ANTENNA AND WAVE PROPAGATION

Terrestrial Microwave Antennas for Point-To-Point Communication

- Terrestrial microwave antennas generate a beam of RF signal to communicate between two locations.
- Point-To-Point communication depends upon a clear line of sight between two microwave antennas.
- Obstructions, such as buildings, trees or terrain interfere with the signal.
- Depending upon the location, usage and frequency, different types can be utilized.
- We will address the basic characteristics of these various types…

Electrical Performance Parameters

- Gain
- Radiation Pattern Envelope
- Front to Back Ratio (F/B)

- Cross-Polar Discrimination (XPD)
- Interport Isolation (IPI)
- Return Loss (VSWR)

Parabolic Antenna Directive Gain

$$G_a\,(\text{dBi}) = 10 \log_{10} \eta \, [\, 4 \pi A_a / \lambda^2 \,]$$

Where:

G_a = Antenna Directive Gain (Catalog spec)

η = Aperture Efficiency (50-55%)

A_a = Antenna Aperture Area

λ = Wavelength (speed of light / frequency)

l Parabolic
na Gain in dBi

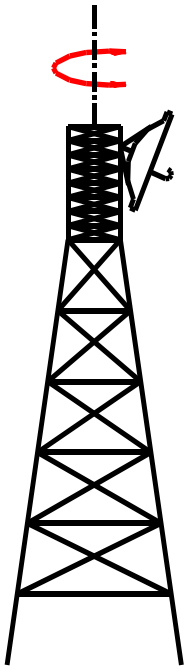
Antenna Diameter

Frequency

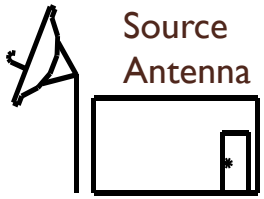
	2 ft (0.6m)	4 ft (1.2m)	6 ft (1.8m)	8 ft (2.4m)	10 ft (3.0m)	12 ft (3.7m)	15 ft (4.5m)
2 GHz	19.5	25.5	29.1	31.6	33.5	35.1	37
4 GHz	25.5	31.6	35.1	37.6	39.5	41.1	43.1
6 GHz	29.1	35.1	38.6	41.1	43.1	44.6	46.6
8 GHz	31.6	37.6	41.1	43.6	45.5	47.1	49.1
11 GHz	34.3	40.4	43.9	46.4	48.3	49.9	51.8
15 GHz	37	43.1	46.6	49.1	51	52.6	NA
18 GHz	38.6	44.6	48.2	50.7	NA	NA	NA
22 GHz	40.4	46.4	49.9	NA	NA	NA	NA
38 GHz	45.1	51.1	NA	NA	NA	NA	NA

