Antenna Mounting and Alignment

ICTP- ITU School on Wireless ICT Low Cost solutions in Developing Countries: best practices

Abdus Salam ICTP, Triest, **February 2009**

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Session Overview

- Antenna mounting requirements
- Wall side mounts
- Roof mounts
- Guyed towers
- Self supporting tower
- Typical installation
- Antenna Alignment

Requirements for the base station mounting structure

- Location of the base station is by far the must important consideration, in order to have the best coverage.
- Access to the power grid, security of the equipment and accessibility of the site come next

Requirements for the base station mounting structure

- Sometimes an existing tower can be used for the new install, if an agreement with owner can be arranged
- The alternative is to build a supporting structure of your own

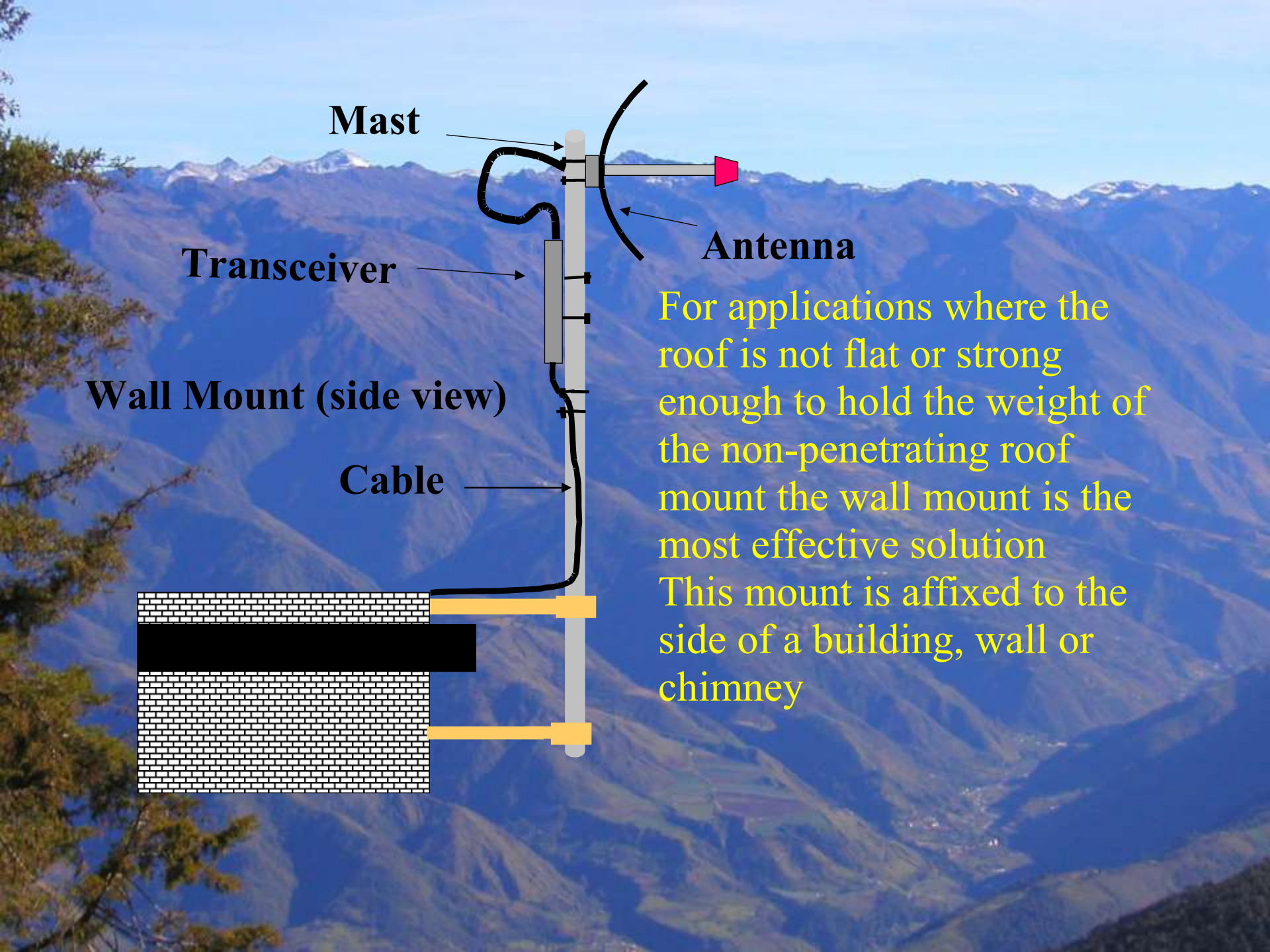
Antenna Mount Options

Free standing Pole
Side Mount
Roof Mount
- Penetrating
- Non Penetrating

Climbable tower
- Guyed
- Self Supporting

Free standing pole

Often it is less expensive than a tower, and can be built by attaching foot rests to any sizable pipe



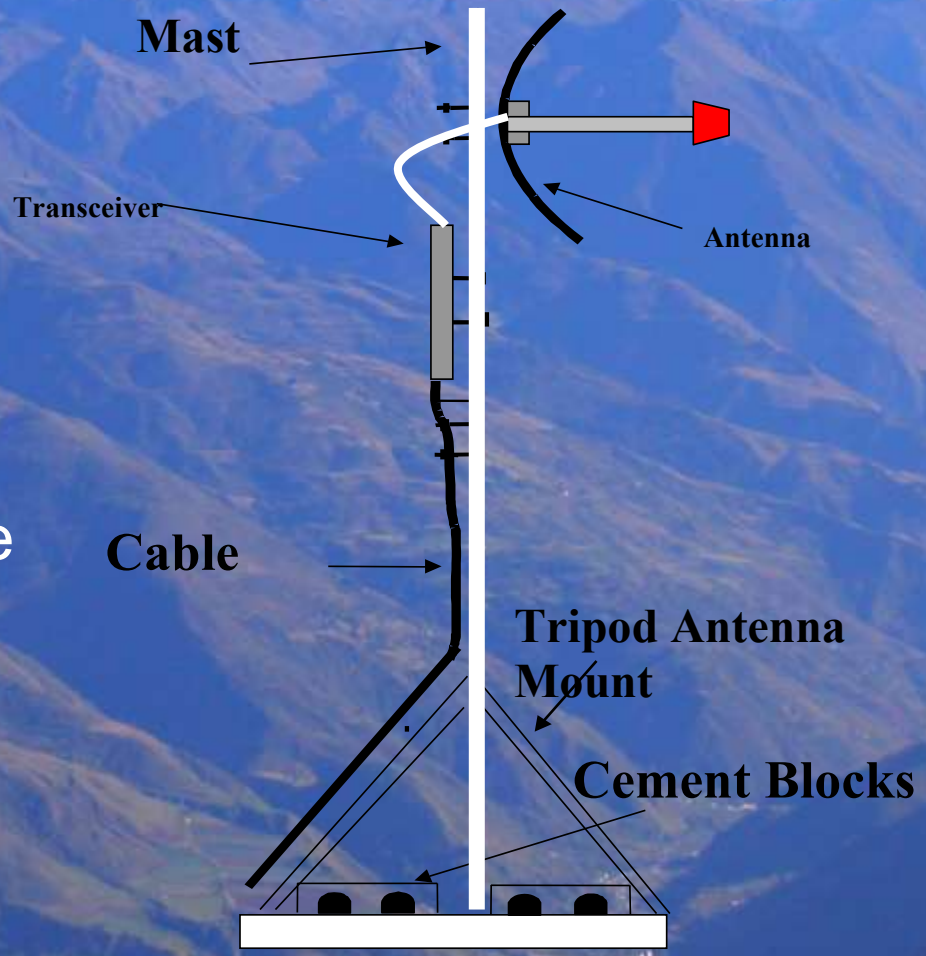
For applications where the roof is not flat or strong enough to hold the weight of the non-penetrating roof mount the wall mount is the most effective solution
This mount is affixed to the side of a building, wall or chimney

