

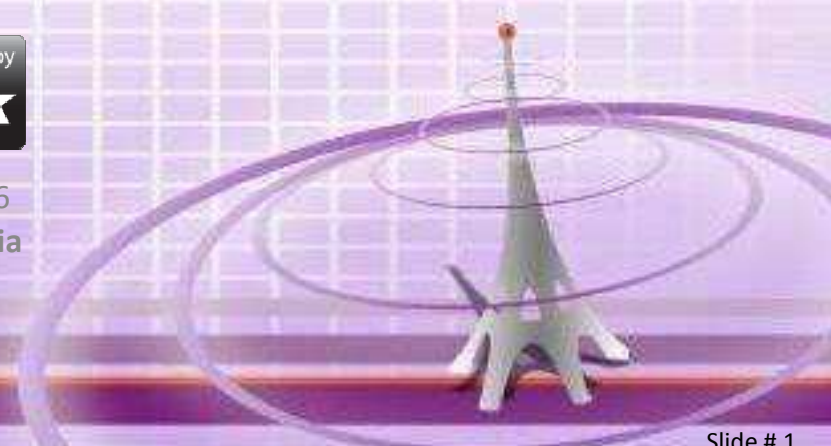
MikroTik User Meeting 2016

Topic

Quality Considerations in Wireless Networking



25-26 / 02 / 2016
Ljubljana, Slovenia



Presented by

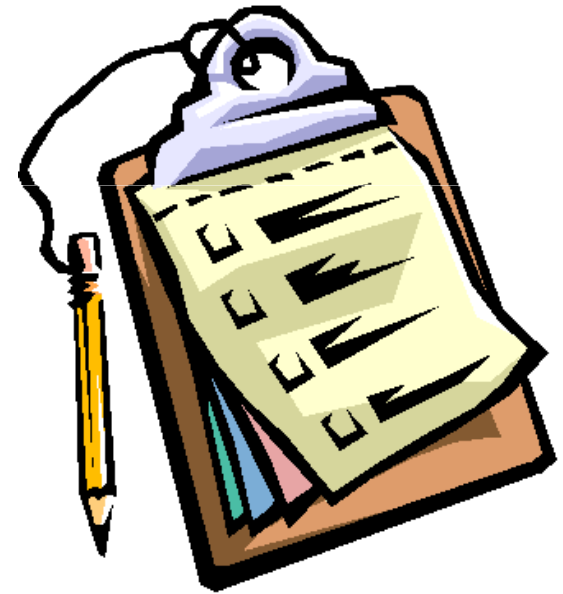


Michel Bodenheimer

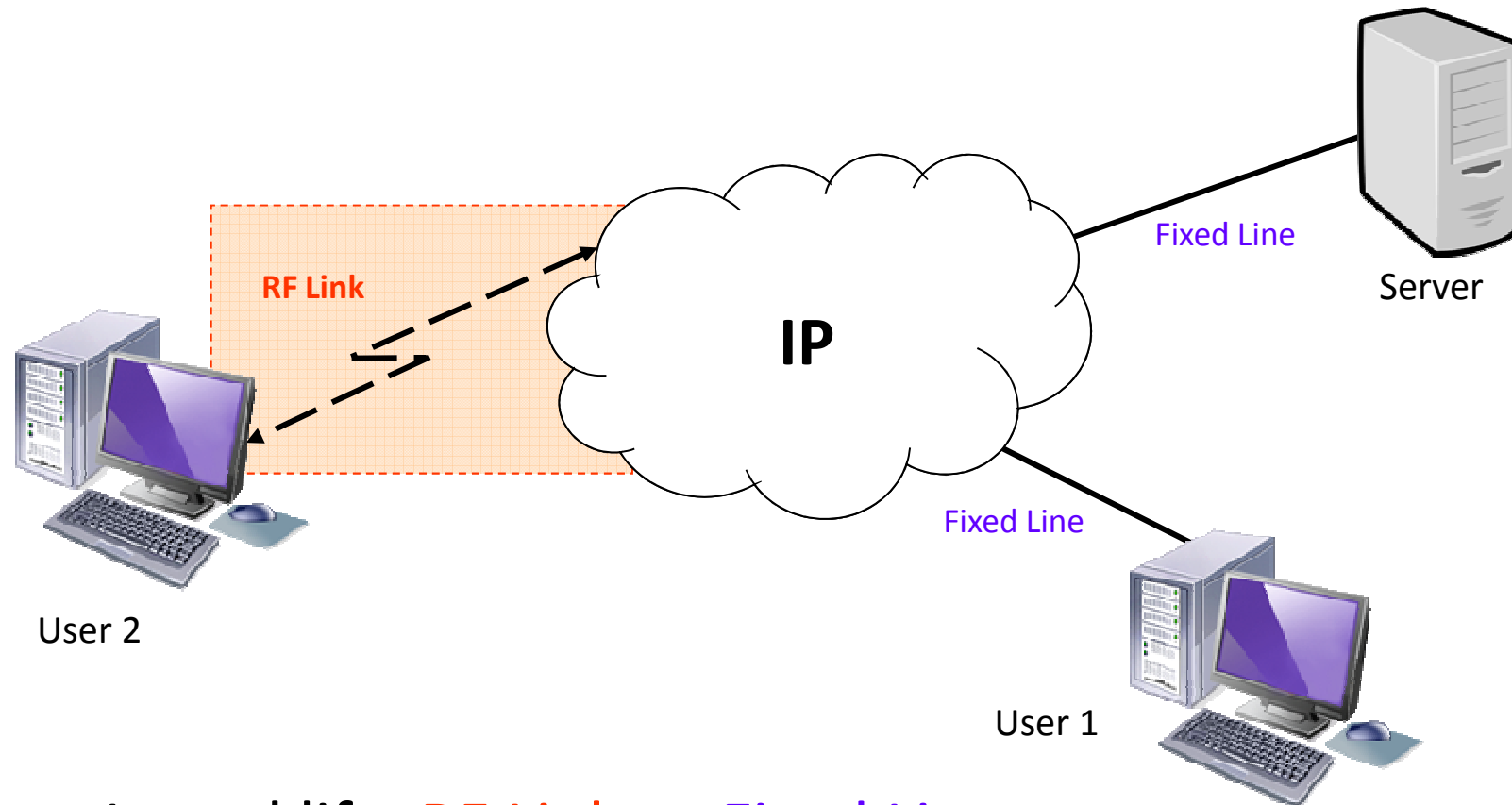
E-mail: michel.bodenheimer@mtiwe.com

Agenda

- The Broad Picture
- Broadband Wireless Access
- Design Considerations
- Antenna Parameters
- BTS / Null Fill
- Vendor Parameters
- Conclusion

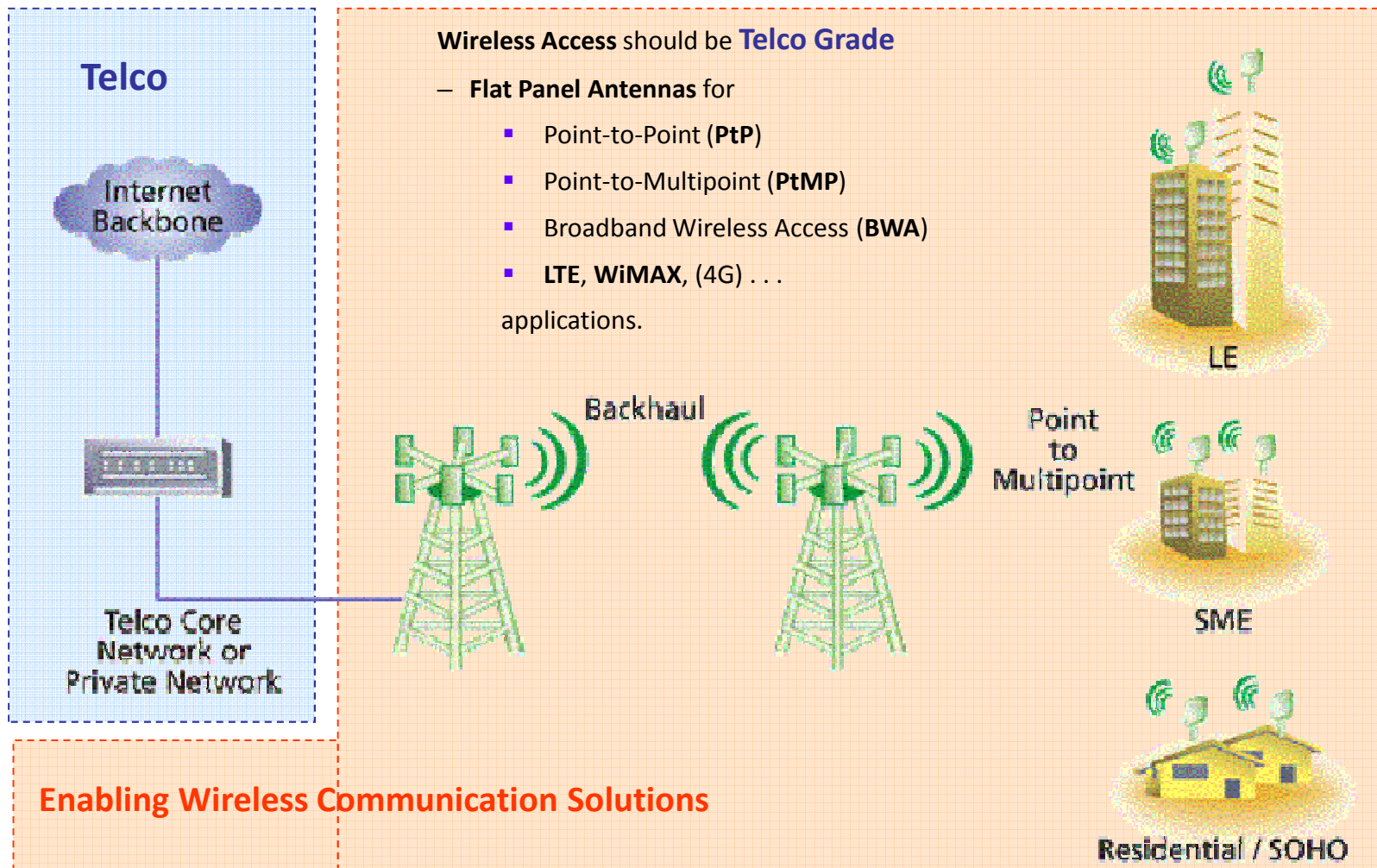


Typical Network



► In real life, **RF Link** $\neq$ **Fixed Line**

Broadband Wireless Access



Broadband Wireless Access

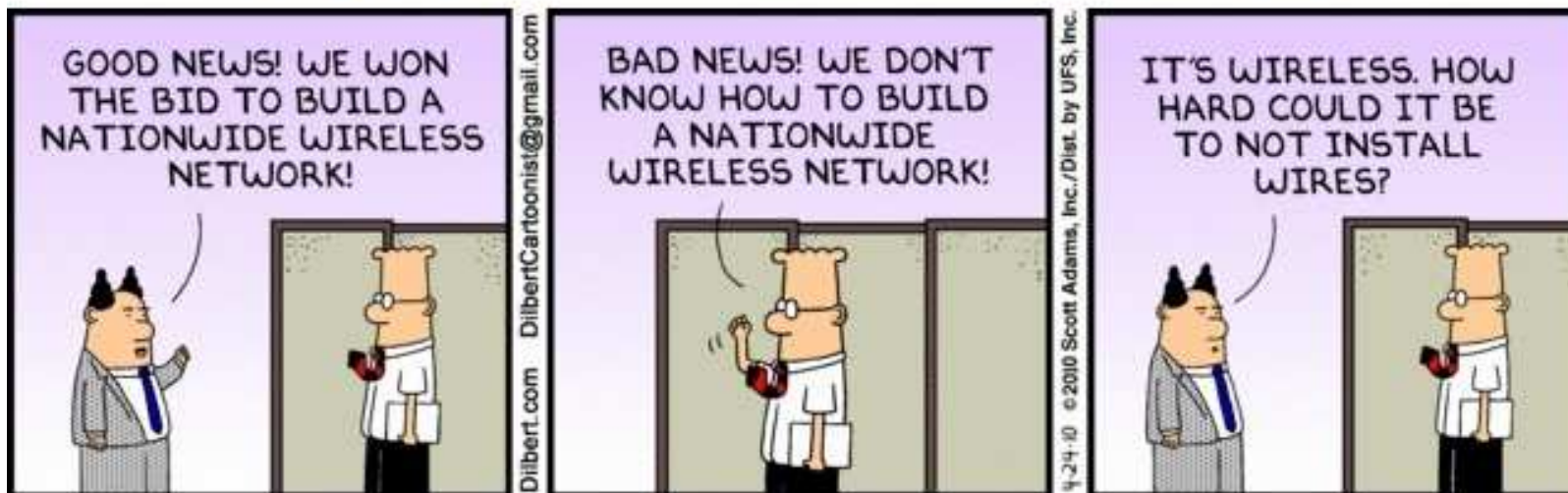
Telco

Wireless Access Should be **Telco Grade**

– Flat Panel Antennas for



It's Wireless. How Hard Could It Be?



Private Network

Enabling Wireless Communication Solutions



Residential / SOHO

The First Question

- How much does it cost?



The Broad Picture

- Network
- Customers
- Requirements
- Applications
- Throughput
- Distance
- Environment
- Etc.



Wireless Systems - Design Considerations

- The **Antenna** is the most critical component in wireless communications.
- Selection of Antenna will directly influence
 - **Distance** of transmission
 - **Throughput** achievable
 - **Quality of Service** (QoS)
 - **Interference** immunity (C/N, C/I)
 - **Frequency** re-use
 - **Reliability**
 - **Survivability**

Of any wireless system



Antenna Parameters

- Frequency
- Gain (main Lobe)
- Half Power Beam Width
- Front to Back Ratio
- Side Lobe
- Nulls
- Cross Polarization
- Environmental Conditions
- . . .



Frequency [Hz]

- **Frequency**

- Frequency is the number of occurrences of a repeating event per time unit. The period is the duration of one cycle in a repeating event, so the period is the reciprocal of the frequency.

- **Radio Frequency**

- That part of the electromagnetic spectrum, between about 3 kHz and 300 MHz, within which radio waves are transmitted.

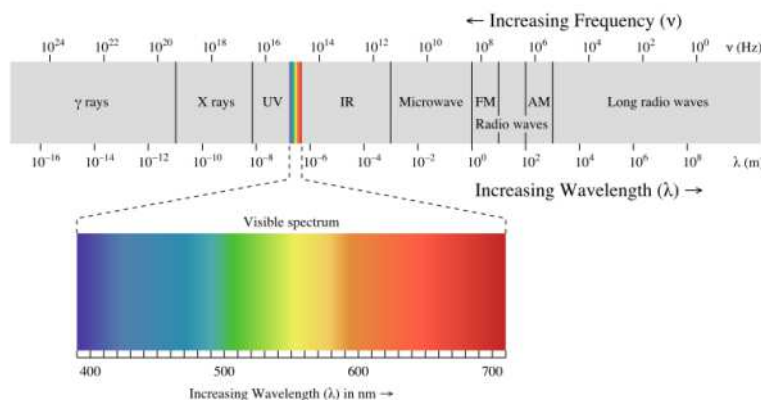
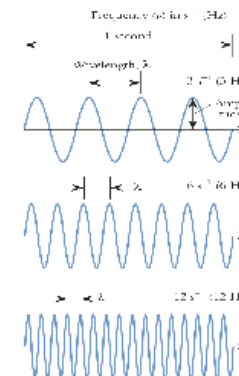


Fig 6-2

A light wave can be described by its wavelength and frequency. Notice that as the wavelength increases, the frequency of the light decreases.

