
- Outage location's daily shift in north/south is about 2.8 degrees (non linearity)



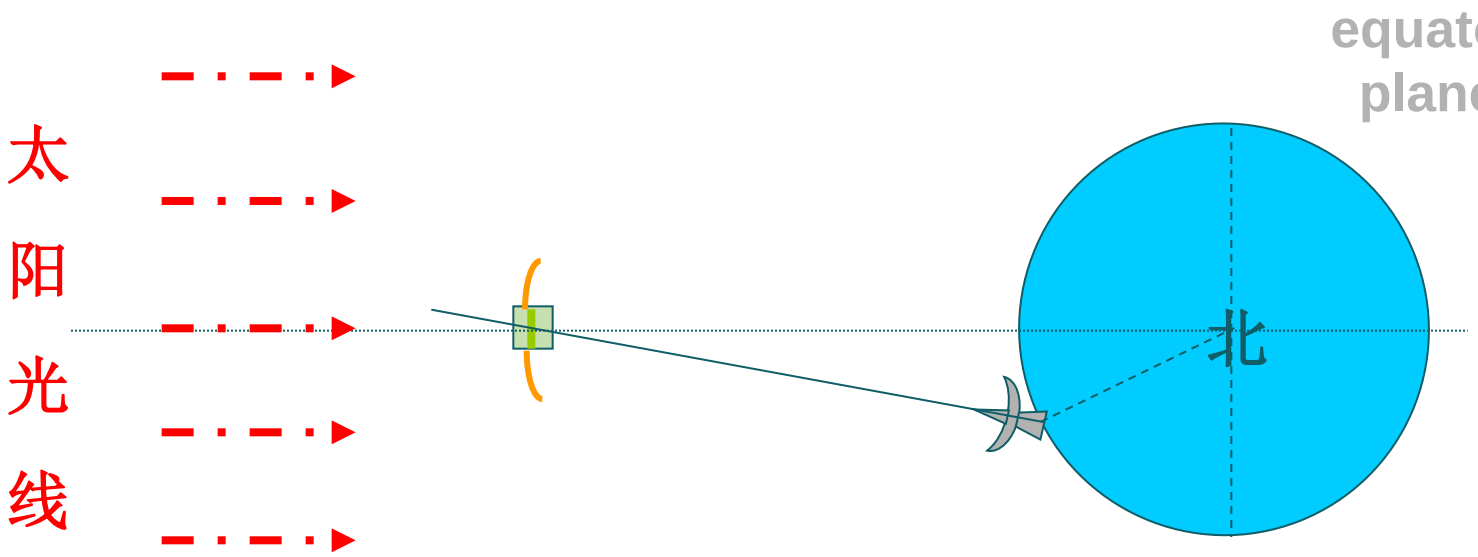
Day	Sun inclination	Outage Lat.
1	0.4	2.64
2	0.8	5.29
3	1.2	7.94
4	1.6	10.62
5	2	13.32
6	2.4	16.04
7	2.8	18.81
8	3.2	21.62
9	3.6	24.48
10	4	27.41

Outage Time

CHINA APMT

- At local noon: E/S longitude equals to satellite orbit
- Before or after local noon: E/S longitude different to orbit slot