Radiation Pattern Concept

Antenna
Under Test

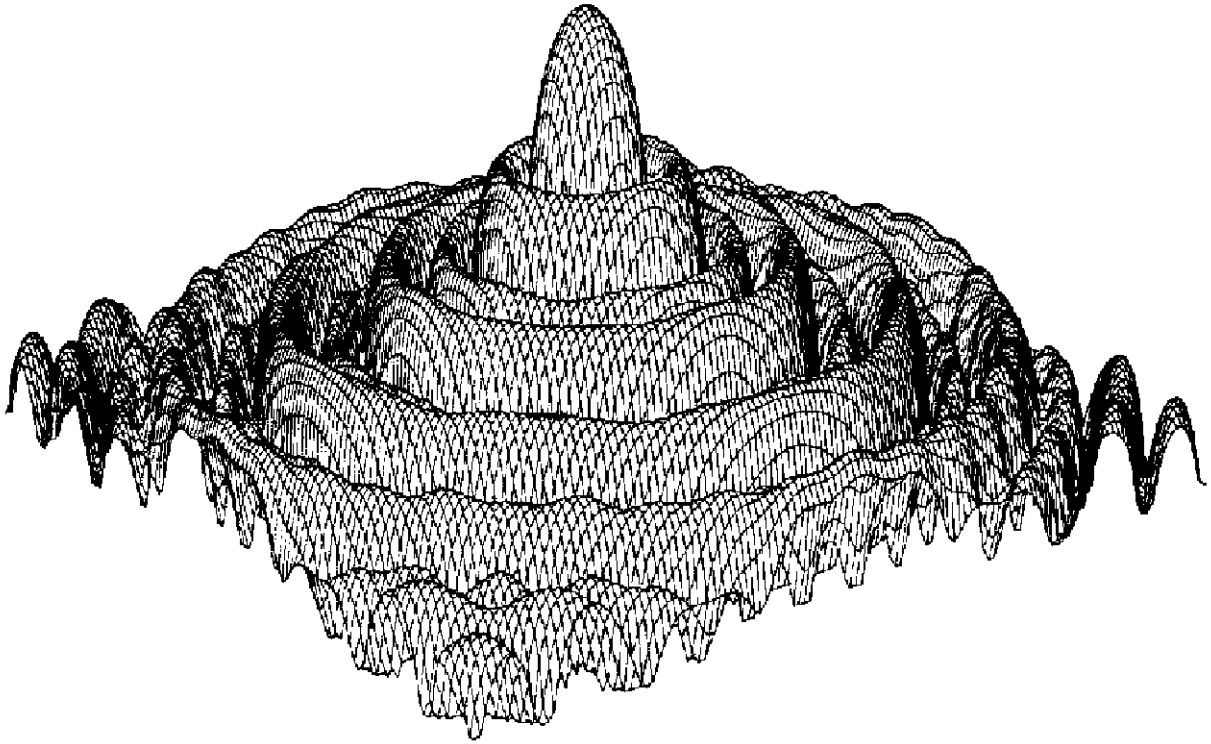


Antenna Test Range

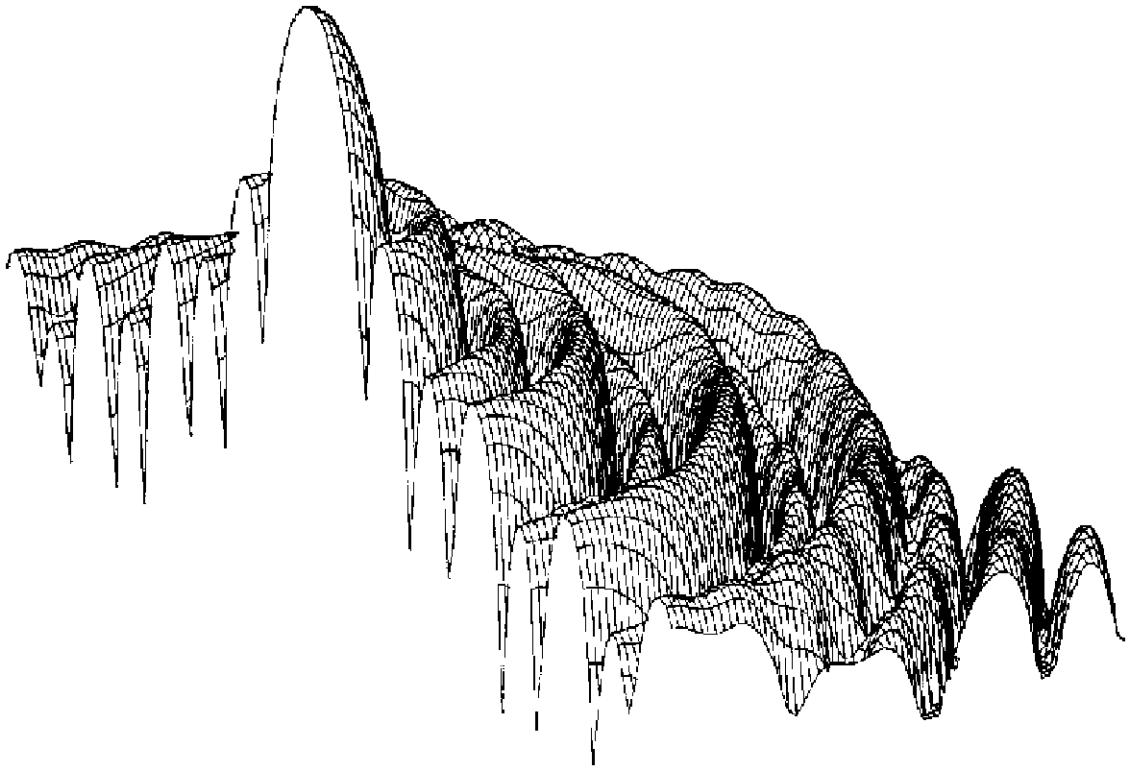


Source
Antenna

Radiation Pattern about Bore sight



Cut Through Radiation Pattern at Boresight