Wall mount

- The structure must be capable of handling the weight of the mast, antennas, and transceiver plus wind loading stress.
- This type of mount requires drilling four holes into the structure.
- When mounting to masonry expansion type bolts or lead anchors should be inserted into the hole drilled as a means of attaching the mounting bracket to the structure.

Non Penetrating Rooftop Mount

At least 4 cement blocks (to be used as ballast) or equivalent, are also required. One piece of 90 cm x 90 cm rubber padding can be placed under the assembly to provide roof protection.



Non penetrating mount example

This home made example can be fitted with containers filled with water or sand to increase wind resistance

Penetrating Roof Mount

Care must be taken in order to prevent water from seeping in through the attachment bolts

Guyed Tower

- A climbable tower is normally made of aluminum with a triangular cross section, about 30 cm per side.
- Each section is about 3 m long and several sections can be bolted together to attain the required height
- The tower must be properly guyed to withstand the expected wind in the area, as well as to support the weight of the equipment and one person

Security

Always use a harness securely attached to the tower when working at heights

Carlo Fonda, Isabela, Galapagos Islands, 2007

Security

- Many countries require special training for people to be allowed to work on towers above a certain height
- Avoid working on towers during strong winds or storms

Security

A lightning arrestor is
a must for any structure
elevated above the surrounds.
An inexpensive solution
is to use a grounding rod
properly connected to ground.

Erecting a tower with a pulley

- A pulley attached to the top of a pole will facilitate the tower installation
- The two tower sections are attached with an articulated joint

Use tensors and proper fittings for the guy wires

Self Supporting Towers

- Self supporting towers are expensive but sometimes needed for the Base Station
- An existing tower can sometimes be used for subscribers, although AM Transmitting station antennas should be avoided because the whole structure is active.
- FM station antennas are O.K.

Protect connectors from exposure

- Connectors should be protected with special tape or compound, since humidity cropping in is the main observed cause of CPE failures
- Cables should have dripping loops to prevent water getting inside the transceiver

Typical Installation

- Equipment
  - Two or more radio devices
  - Antennas (depend on install requirements)
  - Antenna Mount (non penetrating, pole, wall mount, etc)
  - COAX Cable 50 Ohm LMR400 or LMR 600*
  - Alternatively, PoE injector and UTP cables
  - Appropriate connectors
  - Sealing compound or tape for connectors
  - Crimp and Soldering tools
  - Laptop for configuration

Typical Installation

- Make sure you follow local code and regulations
  - MTBR for down links can vary, have spare parts
- Do a free space loss calculation:

  L = 100 + 20 log(km) @ 2,45 GHz

  L = 106 + 20 log(km) @ 5 GHz

Exercise

Find the received signal level at 10 degrees from the boresight of a 24 dBi Hyperlink HG2424 antenna fed from a Linksys WRT54G Router with 12 meters of LMR400 cable. The receiving antenna is omnidirectional, located at 13 km and with a gain of 8 dBi at 2, 4GHz operating frequency. The receiving antenna cable is LMR 200 and 7 meters long. Both antennas are protected by cabling arrestors that introduce 0,5 dB of additional loss each.

The link is meant to attain 11 Mbit/s nominal speed.

Typical Installation

- Do a “Test Install” first:
  - take a 2 m pole and attach a 24 dBi dish
  - connect to radio and search for other end
  - verify connectivity quality and strength
  - note general heading of antenna
  - note elevation (did you have to lift it up, etc)
  - now try antenna you plan to use

Base Station Antennas Mounting Considerations

The first choice for a base station is an omnidirectional antenna.

An omni will provide maximum coverage for your money.