$\Delta t : \Delta long. = 4min/deg$

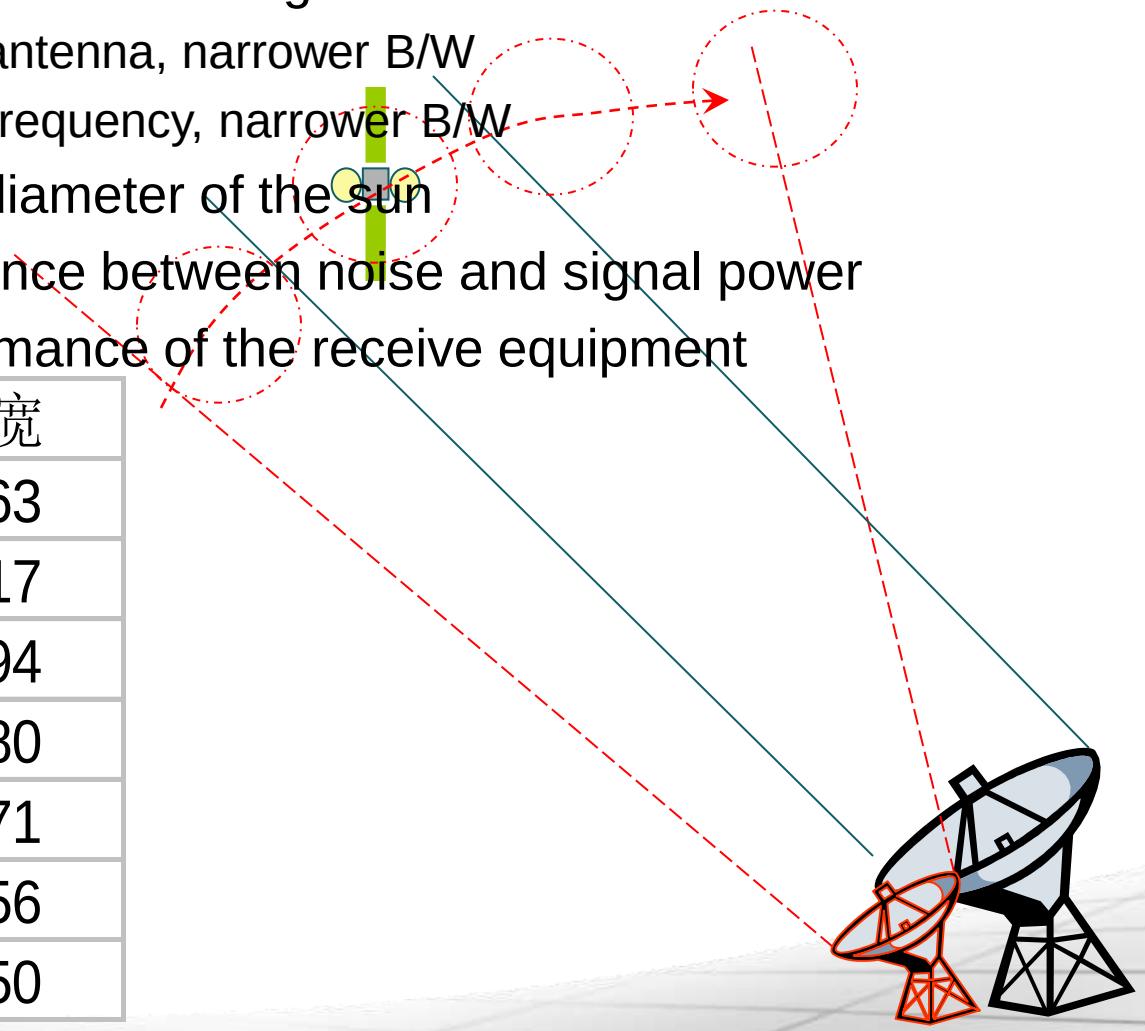


Sun Outage Duration

CHINA APMT

- Outage duration
  - Beam width of receiving antenna
    - ⇨Larger antenna, narrower B/W
    - ⇨Higher frequency, narrower B/W
  - Apparent diameter of the sun
  - The difference between noise and signal power
  - S/N performance of the receive equipment

天线直径	束宽
2	1.63
3	1.17
4	0.94
5	0.80
6	0.71
9	0.56
11	0.50



Outage Prediction Data

CHINA APMT

- Sun outage prediction
  - Communication engineer: preparing customer's information
    - E/S location, antenna size, and frequency band
  - Orbit analyser: calculating outage prediction data
  - Communication engineer: sending data
    - before each outage period during spring equinox and fall equinox
    - to inform customers for preparation
- Outage calculator at satellite operator's homepage
  - Required input parameters
    - E/S location: longitude and latitude in deg, altitude in m
    - satellite orbit slot: in deg
    - antenna size: in m
    - D/L frequency: in GHz