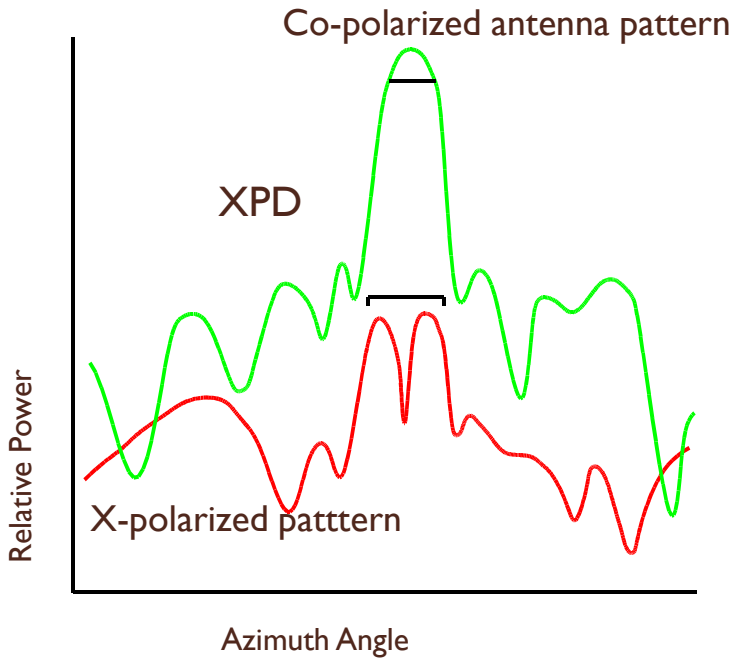
Front to Back Ratio

- Ratio of the signal level at beam peak to that directed behind the antenna
- Considered in intra-system interference calculation (hop overreach)
- Expressed in dB