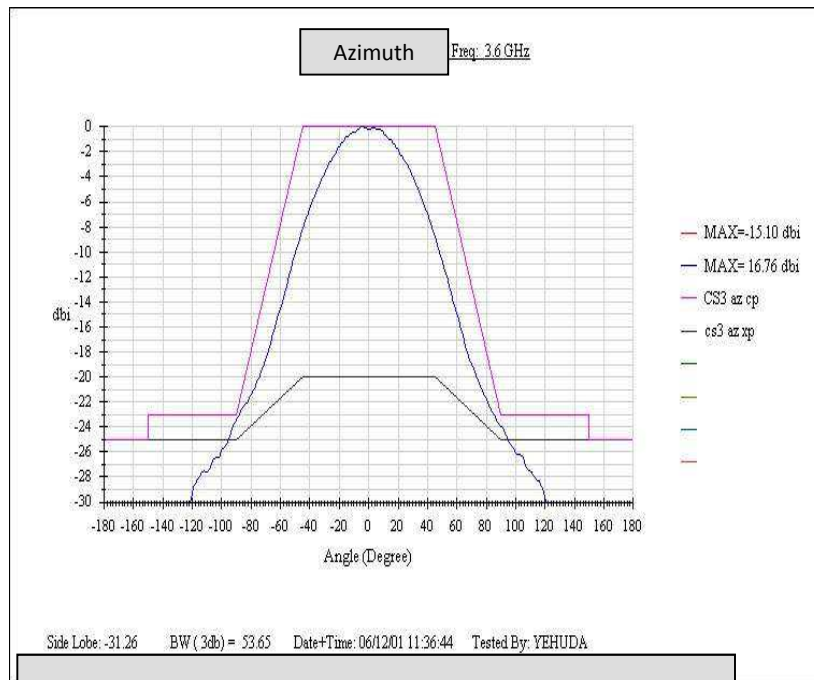


Pg 241

Gain [dBi]

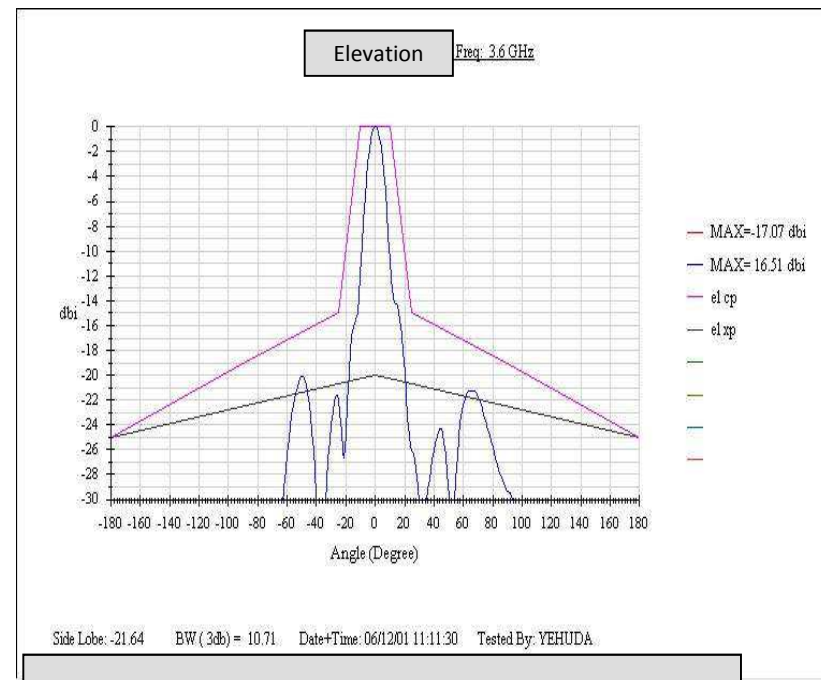
- **Azimuth**

- Main Lobe
- Side Lobe



- **Elevation**

- Main Lobe
- Side Lobe



Beam Width

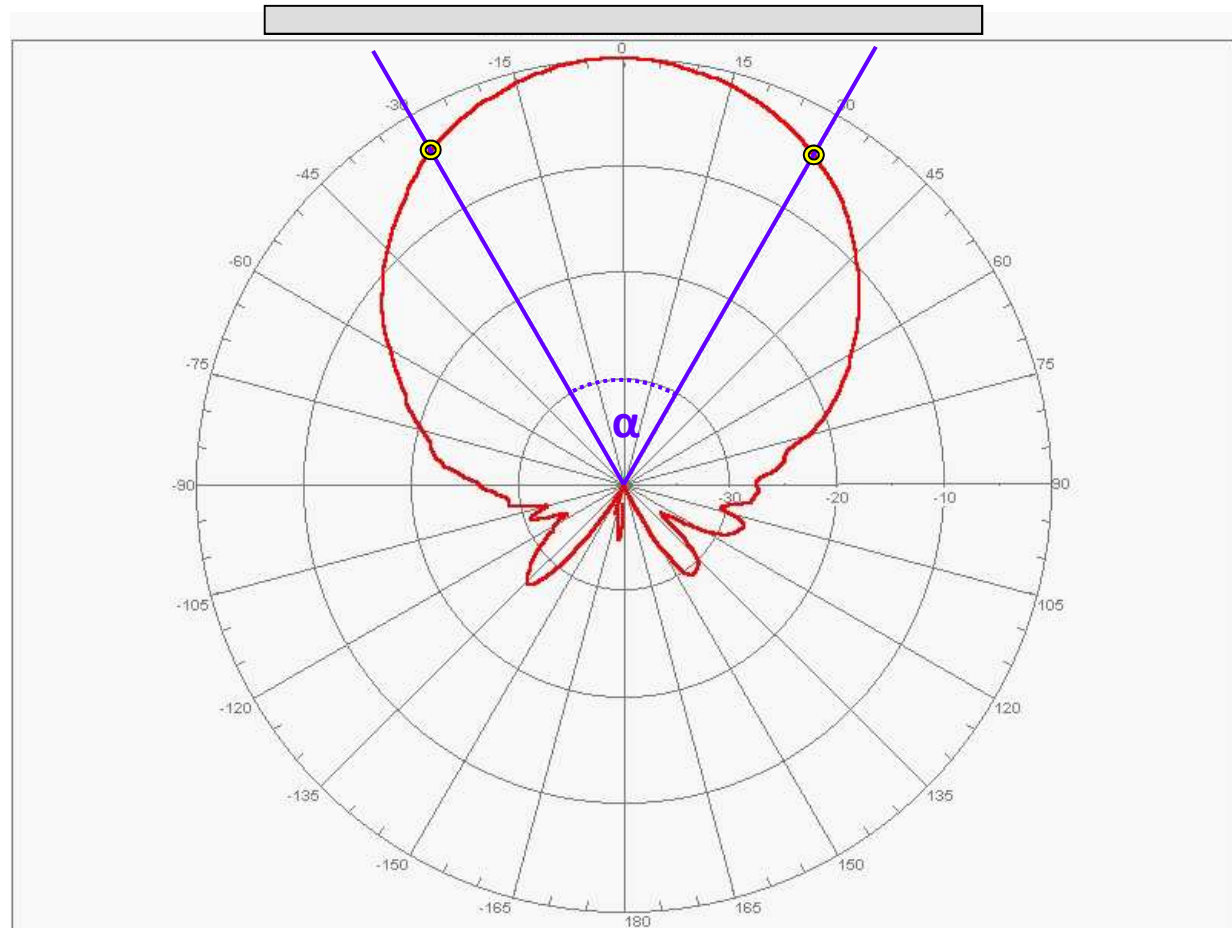
Defined at

- **- 3 dB**

= Half Power



* ETSI EN 302 326-3

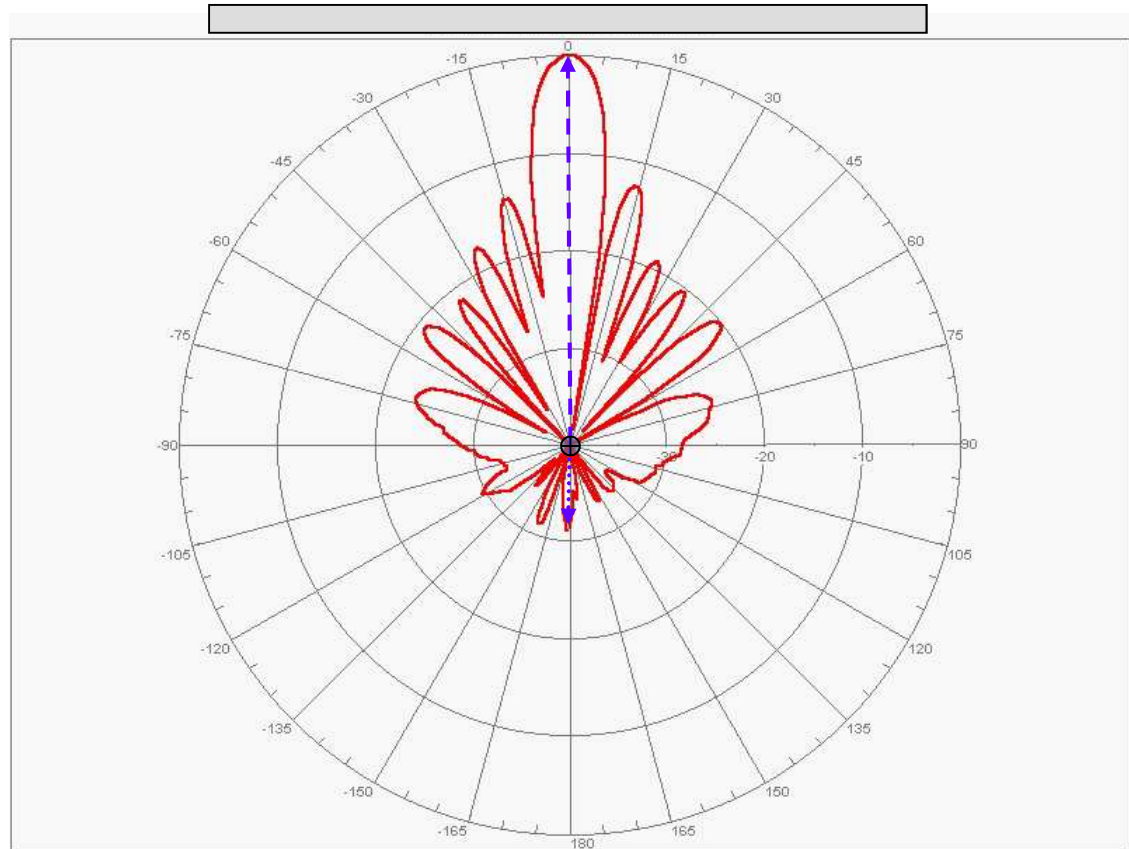


Front to Back Ratio

- Front

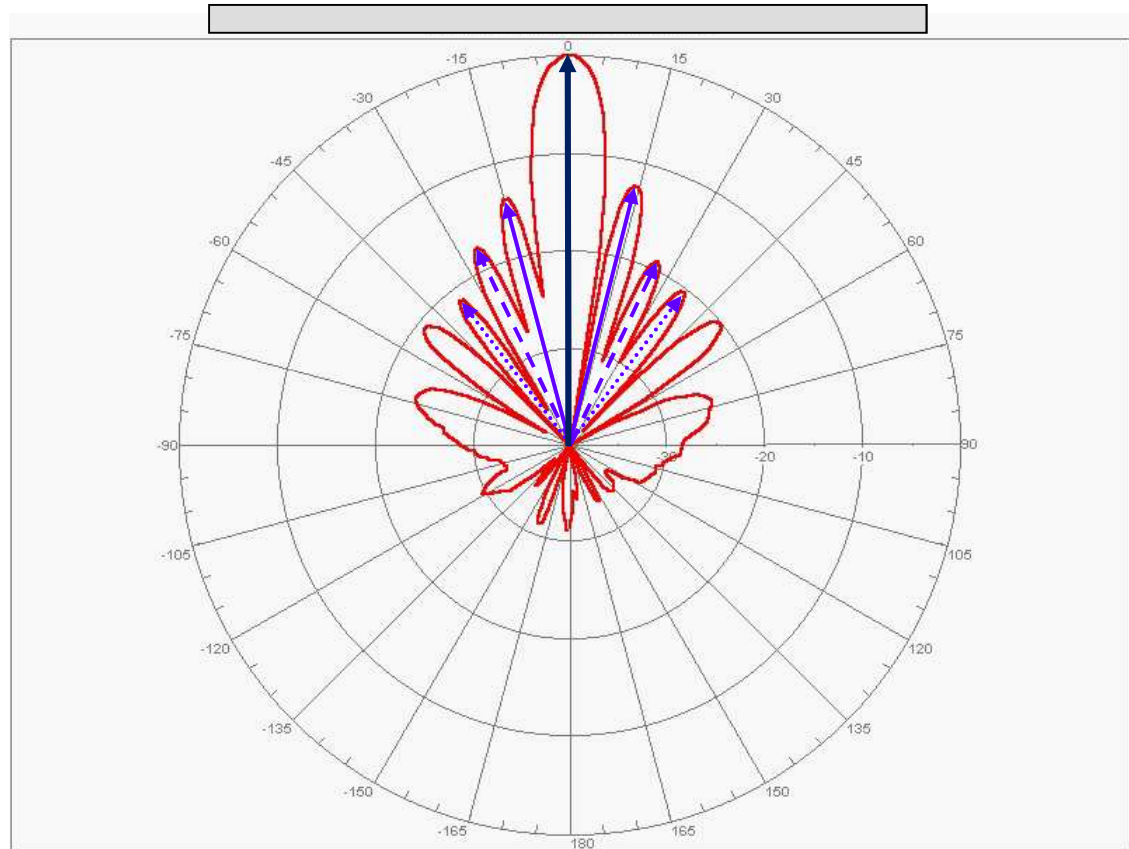


- Back



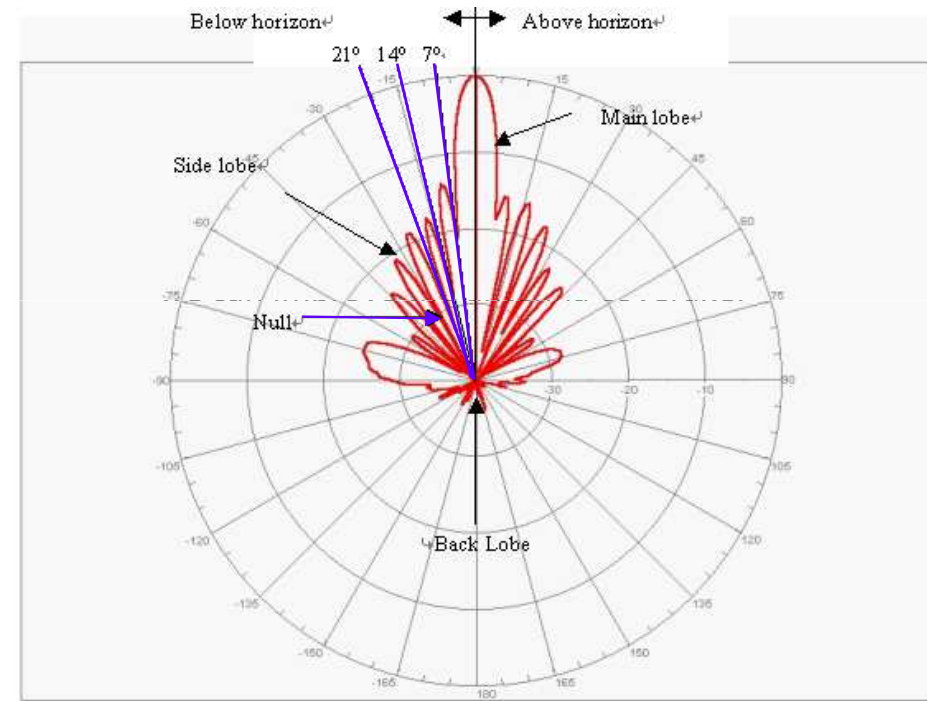
Main Lobe & Side Lobes

- **Main Lobe** →
- **Side Lobe 1** →
- **Side Lobe 2** →
- **Side Lobe 3** →
- ...