Unfortunately, the best location for the omni antenna is at the top of the tower.

Very often this location is already taken so one must resort to attach the omni to one side of the tower.

Typical Installation

- Most important part of install (Antenna)
  - Make sure the mount is STRONG
  - Will NOT move in wind (antenna loads are high)
  - Well grounded, ground rod or similar
  - COAX is tied down with gentle sweeps
  - Lightning arresting equipment is grounded
  - Use a rubber mat for skids, to protect roof

Typical Installation

- Keep COAX length S H O R T
  - No more than 15 meters
- Tape and secure ALL connections
- Use All Weather Tape
  - NOT Electrical tape or duct tape
- Use BLACK Nylon Ties
  - White ones will break down in UV
- If able, place cable in conduit for protection
- If using PoE, weatherproof UTP is a must as well as weatherproof RJ45 connectors (gland)
- If possible, protect the radio from sun and rain

Base Station Antennas Mounting Considerations

Omni antennas have 3 basic specifications:

- VSWR
- Vertical radiation pattern
- Horizontal radiation pattern.

Any nearby metal object will affect all of these

Base Station Antennas Mounting Considerations

This easy to understand if one considers the functioning of a Yagi-Uda antenna:

We have only one active element, but the addition of the reflector and the directors will affect the gain.

So any conducting object that is spaced from our antenna less than 2 wavelengths will affect the performance

Base Station Antennas Mounting Considerations

VSWR

A sizable conducting object will reflect part of the signal.

Radio hams some times tune the VSWR of an antenna by changing its distance from the tower.

A number of coaxial cables or waveguides can constitute a big enough reflector.

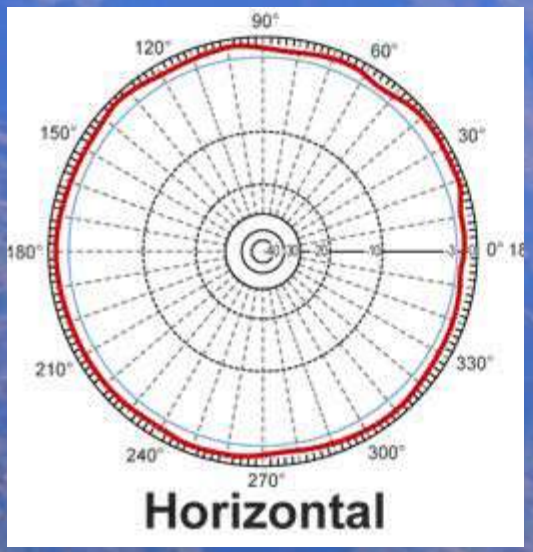
Separating the antenna at least 25 cm will be enough to overcome this effect at 2.4 GHz

Base Station Antennas Mounting Considerations

Horizontal Radiation Pattern

The horizontal pattern of an omni approaches a circle. A small pipe near the antenna can act as a director or reflector, changing the gain up to 3 dB in certain directions, thus disrupting the radiation pattern.

A sizable object like the back of a parabola can completely block the signal in a given direction

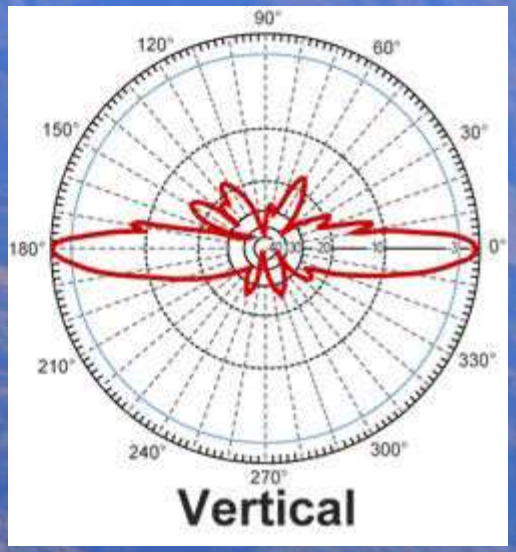


Base Station Antennas Mounting Considerations

Vertical Radiation Pattern

The gain of an omni is obtained by narrowing the vertical pattern.