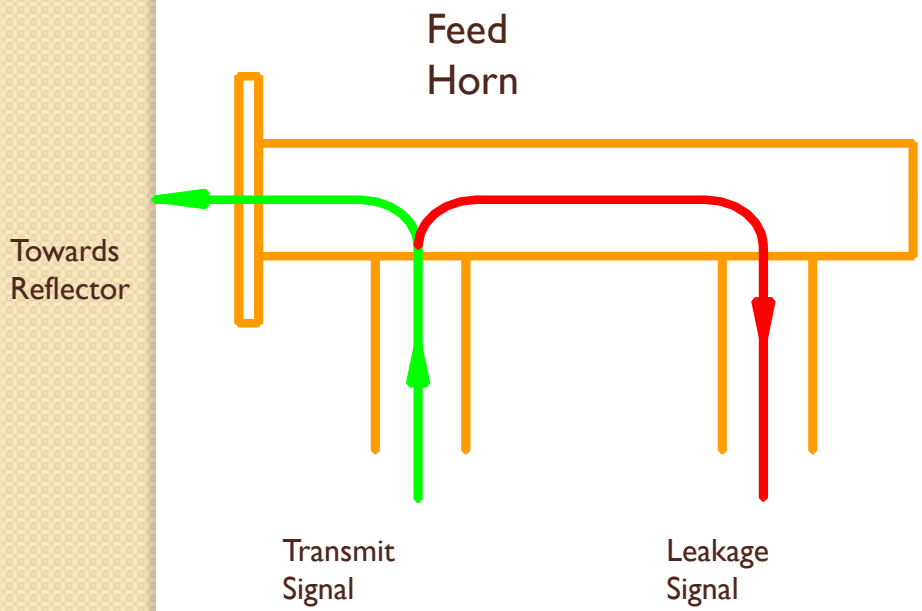
Co-Polarization and Cross-Polarization

- **Co-Polarization**
  - Where Transmit & Receive Antennas have the Same Polarization
  - Either Horizontal or Vertical (HH or VV)
  - In your System, The Wanted Signal

- Cross-Polarization
  - Where Transmit & Receive Antennas have Different Polarizations
  - Either HV or VH.
  - In your System, The Unwanted Signal

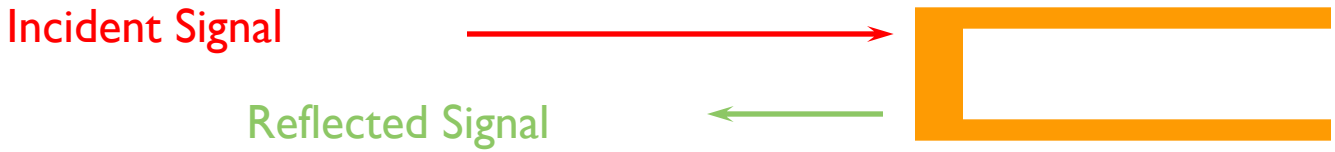


Inter-port Isolation (IPI)



- Leakage of Signal Between Antenna Ports
- Internal Noise
- Expressed in dB

Voltage Standing Wave Ratio (VSWR)



$$VSWR = \frac{1 + (\text{Reflection Coefficient})}{1 - (\text{Reflection Coefficient})}$$

- **VSWR : 1.30** **Reflection Coefficient : 13% (0.13)**
- **VSWR : 1.20** **Reflection Coefficient : 9.1% (0.091)**
- **VSWR : 1.10** **Reflection Coefficient : 4.7% (0.047)**
- **VSWR : 1.08** **Reflection Coefficient : 3.8% (0.038)**
- **VSWR : 1.06** **Reflection Coefficient : 2.9% (0.029)**

Return Loss

The Amount of Energy Lost due to Reflected (Returned) Signal

RL = -20 x log (Reflection Coefficient)

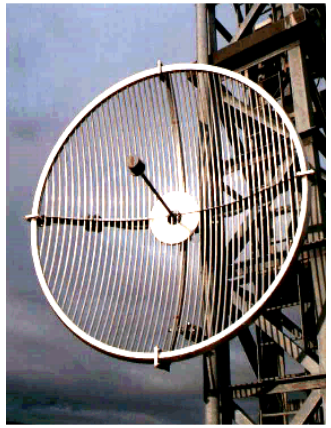
- **RL : 17.8dB Reflection : 13% (0.13) VSWR : 1.30**
- **RL : 20.8dB Reflection : 9.1% (0.091) VSWR : 1.20**
- **RL : 26.7dB Reflection : 4.7% (0.047) VSWR : 1.10**
- **RL : 28.4dB Reflection : 3.8% (0.038) VSWR : 1.08**
- **RL : 30.7dB Reflection : 2.9% (0.029) VSWR : 1.06**