Nulls

- Between the Main Lobe and the Side Lobes: “**Null**”
- No (or very low) signal transmitted / received.

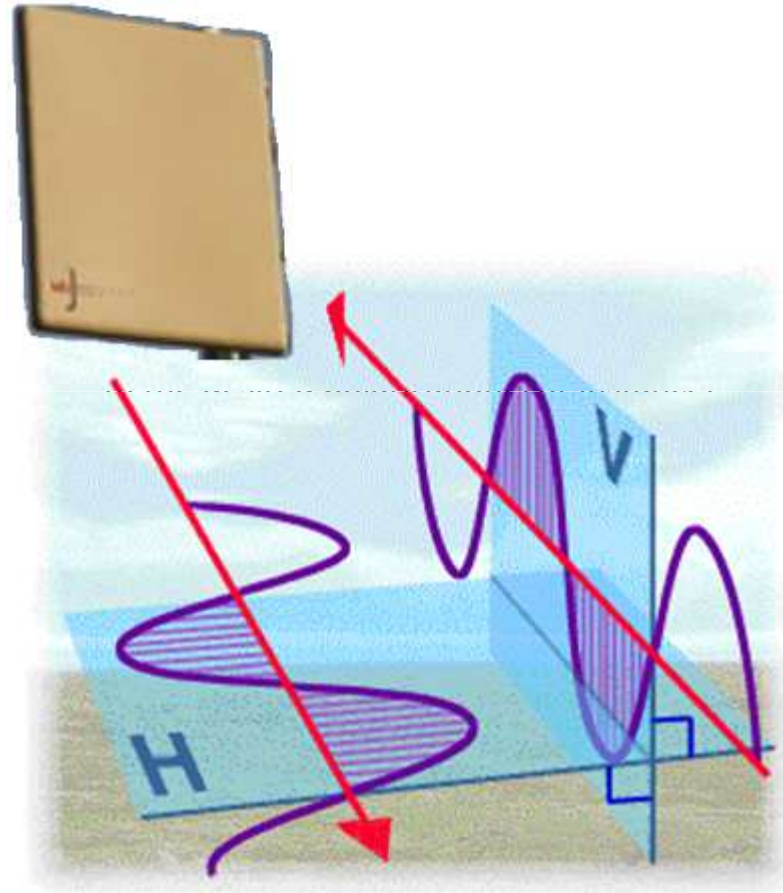


Cross Polarization

- Vertical
X
- Horizontal

Often Cross Polarization is confused with

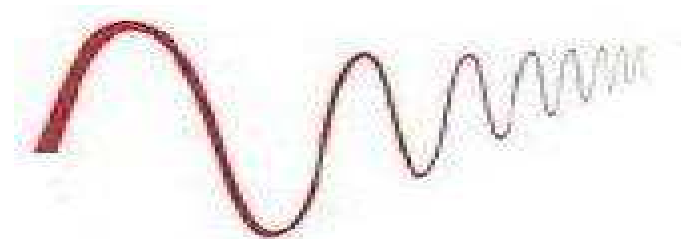
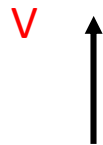
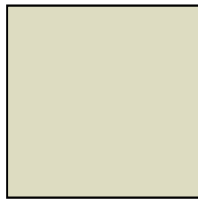
- Dual Polarization (V&H)
- Dual Slant ($\pm 45^\circ$)



Single Polarization

Single Polarization

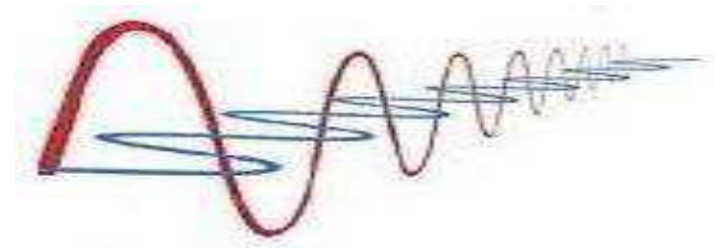
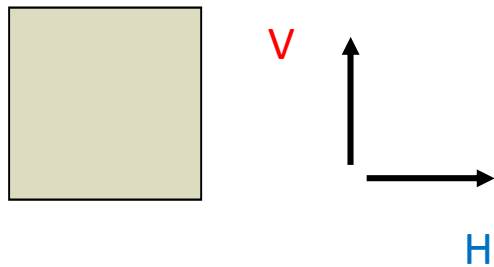
- Vertical



Dual Polarization

Dual Polarization (DP)

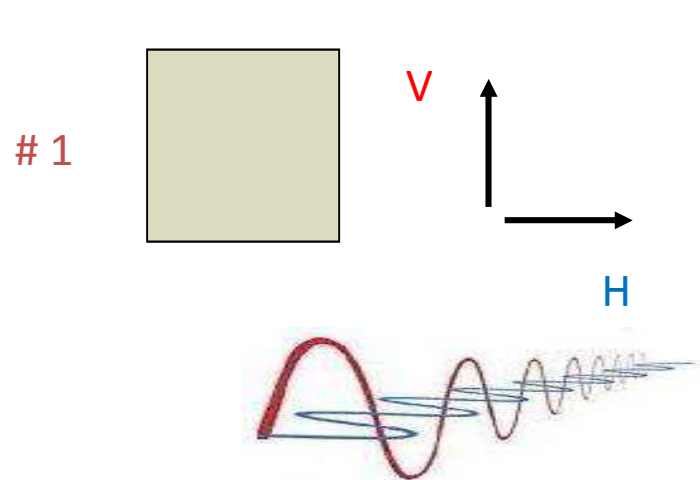
- Vertical + Horizontal



Dual Polarization / Dual Slant

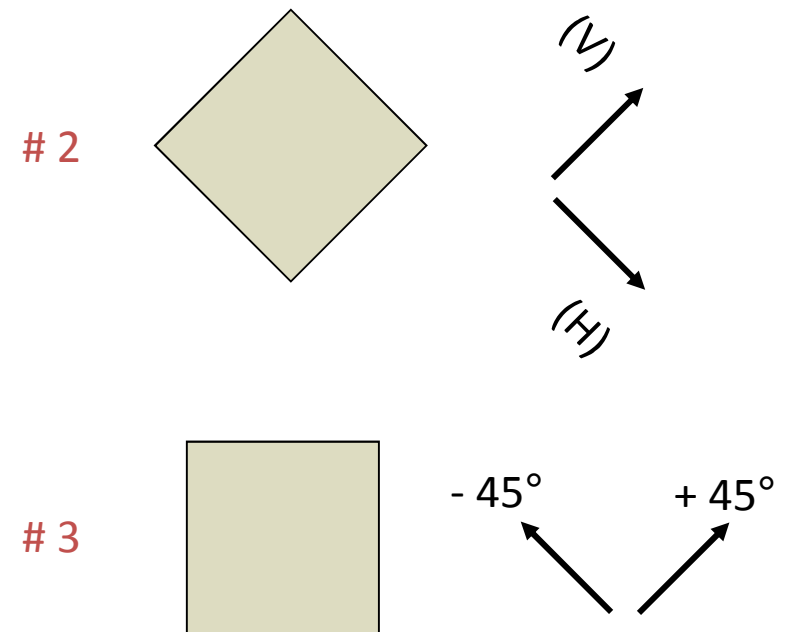
Dual Polarization (DP)

- Vertical + Horizontal



Dual Slant (DS)