This applies when the antenna is far from conducting objects, and constitutes a good approximation when the antenna is at the very top of the tower



Base Station Antennas Mounting Considerations

A self supporting tower very often has a tapered design, becoming narrower with height. This will uptilt the beam of a side attached omni up to 5 degrees. A typical 15 dBi omni has an 8 degree vertical beamwidth.

The beam can be tilted upwards so much as to send all the signal where it does no good.

Base Station Antennas Mounting Considerations

- Sectorial Antennas are less affected by the tower and can easily be downtilted.
- This is particularly necessary when the subscriber is close to the base station or when the base station is much higher.
- Mechanical downtilting can compensate for the effect of the structure.
- Electrical downtilting can be accomplished by changing the phase of feeding elements.

Subscriber Antenna Mounting Considerations

- Locate the antennas so that they have clear line of sight to the antennas at the opposite endpoint of the link.
- There should be no obstructions within ±10 degrees azimuth of the antenna bore sight.
- Beware of possible reflecting structures in or behind the path
- Beware of trees whose growth might obstruct the path
- Avoid trajectories over bodies of water

Subscriber Antenna Mounting Considerations

Mounting the antennas close to the edge of the rooftop (on a flat top roof) helps to avoid problems with the latter requirement and with reflections. This should be done at the edge facing the air

Subscriber Mounting Considerations

- Other considerations include proximity to the cable run to the rooftop.
- When locating the antenna mast it is desirable to have it in close proximity to the building rooftop ground system if present. It then becomes a simple matter to provide a short, low resistance, connection to the building ground system.

Subscriber Mounting Considerations

- Conditions for microwave path design must be considered such as Earth curvature and Fresnel zone clearance.
- Observe local building and electrical codes when running all cables.

Antenna Alignment

A string a few meters long can help estimating the direction at which the antenna is pointing.

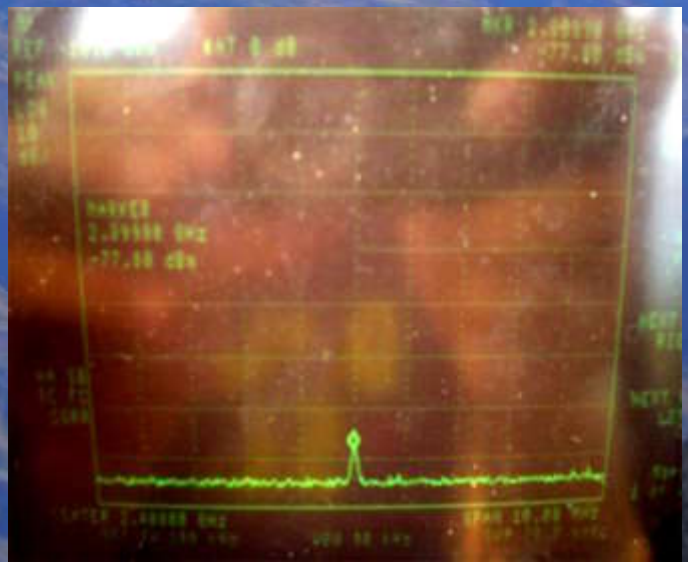
It also helps separating the compass from the influence of ferrous objects in the antenna mounting structure that might alter the compass reading