Basic Antenna Types

Standard Parabolic Antenna

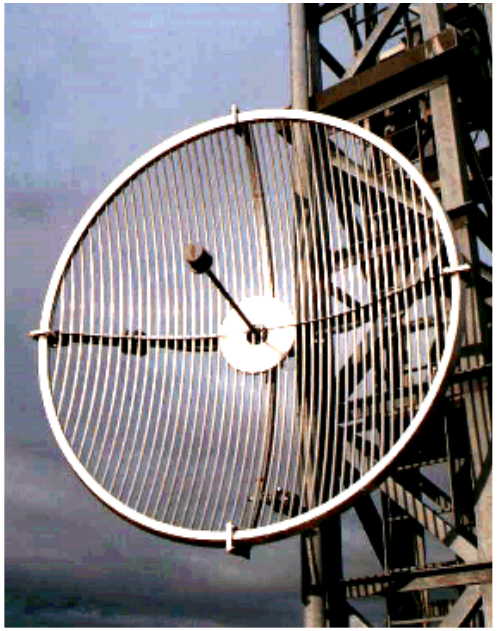
Shielded Antenna

Focal Plane Antenna



GRIDPAK® Antenna

GRIDPAK® Antenna



- Grid Reflector
- Low Wind load
- Single Polarized
- Below 2.7GHz
- Shipped in Flat, Lightweight Package

Standard Parabolic Antenna

- Basic Antenna
- Comprised of
  - Reflector
  - Feed Assembly
  - Mount

Focal Plane Antenna

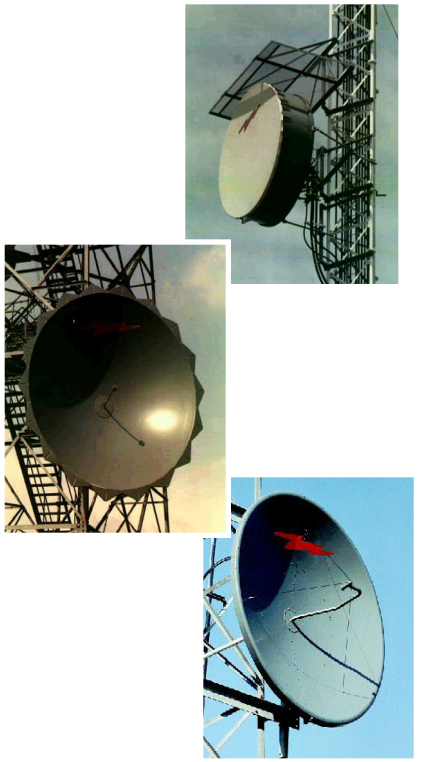
- Deeper Reflector
- Edge Geometry
- Improved F/B Ratio
- Slightly Lower Gain

Shielded Antenna

- Absorber-Lined Shield
- Improved Feed System
- Planar Radome
- Improved RPE

Antenna Efficiency

Well-designed antennas have efficiency ratings of 45 - 65%

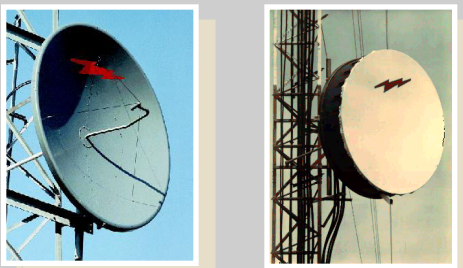


Efficiency Factor Affected By :