Communication Payload

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- Sun Outage

Frequency Coordination

Regulation of Frequency Coordination

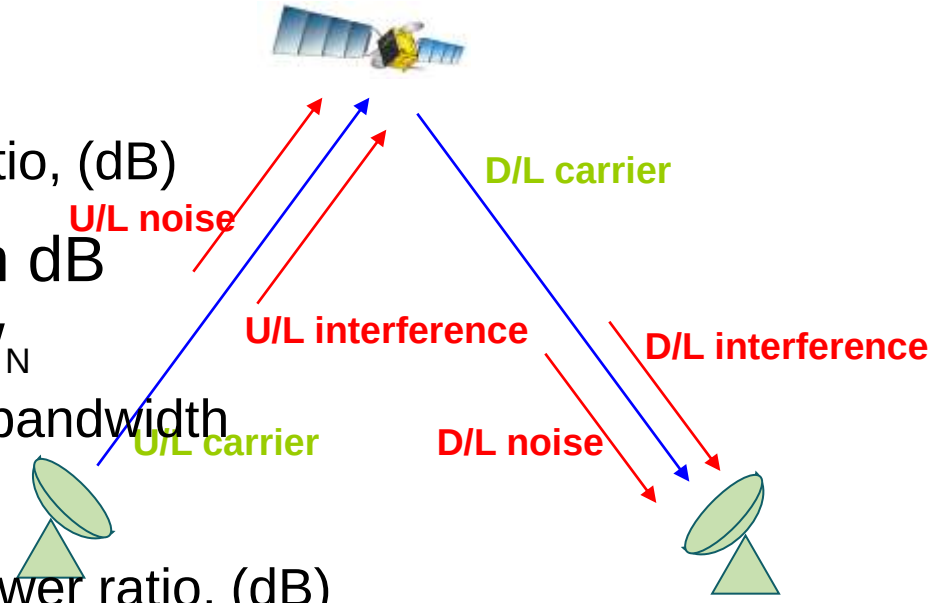
- Regulation
  - Only completed the coordination, could operator use the applied orbital resource
  - Standard for coordination: C/I
    - ⇨ coordination for co-coverage and co-frequency band, 10 degrees separation may not meet the requirement
    - ⇨ 2 degrees or more is enough for common operation
- Regulation vs. reality
  - Relative priority vs. coordination request
  - Out-of-date standards vs. technical improvement
  - Filing coordination vs. channel by channel discussion
  - Face-saving administration vs. hungry so unreasonable operator

C/T, C/N and C/I

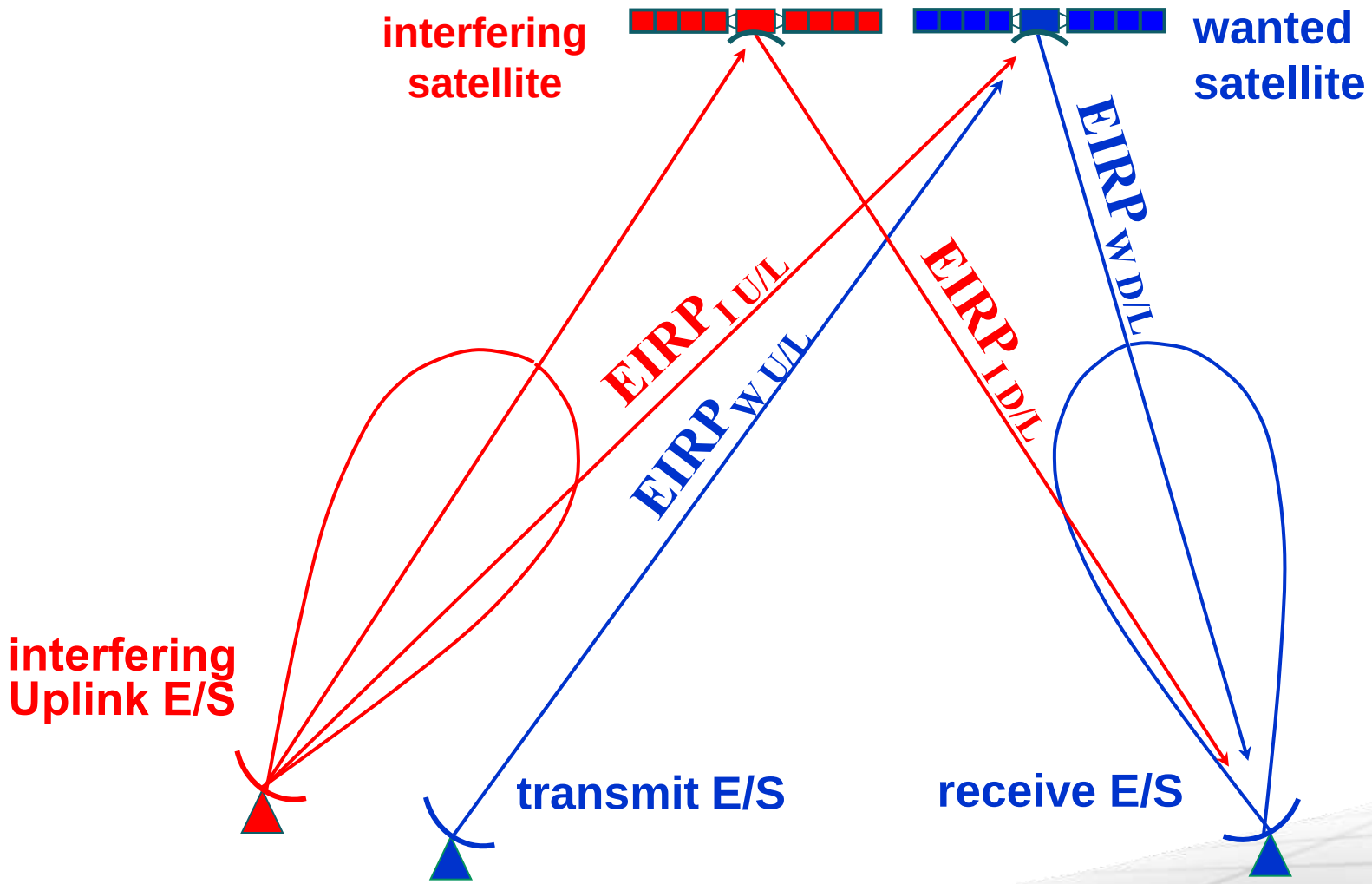
- C/T
  - Carrier power to thermal noise ratio, (dBW/k)
  - Internal noise and influence, controlled through link design
- C/N
  - Carrier to noise power ratio, (dB)
- C/T to C/N calculation in dB