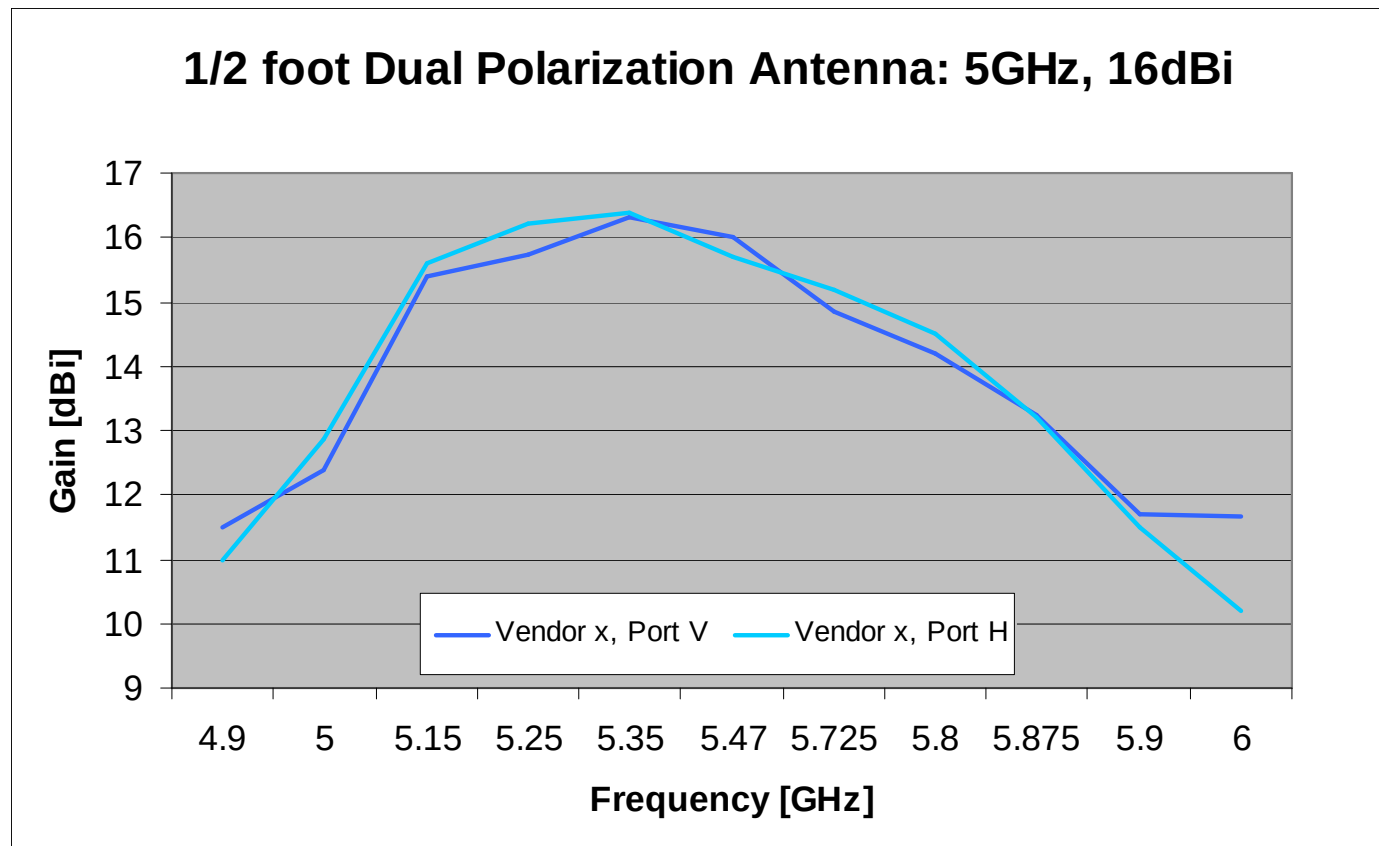
- $\pm 45^\circ$



Compare DP Antenna

- **5 GHz, 16 dBi: Brand x**

single PCB, FR-4

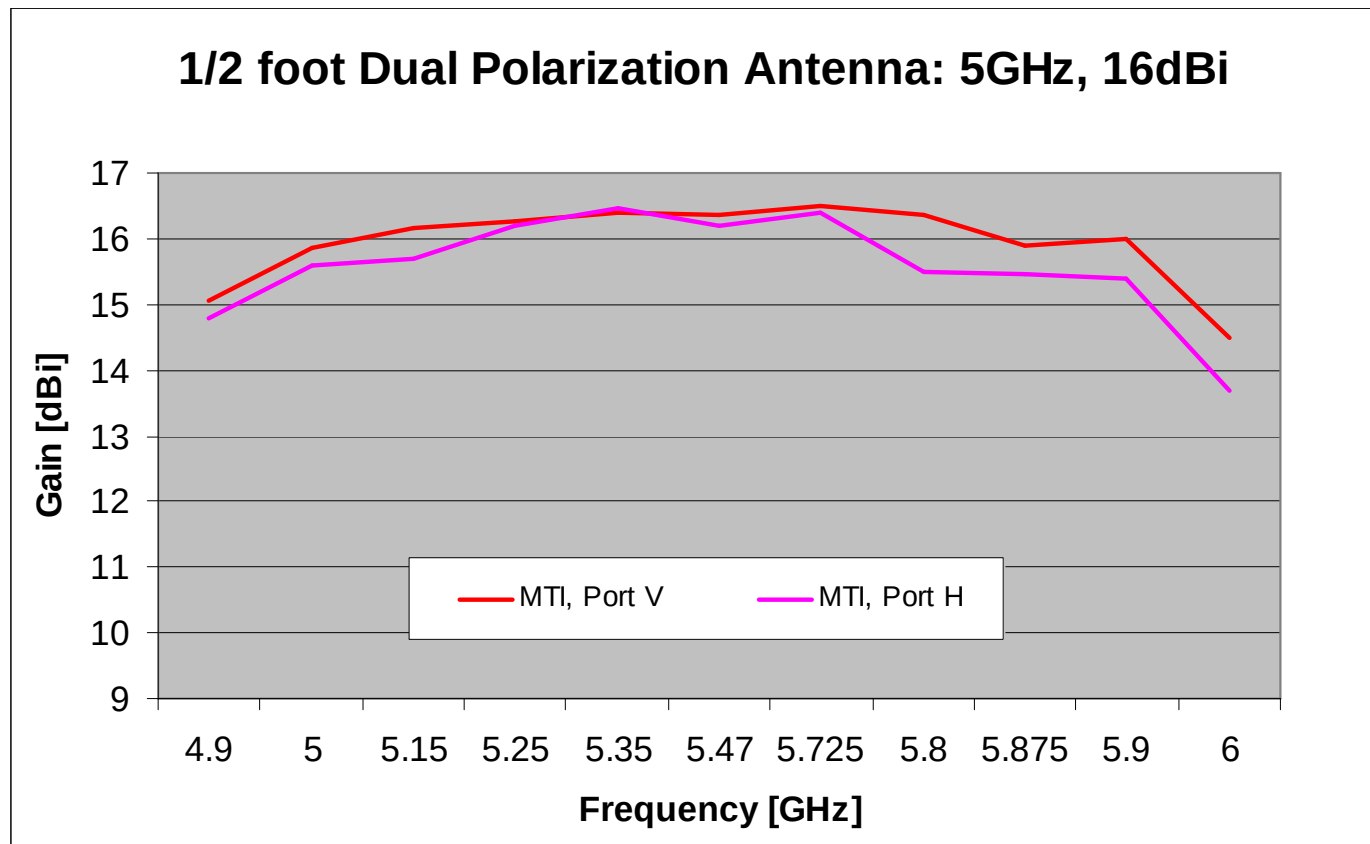


Compare DP Antenna

- **5 GHz, 16 dBi:**

Quality

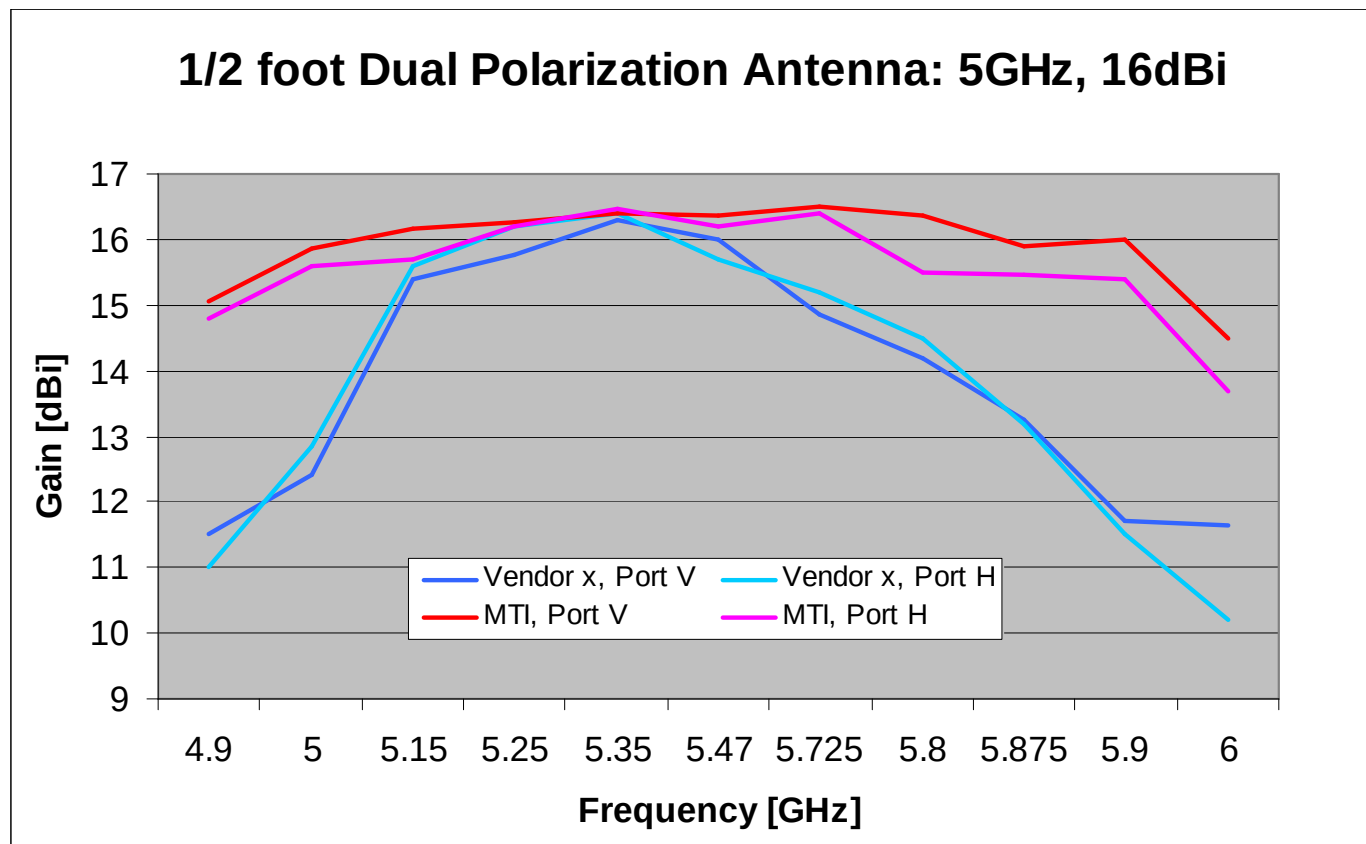
single PCB, FR-4



Compare DP Antenna

- **5 GHz, 16 dBi:** Brand x / Quality

single PCB, FR-4



Compare DP Antenna

- **5 GHz, 16 dBi:** Brand x / Quality

single PCB, FR-4

Compare DP Antenna

- **5 GHz, 16 dBi:** Brand x / Quality

single PCB, FR-4

At least 4 different ways to implement:

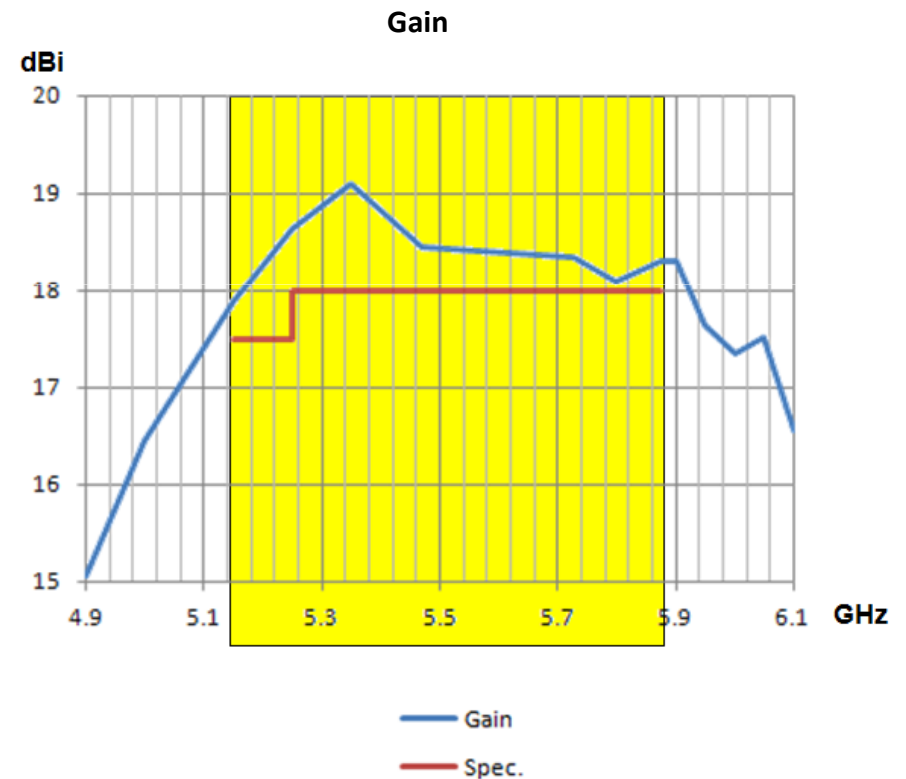
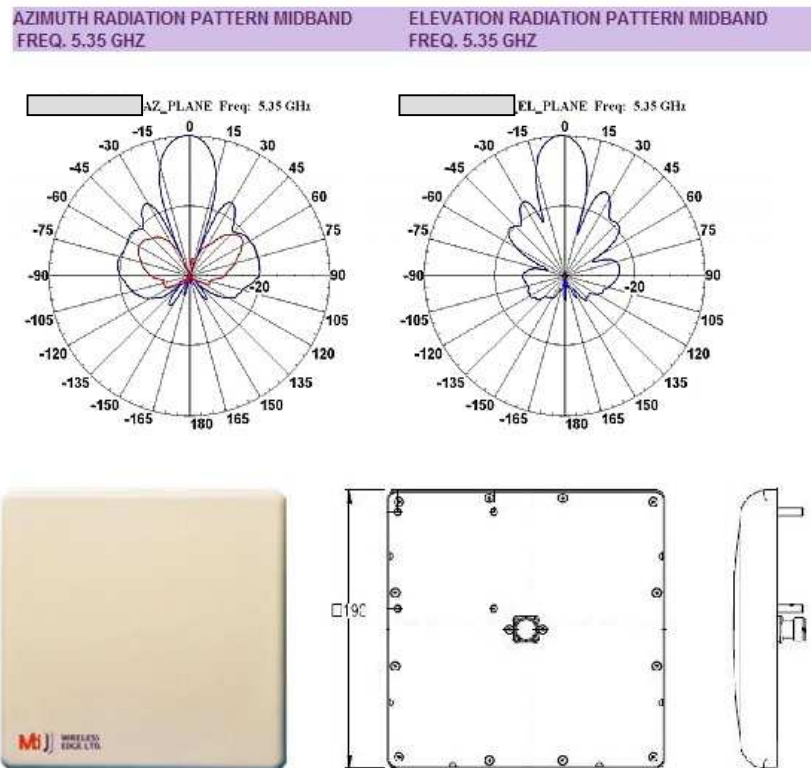
1. Single PCB, FR-4
2. Two PCBs, FR-4
3. Two PCBs, FR-4 and other
4. Two PCBs, different

Each will have **different performance,**
different cost !

Antennas may Outperform Specifications

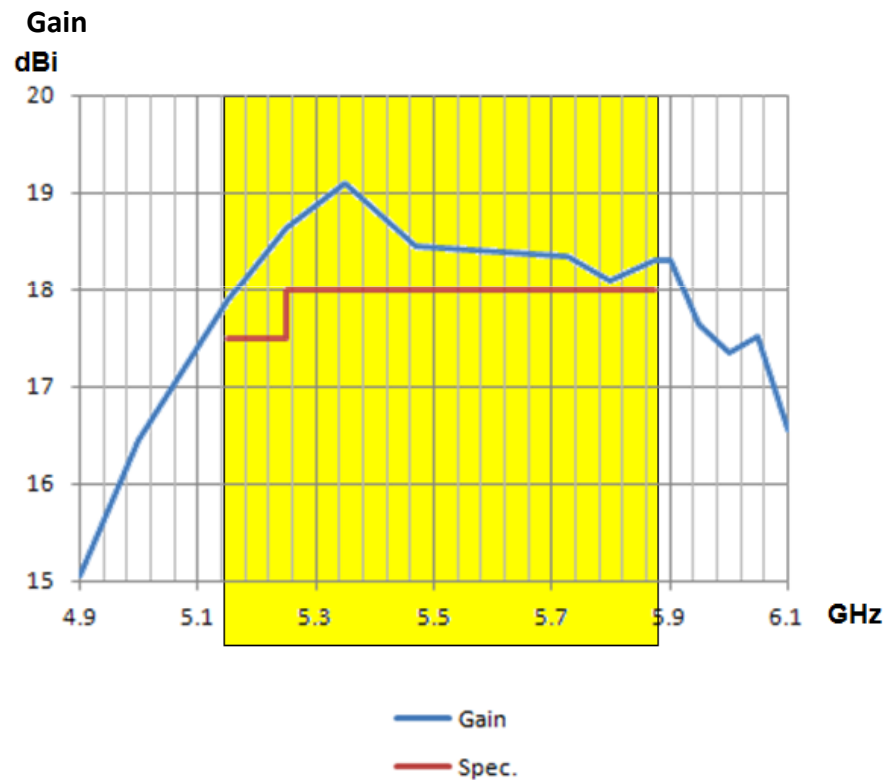
5.15-5.875 GHz, 18 dBi, CPE antenna

Specification vrs. Broadband performance

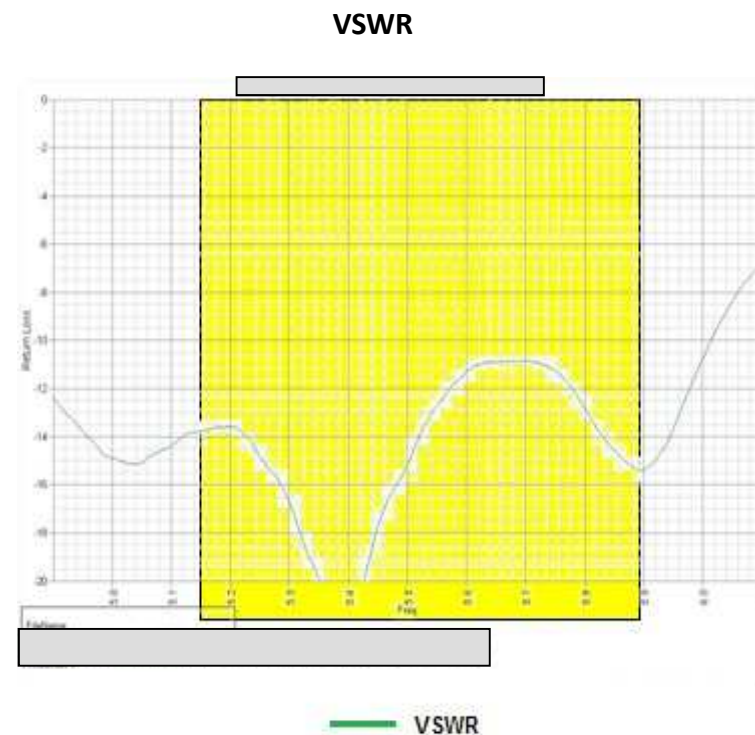


Antennas performance out of specified bandwidth

Specification vrs. Broadband performance



Specification vrs. Broadband performance



- Note some degradation in performance of Gain and VSWR out of specified range.
- Customer should verify performance if he wishes to use antenna outside of specified frequency range.