For long distances instruments are required

Long Distance Antenna Alignment Instruments

- Signal Generator
- Spectrum Analyzer

Antenna Alignment using instruments



Pietrosemoli

Long Distance Antenna Alignment Requirements

Expensive instruments beyond the reach of communities endeavors

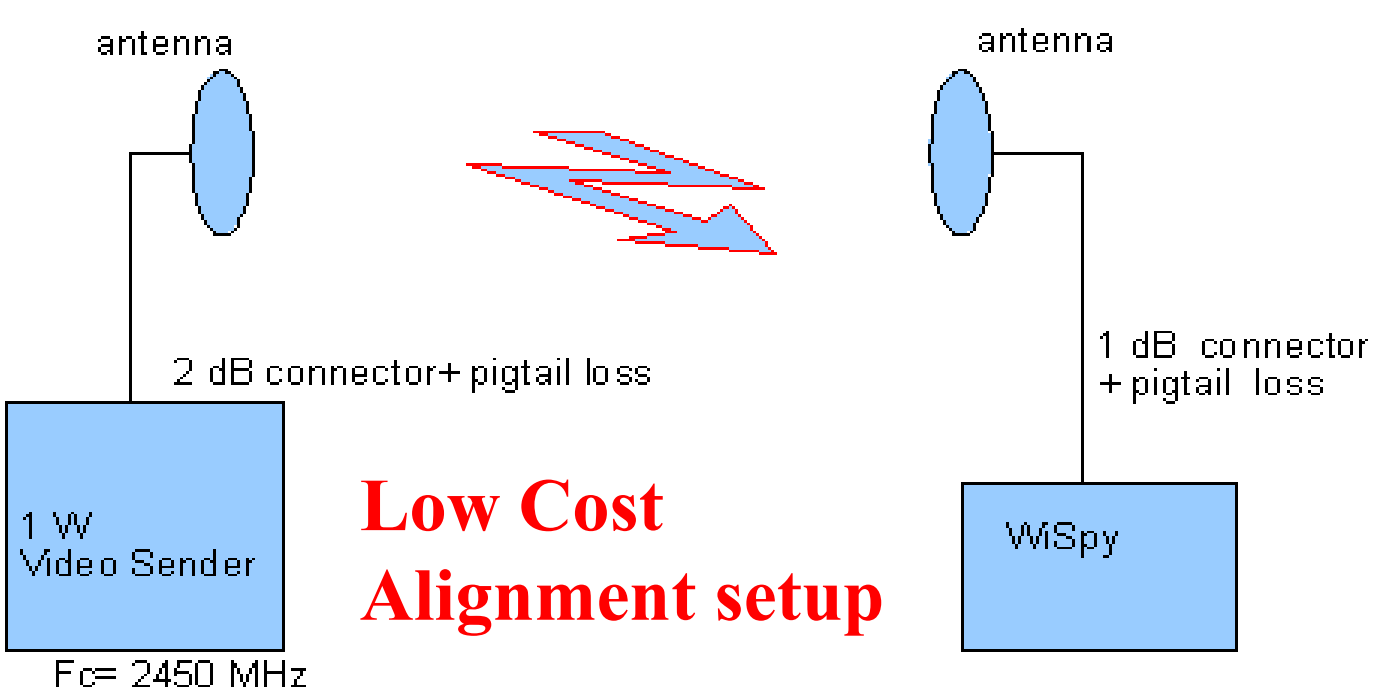
Need for cheaper solutions

Antenna Alignment

Analog video transmitters in the 2,4 GHz band

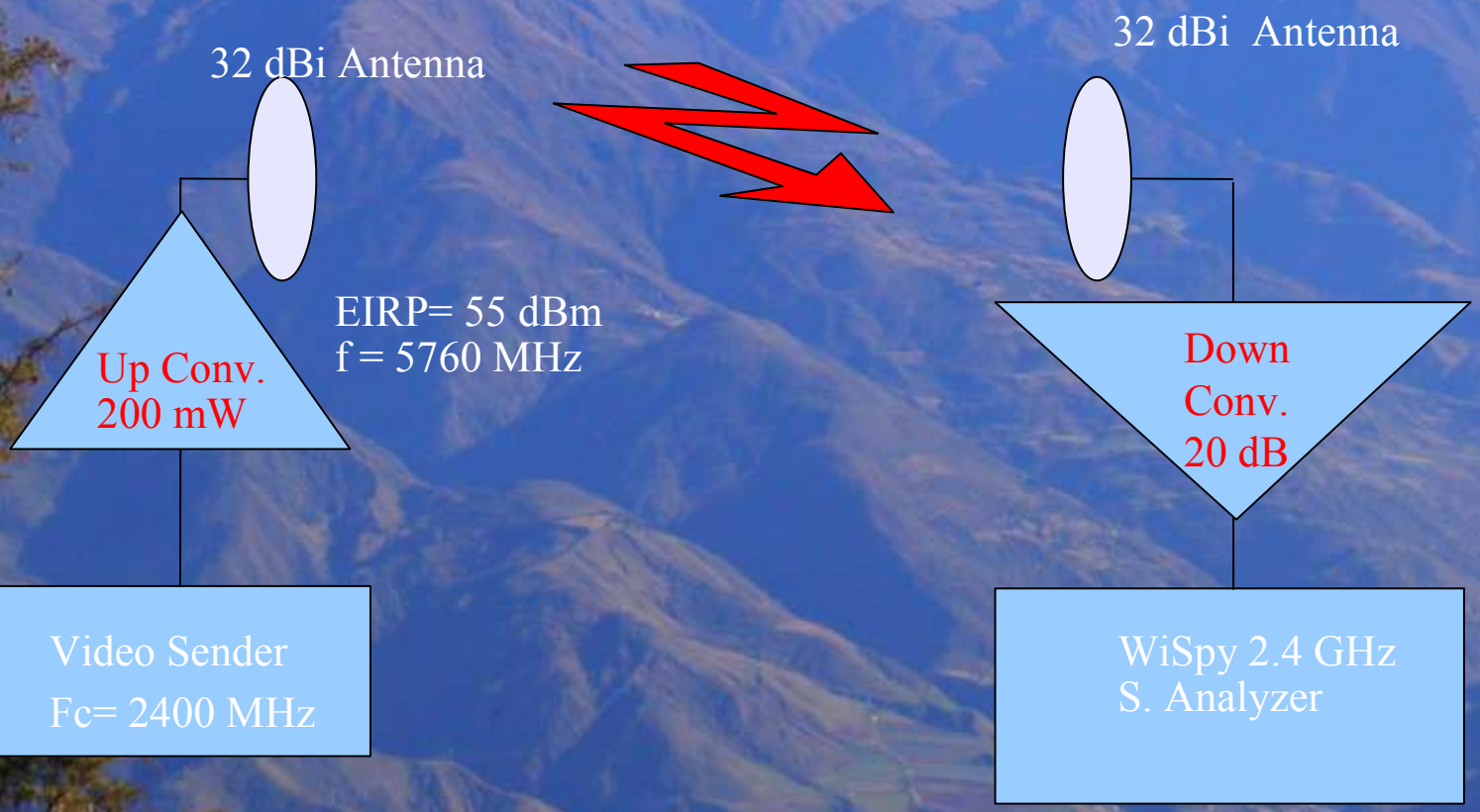
- Video sender:
  - Operates at 2,4 GHz
  - Allows the choice of 8 different tones spanning the 2.4 GHz band
  - 1 W output power