  $C/N = C/T + 228.5 - BW_N$

  where, BW_N is noise bandwidth
- C/I
  - Carrier to interference power ratio, (dB)
  - By interference power to noise temperature conversion, C/I and C/T can be converted each other



D/L and U/L Adjacent Satellite C/I



C/T, C/N and C/I (cont.)

- C/(N+I)
  - Carrier power to noise and interference power ratio
  - Same as thermal noise, interference will also degrade service quality
- Relationship between C/T, C/N, C/I, C/(N+I)

$$\left(\frac{C}{I}\right)_U^{-1} = \left(\frac{C}{I_{ACI}}\right)_U^{-1} + \left(\frac{C}{I_{ASI}}\right)_U^{-1} + \left(\frac{C}{I_{XPI}}\right)_U^{-1} + \left(\frac{C}{I_{IM}}\right)_U^{-1} + \ldots$$

$$\left(\frac{C}{I}\right)_D^{-1} = \left(\frac{C}{I_{ACI}}\right)_D^{-1} + \left(\frac{C}{I_{ASI}}\right)_D^{-1} + \left(\frac{C}{I_{XPI}}\right)_D^{-1} + \left(\frac{C}{I_{IM}}\right)_D^{-1} + \ldots$$

$$\left(\frac{C}{N+I}\right)_U^{-1} = \left(\frac{C}{I}\right)_U^{-1} + \left(\frac{C}{N}\right)_U^{-1}$$

$$\left(\frac{C}{N+I}\right)_D^{-1} = \left(\frac{C}{I}\right)_D^{-1} + \left(\frac{C}{N}\right)_D^{-1}$$

$$\left(\frac{C}{N+I}\right)_T^{-1} = \left(\frac{C}{N+I}\right)_U^{-1} + \left(\frac{C}{N+I}\right)_D^{-1}$$