Environmental Conditions

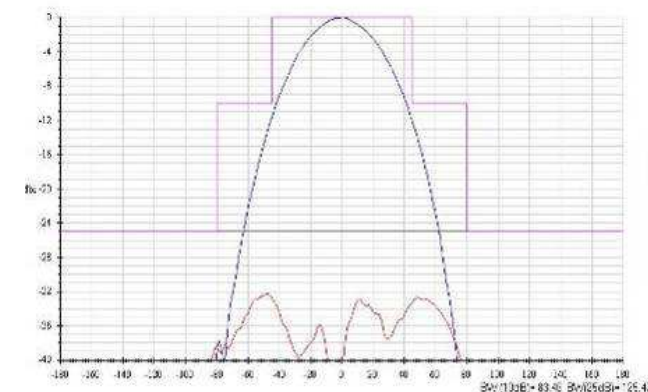
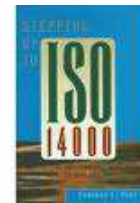
- Operating Temperature -40°C to +71°C
- Vibration IEC 60721-3-4 Random 4M3
- Mechanical Shock IEC 60721-3-4 4M3
- Humidity ETSI EN300-2-4 T4.1E
- **Dust & Water Tightness** IEC529, **IP67**
- **Salt Spray** 500 hours per IEC 68
- Solar Radiation ASTM G53
- Ice and Snow 25mm radial
- Flammability UL-94 V2
- Wind Load Survival EN 302-085
(survival 220 km/h,
operating 160 km/h)

QTP for every new antenna
100% VSWR Test



Quality Standards

- Qualified to meet ETSI standards
- Toughest environmental conditions
- QTP for every new product
- 100% VSWR test
- Customer Support



Vendor Parameters

- Public / Private
- Proven track record
- Technical capabilities
- R&D, Manufacturing, Testing
- Products Portfolio
- Expertise
- Reliability of technical information
- more ...



Lessons learned the hard way

Remarks

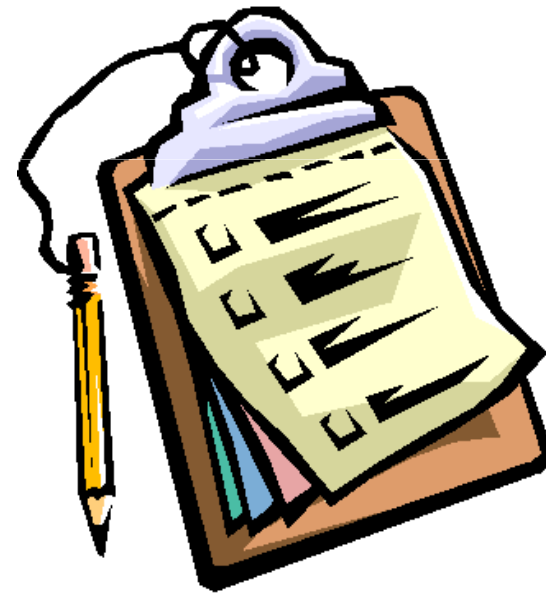
- The following comments are examples of a large number of similar cases only.
- We do not wish to comment on any vendor specifically, whether his documentation was randomly selected or not.

Just some of many examples



Examples

1. **(a & b)** Specification versus Actual
2. Beam Width
3. Throughput
4. Coverage
- ...

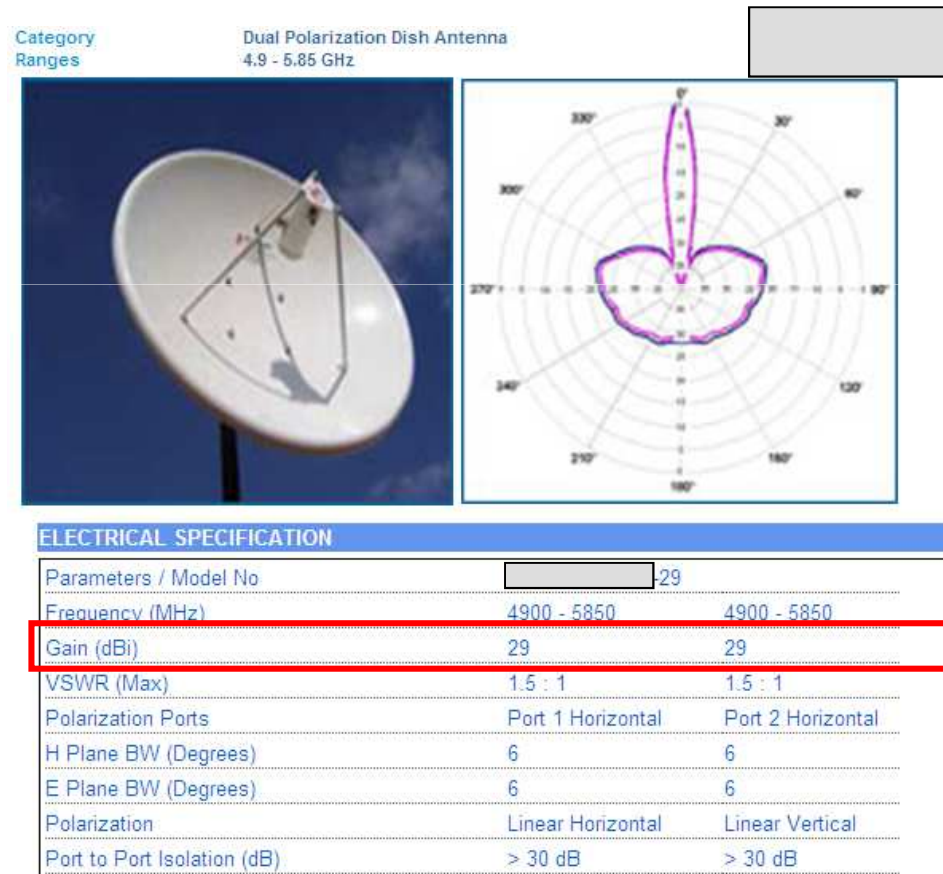


Ramifications

Specification

1.a.

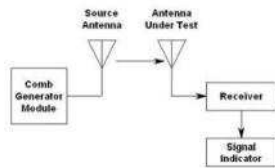
- 29 dBi Dual Polarization Dish Antenna



Gain: 29 dBi

Measured

- 29 dBi Dual Polarization Dish Antenna ?



AZIMUTH - PORT H

Freq (GHz)	Squint (deg)	SideLobe (dB)	Max Gain (dBi)	Front-to-Back (dB)	3dB-BW (deg)	XPOL (dB)	Gain measured VS. Gain by Spec (dB)
4.9	0.29	-15.81	26.54	37.48	6.5	-23.85	-2.46
5	0.3	-15.77	25.93	37.56	6.43	-23.59	-3.07
5.15	0.47	-12.66	25.86	34.41	5.93	-24.49	-3.14
5.25	0.45	-11.93	25.85	32.97	5.61	-21.24	-3.15
5.35	0.55	-11.81	25.29	32.11	5.47	-20.62	-3.71
5.47	0.57	-11.45	24.99	31.49	5.4	-21.68	-4.01
5.625	0.62	-11.97	25.23	31.72	5.5	-20.1	-3.77
5.725	0.69	-14.53	25.6	33.26	6.17	-18.54	-3.4
5.8	0.76	-12.96	24.9	32.02	7.17	-18.93	-4.1
5.875	1	-10.7	25.09	30.6	6.64	-19.11	-3.91
5.95	0.91	-10.11	25.2	29.93	6.03	-18.33	-3.8
6	0.95	-10.16	24.97	30.04	5.86	-18.24	-4.03

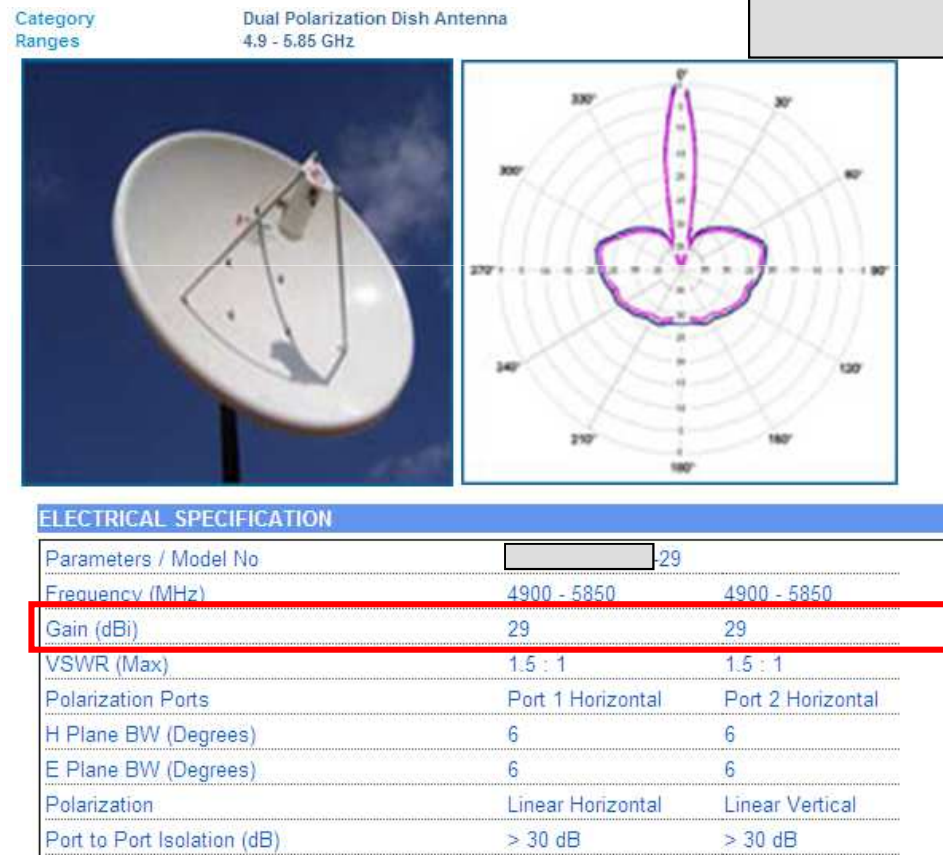
ELEVATION - PORT H

Freq (GHz)	Squint (deg)	SideLobe (dB)	Max Gain (dBi)	Front-to-Back (dB)	3dB-BW (deg)	XPOL (dB)	Gain measured VS. Gain by Spec (dB)
4.9	-1.47	-11.84	26.87	39.88	5.68	-26.49	-2.13
5	-1.54	-12.26	26.35	40.55	5.65	-27.22	-2.65
5.15	-1.65	-9.54	26.41	38.11	5.33	-29.28	-2.59
5.25	-1.67	-8.81	26.51	36.71	5.11	-32.59	-2.49
5.35	-1.79	-6.89	26.09	36.06	4.77	-33.21	-2.91
5.47	-1.87	-6.15	25.72	35.18	4.47	-29.68	-3.28



Measured ⁽²⁾

- **26 dBi** Dual Polarization Dish Antenna !



“Cheap” Antenna

1.a.

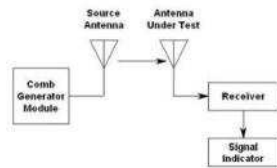
- You paid for a:
29 dBi Dual Polarization Dish Antenna
- You received a:
26 dBi Dual Polarization Dish Antenna
- Value for money?

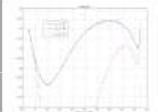
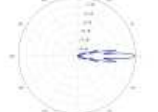
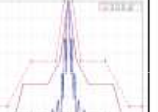
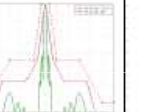
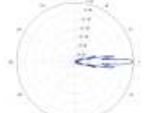
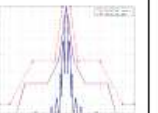
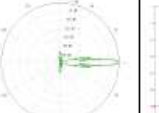
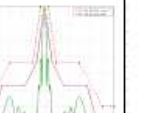


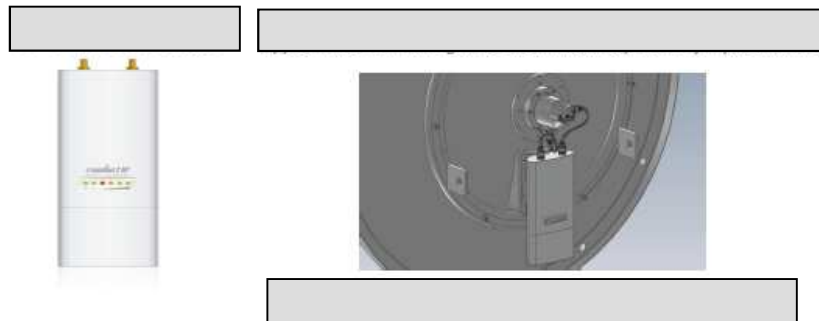
Specification

1.b.

- 5 GHz, Dual Polarization Dish Antenna

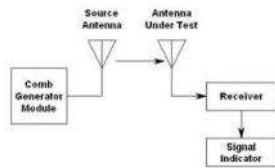


5G-30						
Antenna Characteristics		Return Loss	E-Plane, 5500MHz	E-Plane Specs	H-Plane, 5500MHz	H-Plane Specs
	Frequency Range 14.9-5.90 GHz Gain 28.0-36.25 dBi Polarization Dual Linear Cross-pol Isolation 25dB min Max VSWR 1.4:1 Half Beamwidth (3dB) 5 deg. Half Beamwidth (10dB) 3 deg. VSWR 1.5:1 ETSI Specification EN 302 328 D12 Dimensions 640mm diameter Weight 9.9 kg Wind Survivability 120 mph Windloading 113kg/100sqm					
5G-34						
Antenna Characteristics		Return Loss	E-Plane, 5500MHz	E-Plane Specs	H-Plane, 5500MHz	H-Plane Specs
	Frequency Range 14.9-5.90 GHz Gain 32.1-34.2 dBi Polarization Dual Linear Cross-pol Isolation 25dB min Max VSWR 1.4:1 Half Beamwidth (3dB) 5 deg. Half Beamwidth (10dB) 3 deg. VSWR 1.5:1 ETSI Specification EN 302 328 D12 Dimensions 972mm diameter Weight 13.5 kg Wind Survivability 125 mph Windloading 250kg/100sqm					



Measured: Gain

- Test Results



Port V

Freq(GHz)	Gain - measured (dBi)	Gain - Spec (dBi)
4.9	26.54	28 - 30.25
5	27.67	28 - 30.25
5.15	27.69	28 - 30.25
5.25	27.99	28 - 30.25
5.35	27.97	28 - 30.25
5.47	28.04	28 - 30.25
5.625	28.53	28 - 30.25
5.725	29	28 - 30.25
5.875	29.16	28 - 30.25
6	28.64	28 - 30.25

Port H

Freq(GHz)	Gain - measured (dBi)	Gain - Spec (dBi)
4.9	25.7	28 - 30.25
5	26.69	28 - 30.25
5.15	27.07	28 - 30.25
5.25	27.29	28 - 30.25
5.35	27.48	28 - 30.25
5.47	27.64	28 - 30.25
5.625	28.28	28 - 30.25
5.725	28.74	28 - 30.25
5.875	28.83	28 - 30.25
6	28.43	28 - 30.25



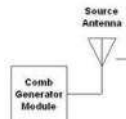
Compare: Gain

- Performance

HQ D/P Dish antenna HQ-x Vs. B-y

Gain @ Port V

Freq (Ghz)	Ant B	Gain (dBi)	HQ	Gain (dBi)	HQ	Extra Gain (dBi)
4.9	26.54		28.20		1.66	
5	27.67		28.11		0.44	
5.15	27.69		28.42		0.73	
5.25	27.99		28.78		0.79	
5.35	27.97		28.82		0.85	
5.47	28.04		29.20		1.16	
5.625	28.53		29.41		0.88	
5.725	29		29.40		0.40	
5.875	29.16		29.87		0.71	
6	28.64		29.67		1.03	



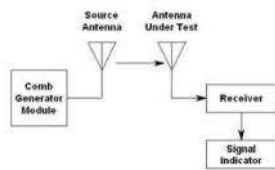
Gain @ Port H

Freq (Ghz)	Ant B	Gain (dBi)	HQ	Gain (dBi)	HQ	Extra Gain (dBi)
4.9	25.7		28.00		2.3	
5	26.69		28.13		1.44	
5.15	27.07		28.34		1.27	
5.25	27.29		28.69		1.4	
5.35	27.48		28.77		1.29	
5.47	27.64		28.97		1.33	
5.625	28.28		29.37		1.09	
5.725	28.74		29.50		0.76	
5.875	28.83		29.56		0.73	
6	28.43		29.31		0.88	

Compare: Port Isolation & Side Lobes

- Performance

HQ D/P Dish antenna **HQ-x** Vs. **B-y**



- Side Lobes

- HQ** antenna: -20dB typical in both ports.
- Ant B** antenna: -10dB typical in port H
-15dB typical in port V.