- Feed Illumination
- Aperture Blockage
- Reflector Surface Tolerance

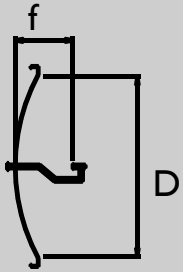
Efficiency can never be 100%

Antenna f/D Ratio



f/D = 0.333

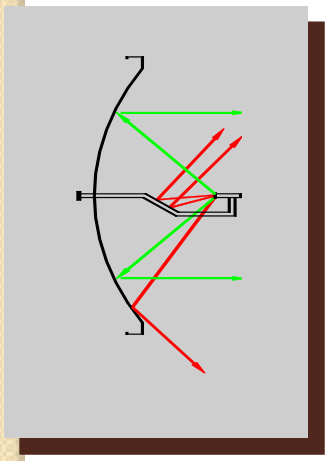
Standard & Shielded Antennas



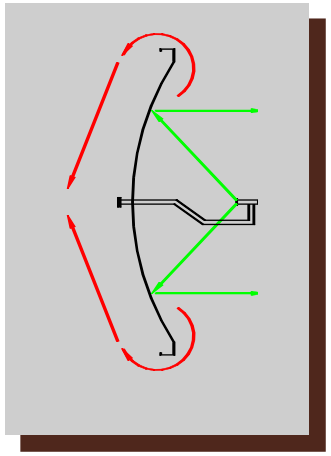
f/D = 0.250

Focal Plane Antennas

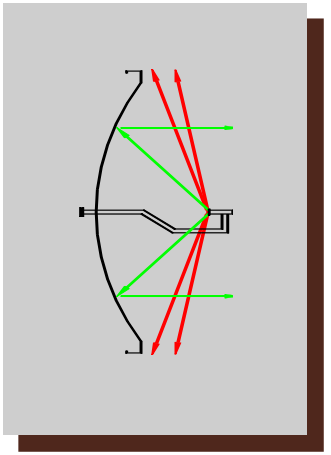
Unwanted Signals



Scattering

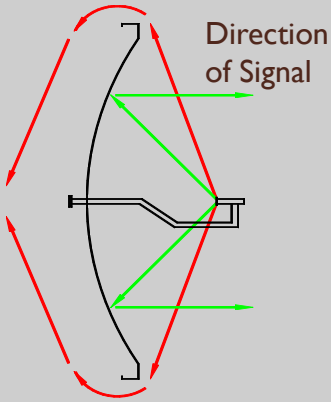


Diffraction

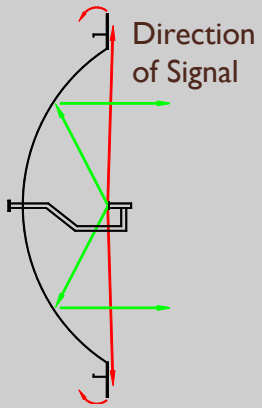


Spillover

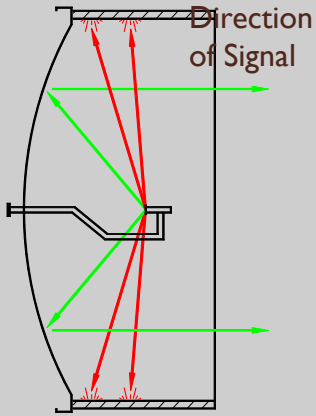
Front to Back Ratio



Standard Parabolic Antenna

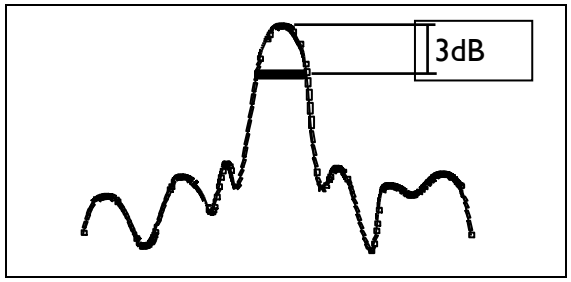


Focal Plane Antenna



Shielded Antenna

Parabolic Reflector Beamwidth