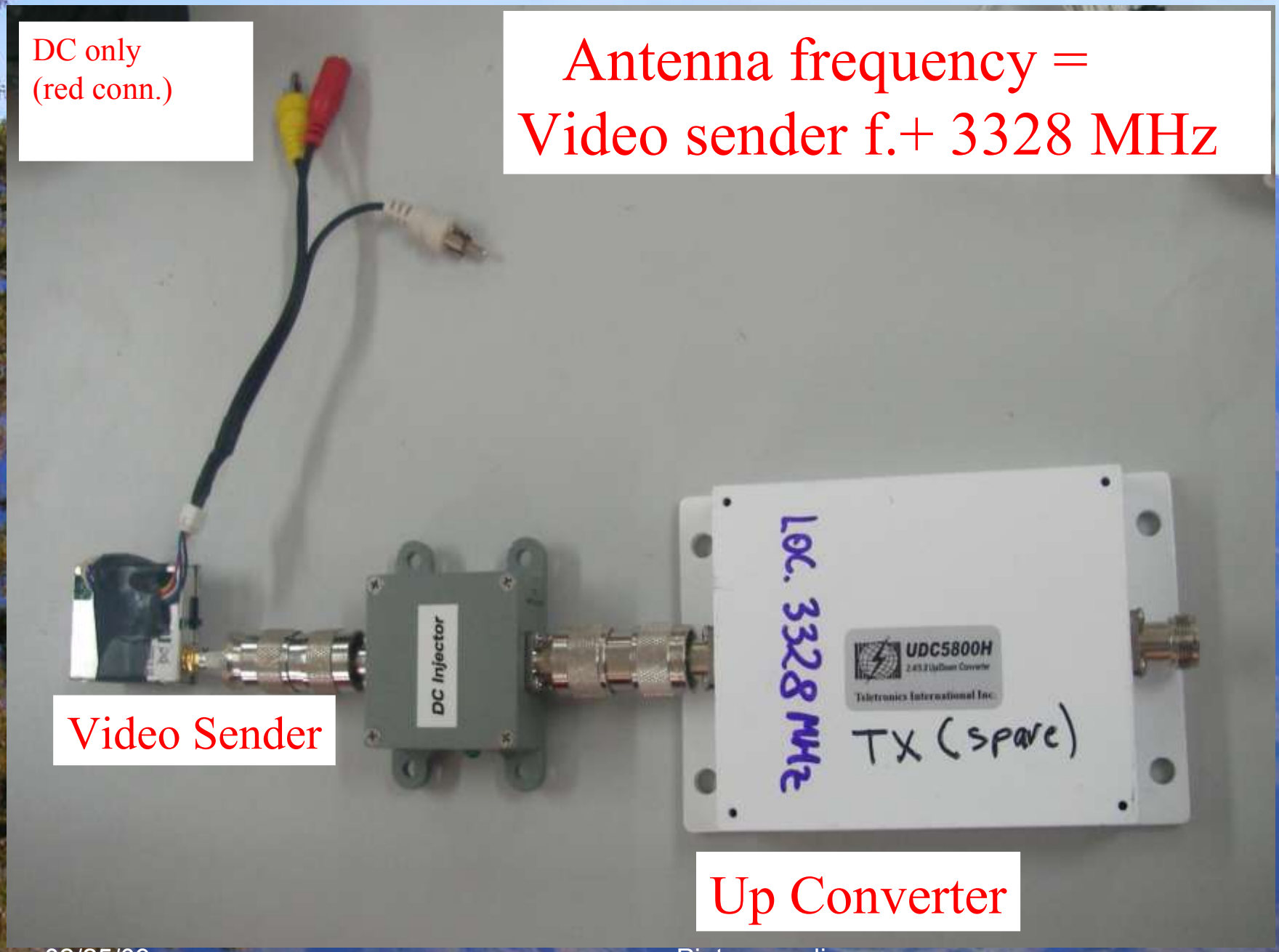
Video sender and spectrum analyzer



Low Cost Alignment setup

Inexpensive 5 GHz Alignment Setup




DC only
(red conn.)
Antenna frequency =
Video sender f.+ 3328 MHz
DC Injector
LOC. 3328 MHz
UDC5800H
TX (spare)
Video Sender
Up Converter

Summary

- Location of the base station antenna is paramount for good coverage
- If available, sharing an existing structure can be very convenient
- Non penetrating roof top mounts are preferred
- Guyed towers are cost effective and can be locally manufactured
- Grounding and lightning protection required for a successful operation