- Port Isolation

Antenna	Isolation - Peak	Isolation - Avg.
HQ	-33dB	-38dB
Ant B	-21dB	-28dB



Implications

1.b.

- **Link Budget:**

Even a relatively small difference in the **Gain** of 1-2 dBi, in a **PtP** application, will result in **2-4 dBi Gap over the Link**.

- **QOS & Throughput:**

Side Lobes and **Port Isolation** are very critical parameters for **Quality of Service** and **Throughput**. These antennas are used in PtP systems with high level QAM modulation. So if an adaptive system will have to switch from **QAM 256** to **QAM 64**, your **Throughput will degrade by a factor of 4!**

- **Value for money?**



2.

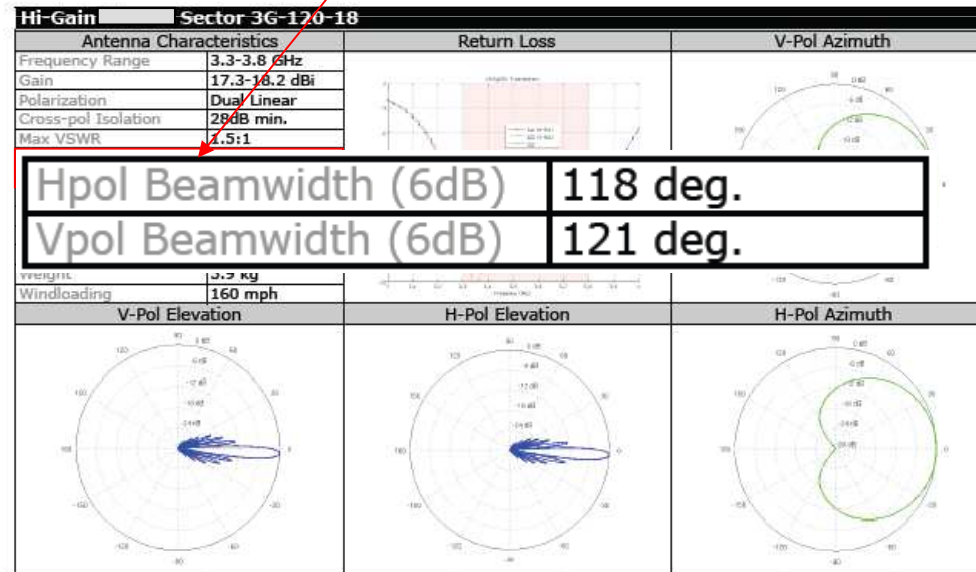
Reading Specifications



Revolutionary Cost/Performance Carrier Class 3GHz MIMO
BaseStation Antenna



Hpol Beamwidth (6dB)	118 deg.	- 6 dB ???
Vpol Beamwidth (6dB)	121 deg.	



Beam Width

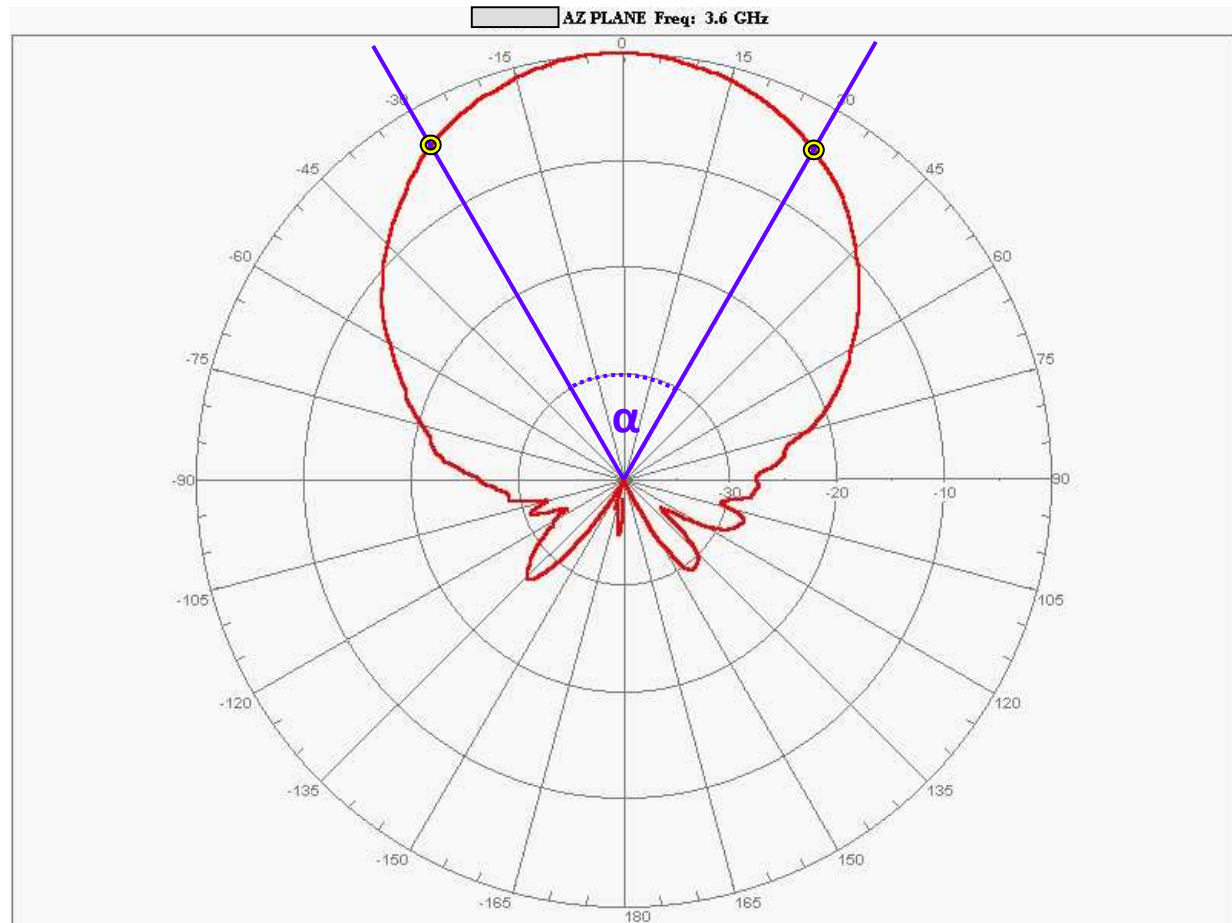
Defined at

- **- 3 dB**

= Half Power



* ETSI EN 302 326-3



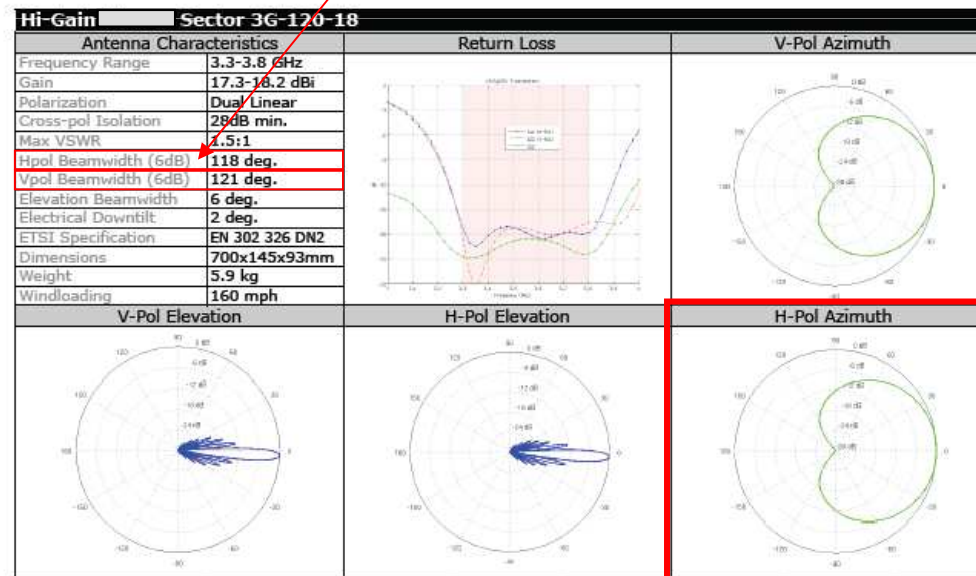
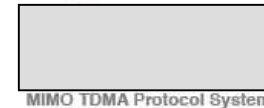
Reading Specifications (2)



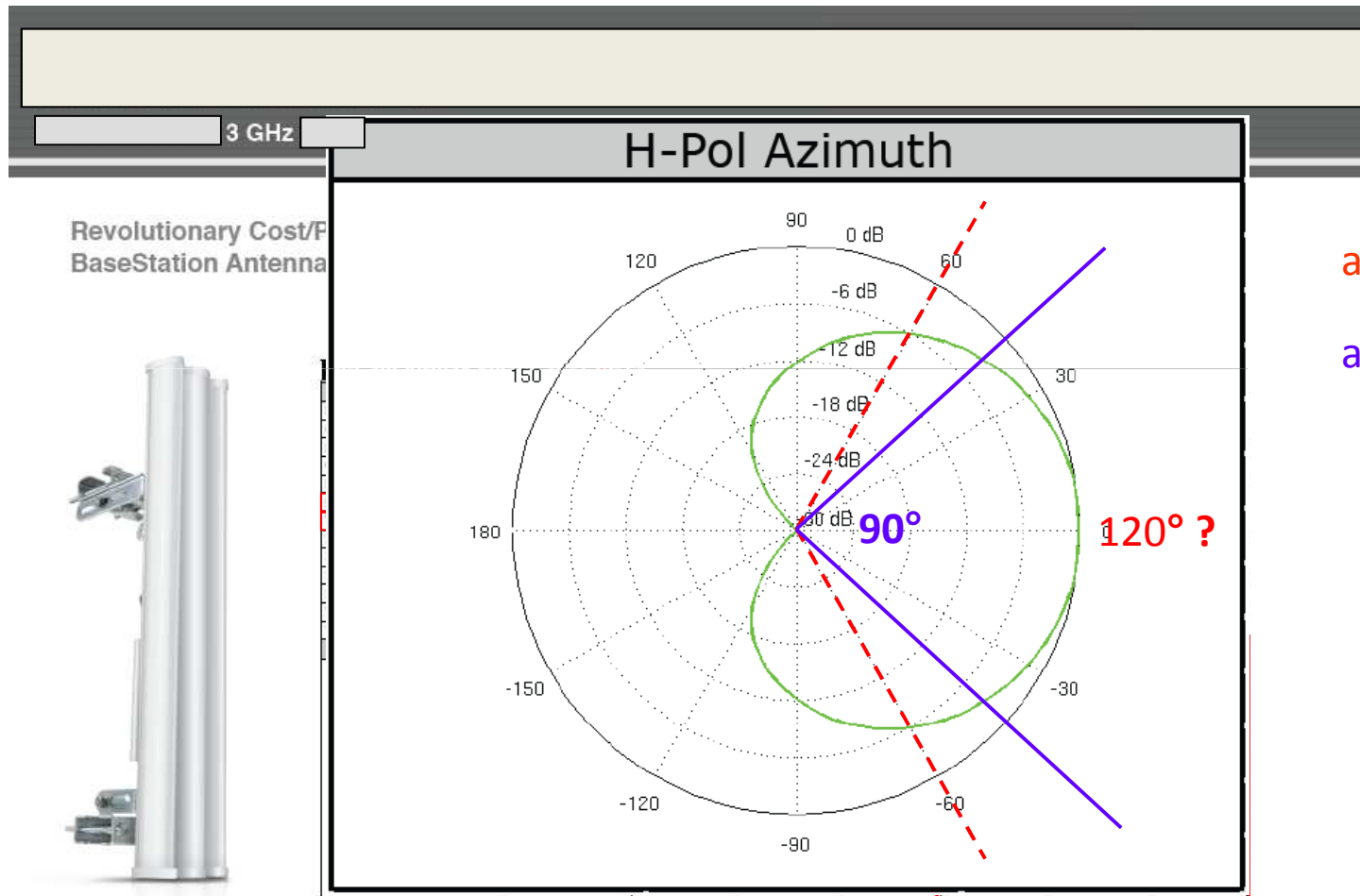
Revolutionary Cost/Performance Carrier Class 3GHz MIMO
BaseStation Antenna

Hpol Beamwidth (6dB)	118 deg.
Vpol Beamwidth (6dB)	121 deg.

- 6 dB ???