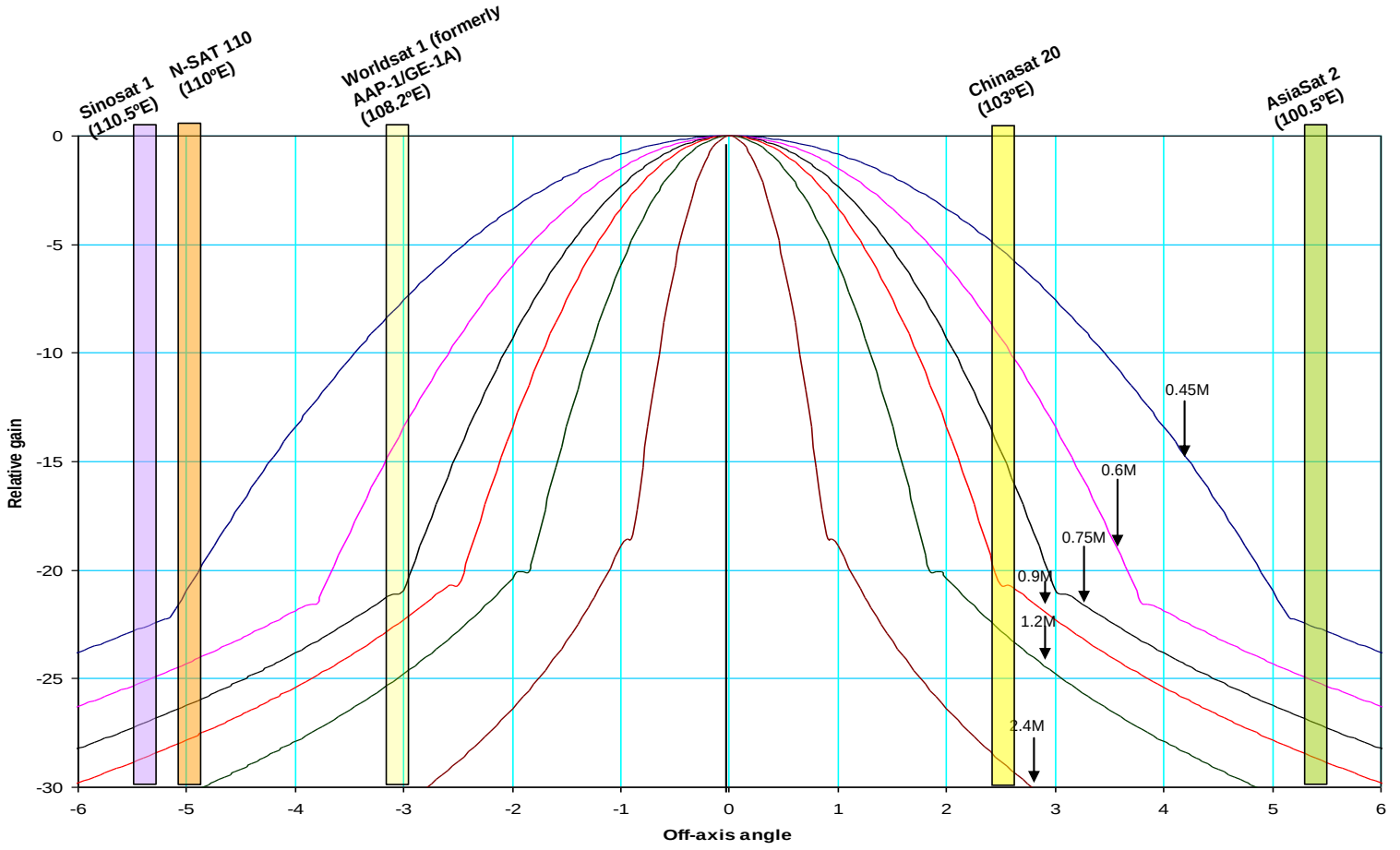
where, symbol [ ] means logarithmic notation (dB)

Limited Antenna Size and Power Density

- Transponder performance may be limited in use
  - For reducing interference to adjacent satellite, some limitation at antenna size and uplink power density might be committed by the operator
- System margin may be lower than link budget
  - For uplink interference from adjacent satellite network transmitted by small Tx antenna
  - For downlink interference from adjacent satellite received by small Rx antenna
  - The C/I may be much lower than link budget estimated

Sample of C/I and Antenna Size Relationship

Reception of interference for Ku-band antennas pointing towards AsiaSat 3S (105.5ºE)



Relative antenna gain contours for 0.45, 0.6, 0.75, 0.9, 1.2 and 2.4m at 12.2 GHz (ITU-R-BO 1213)

Reference:

AsiaSat: Customer Training Materials, April 2004

Thanks!

Welcome to my homepage

www.satcomengr.com