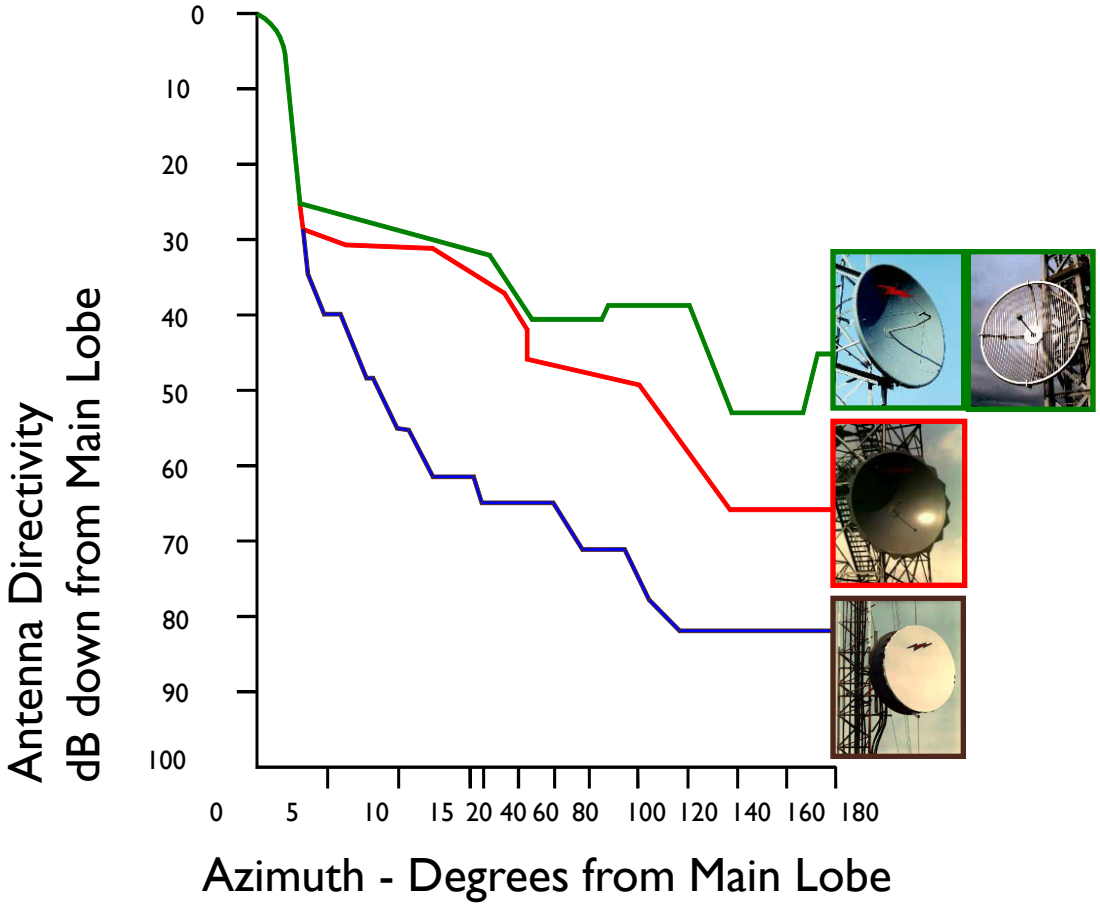


Diameter

Frequency	0.3 m	0.6 m	1.2 m	1.8 m	2.4 m	3 m	3.7 m	4.5 m
2 GHz	35	17.5	8.75	5.83	4.38	3.5	2.84	2.33
6 GHz	11.67	5.83	2.92	1.94	1.46	1.17	0.95	0.78
8 GHz	8.75	4.38	2.19	1.46	1	0.88	0.71	0.58
11 GHz	6.36	3.18	1.59	1	0.8	0.64	0.52	0.42
14 GHz	5	2.5	1.25	0.83	0.63	0.5	0.41	0.33
18 GHz	3.89	1.94	0.97	0.65	0.49	0.39	0.32	0.26
23 GHz	3	1.52	0.76	0.51	0.38	0.3	0.25	0.2
38 GHz	1.84	0.92	0.46	0.31	0.23	0.18	0.15	0.12

Beamwidth in Degrees

Radiation Pattern Envelope



Radomes

- Reduce Windloading on Tower
- Protection Against Ice, Snow and Dirt

Other Antenna Options

High XPD antennas

Dual beam antennas

Dual band antennas

Low profile antennas

Integrated antennas