Reading Graphs

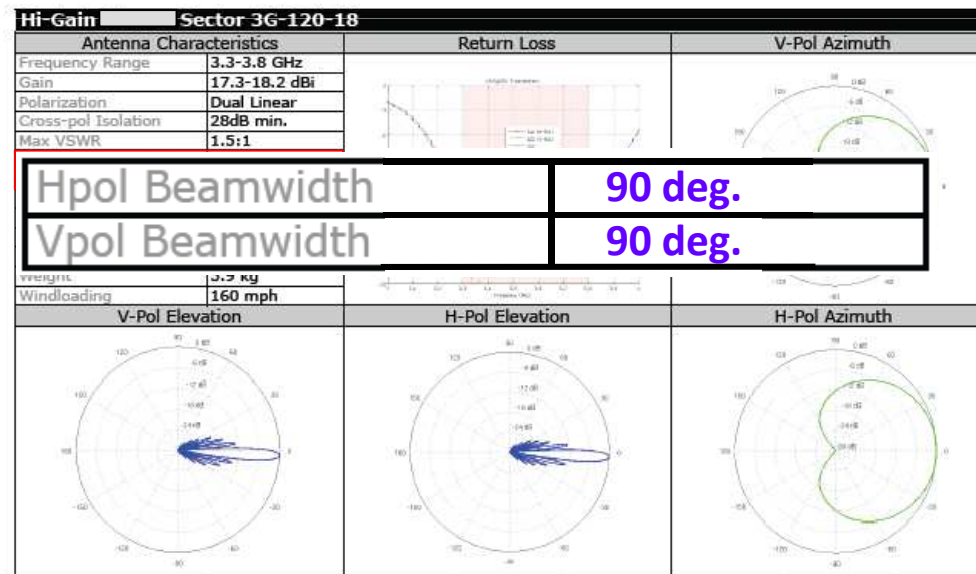


Reading Specifications (3)



Revolutionary Cost/Performance Carrier Class 3GHz MIMO
BaseStation Antenna

MIMO TDMA Protocol System

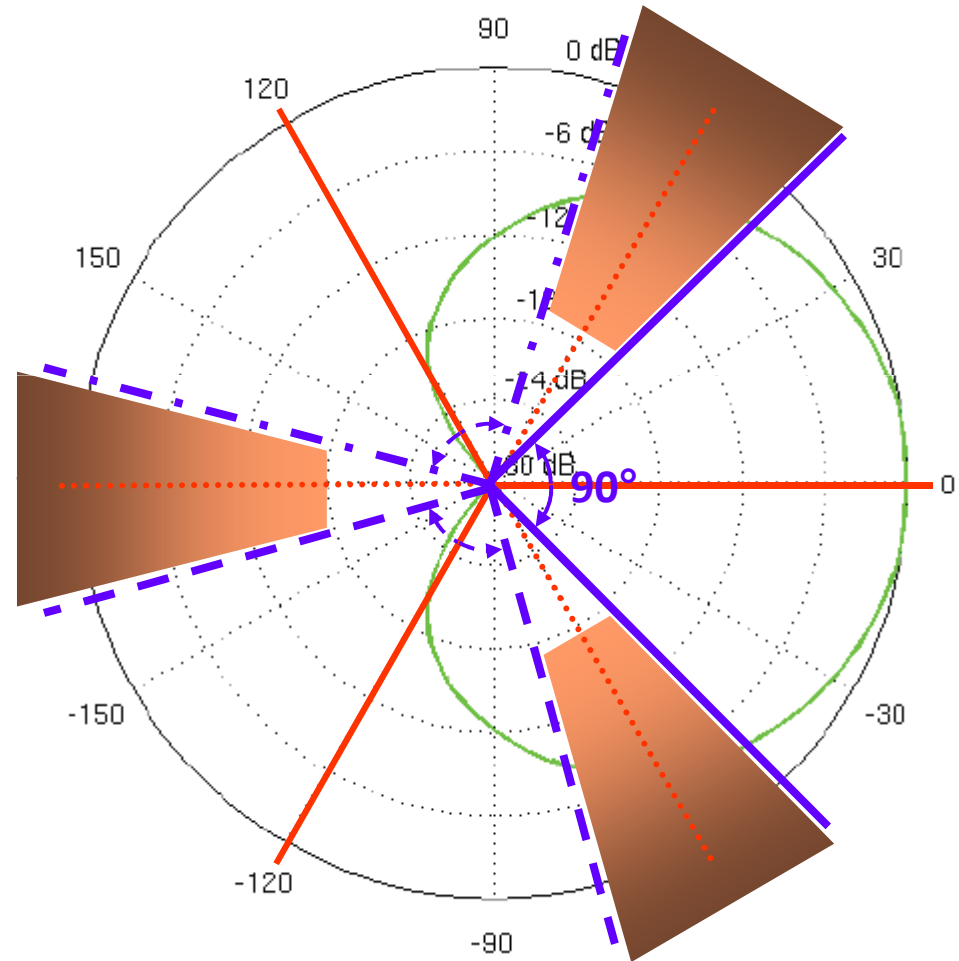


It's not only Specifications !

- 120° labeled antennas in real life.

- 90° sectors

 **No (or very low) reception !!!**



Return on Investment (ROI)

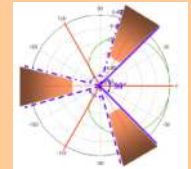
2.

- 120° labeled antennas in real life.
- 90° sectors

 **No (or very low) reception !!!**



- Clients in between the sectors get **no** (or very low) **signal**.



- Operator **looses 25%** of coverage / customers / revenues.

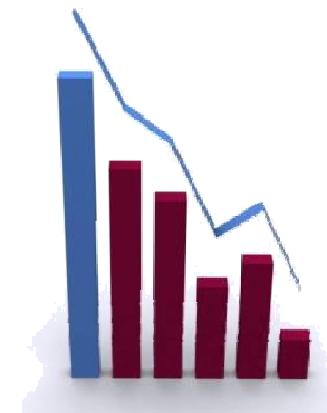


3.

Throughput

Wireless communications system

- Throughput
 - With Hi-Quality Antennas: **>80 Mbps**



Throughput

3.

Wireless communications system

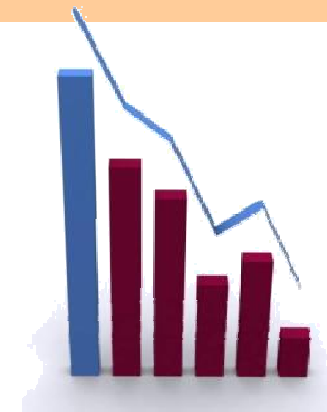
- Throughput
 - With Hi-Quality Antennas: **>80 Mbps**
 - With cheap Antennas: **<50 Mbps**
- => Penalty of 40% in performance !



Lessons learned the hard way

Note: Throughput

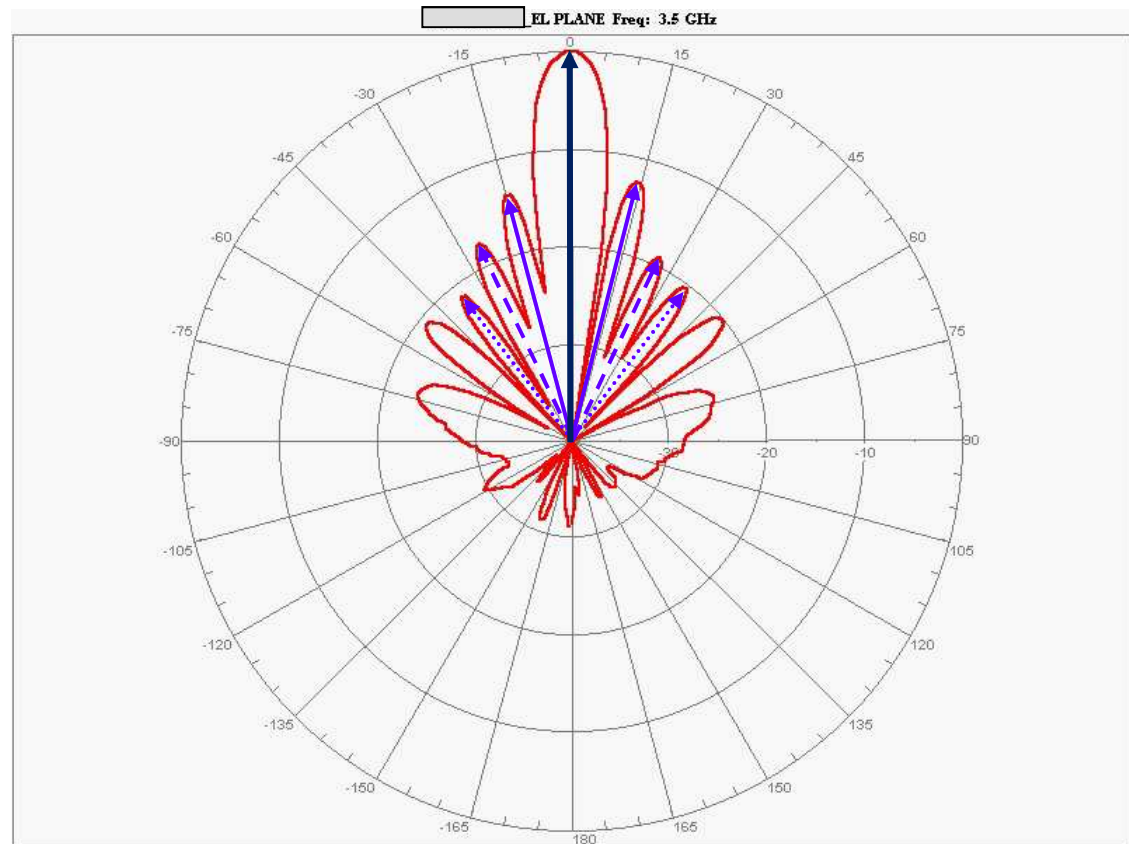
- ★ The absolute numbers (80/50 Mbps) are not so impressive by today's standards.
 - ★ However, note the dramatic performance improvement in excess of 40 % by using Hi-Quality antennas versus inferior products.
- Today, the improvement rate (%) would be similar or bigger (MIMO).



4.

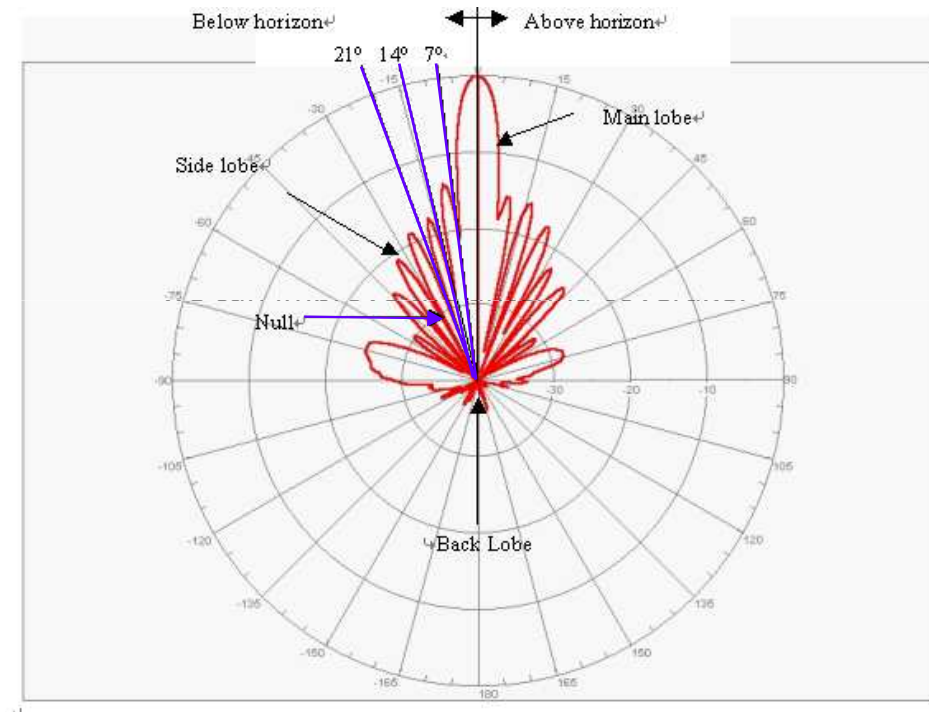
Main Lobe & Side Lobes

- **Main Lobe** →
- **Side Lobe 1** →
- **Side Lobe 2** →
- **Side Lobe 3** →
- ...



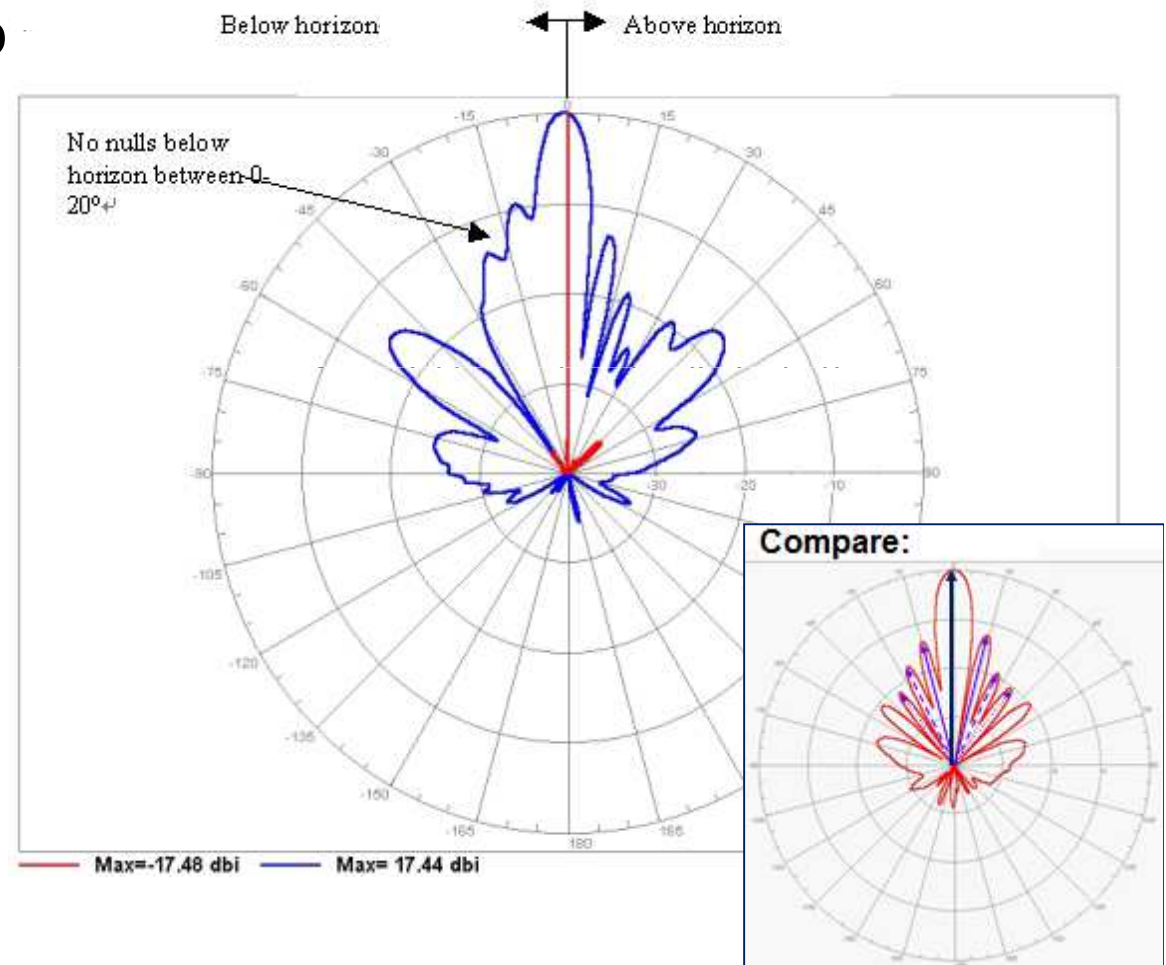
Nulls

- Between the Main Lobe and the Side Lobes: “**Null**”
- No (or very low) signal transmitted / received.



Null Fill

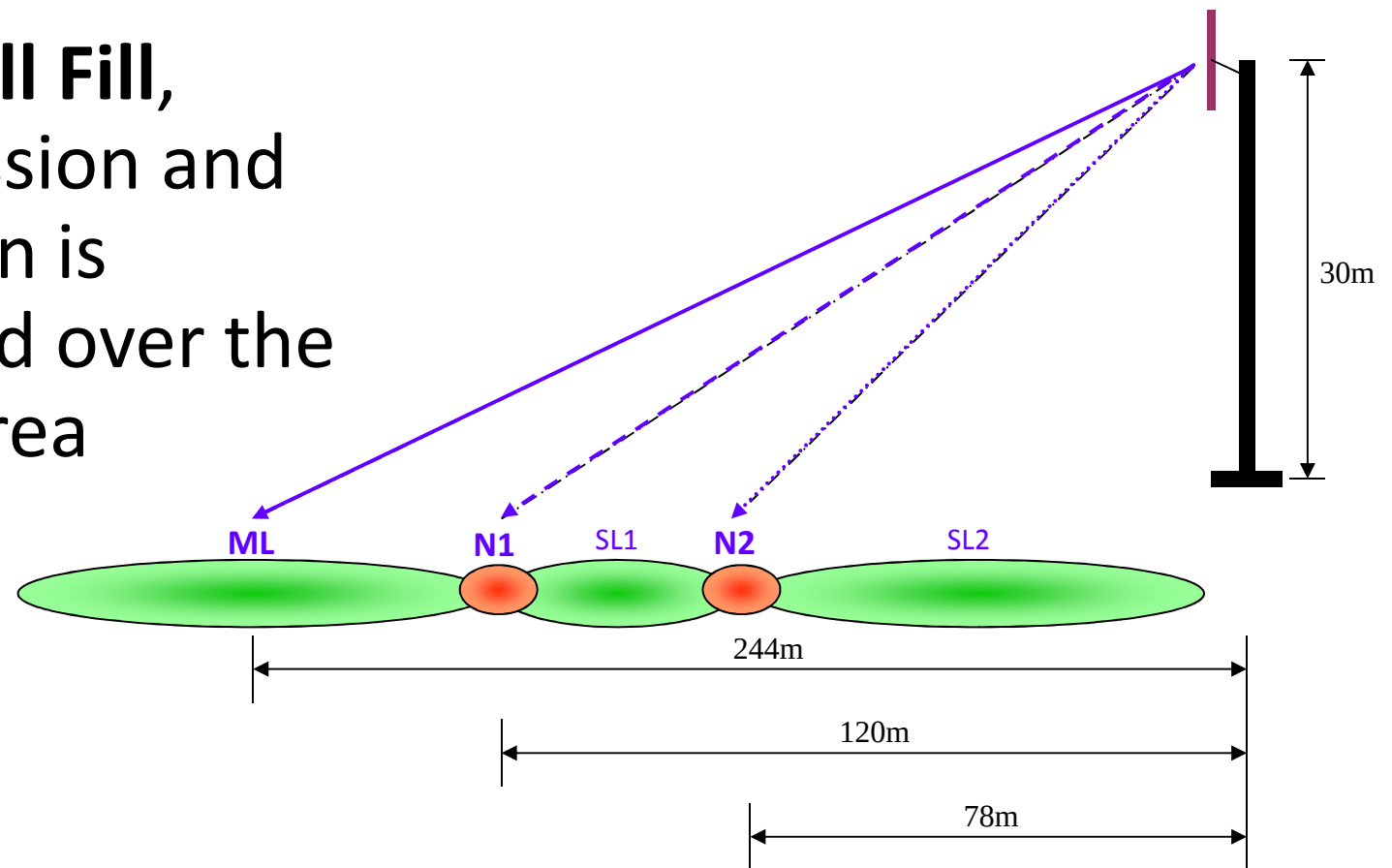
- Special technology to **eliminate Nulls** below horizon



Main Lobe & Side Lobes

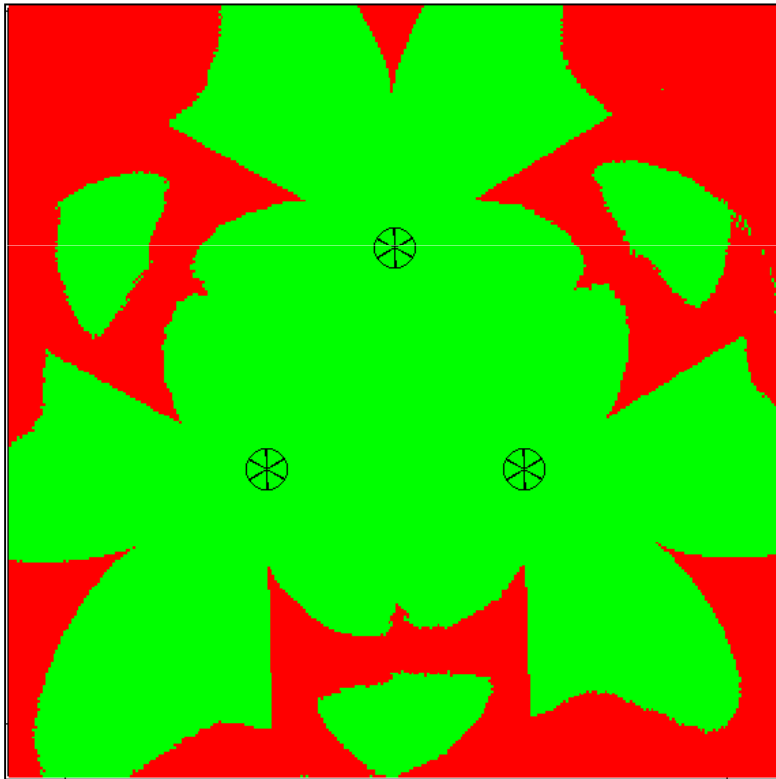
Nulls in between

- With **Null Fill**, transmission and reception is improved over the whole area

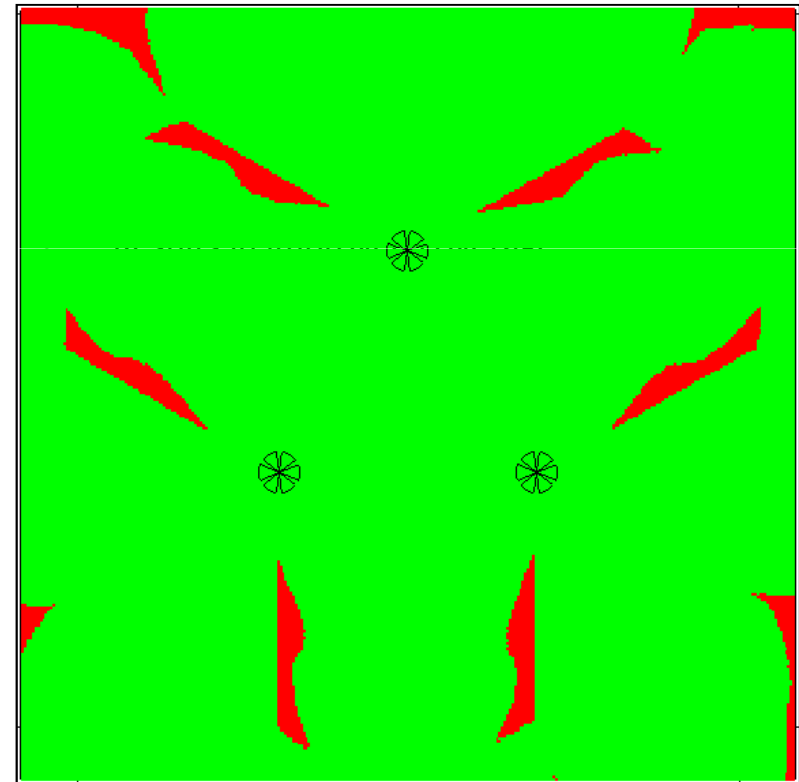


Result of Null-Fill (Simulation)

- Improved Coverage!
- Increased ROI



Coverage **without** Null Fill



Coverage **with** Null Fill

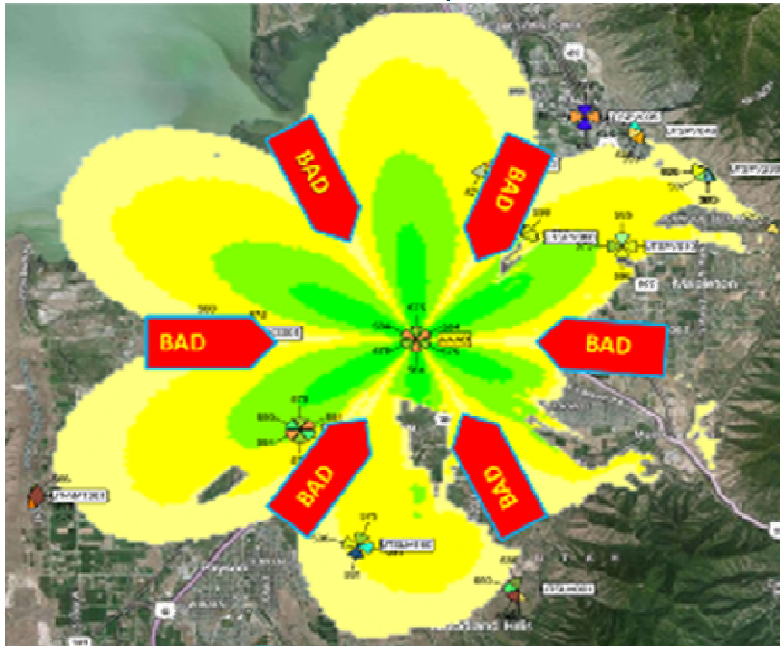
Result of Null-Fill

Real Life Example

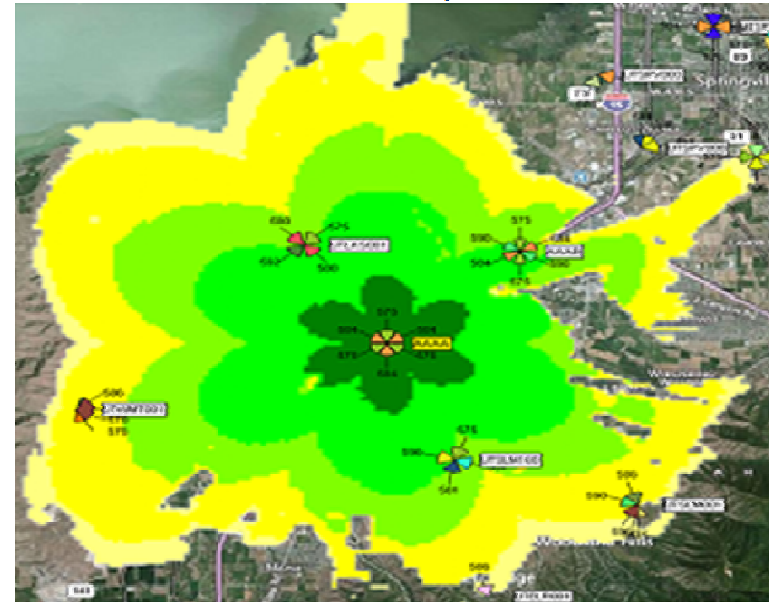
This is how customer dramatically improved performance of their network by switching to High Quality Base Station Antennas **HQ-x**, 5.15-5.875 GHz, 16 dBi, 60°, Dual Polarization **Antenna with Null Fill**.

Shown with Collocation Channels Performance.

450 Antenna
with 2 channels, 6 sectors



HQ **HQ-x**
with 2 channels, 6 sectors



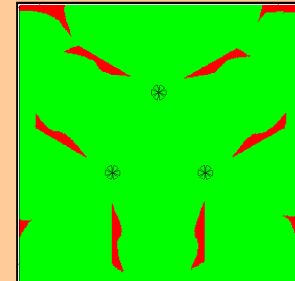
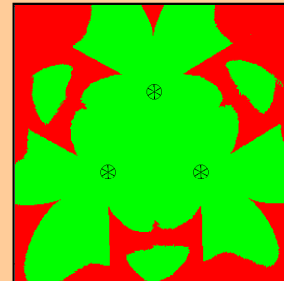
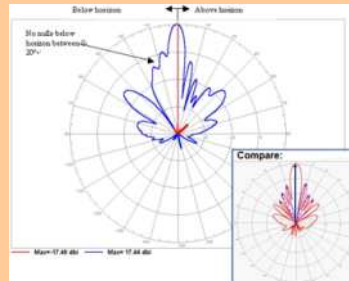
Improved network **coverage**, **throughput**
and **capacity** of cell sites!

Implications

4.

- **High Performance:**

A high performance base station antenna (BTS) with **Null Fill** may have a slightly higher price tag than a low cost BTS antenna.



- **Benefit:**

Null Fill antenna will **improve** network **coverage**, **throughput** and **capacity** over the whole area. Therefore, return on investment (ROI) may be measured in a matter of weeks.

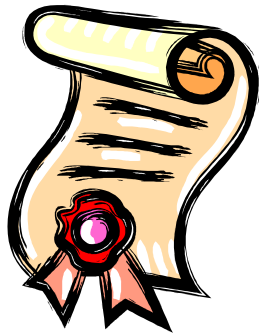
- **Value for money?**



Data Sheets and Reality

Topic

Quality
?



“Papier ist geduldig” (German Proverb):

“You can write anything on paper”



The Real Question !

- How Much does it cost?
- Performance
- High Quality, Low Cost
- ROI – Return on Investment
- TCO – Total Cost of Ownership
- **Cost / Benefit !**

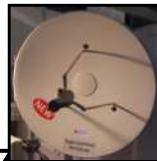




Products

Antennas & Accessories for MikroTik

- 700 MHz
- 900 MHz
- 1.3 – 1.9 GHz
- ➔ **2.4 GHz**
- ➔ **3.5 GHz**
- 4.4 – 4.9 GHz
- ➔ **5.8 GHz**
- 🇷🇺 6 – 6.4 GHz
- 10.5 GHz
- 60 GHz
- **80 GHz**



- **Base Station Antennas**
(BTS)

- **Subscriber Antennas**
(CPE)



- **Omnidirectional Antennas**
(Omni)



- **Enclosures (1' & ½')**
- **Mounting Kits**

Antennas for MikroTik based Wireless Networking





Summary



- Over **40 years Experience** in Antenna Design, Production & Manufacturing
- Over **450 standard Antennas** for BWA
- **Omni, BTS & CPE (Subscriber) Antennas**
- Special requirements and **OEM** capabilities
- Best **cost/benefit** performance
- Unrivalled **Quality**



YOUR Wireless Edge

**The performance of your
MikroTik based wireless network
will be critically influenced by
your choice of antennas.**



Contact



Michel Bodenheimer

Tel: (+972)-3-900 89 00, Ext: 365

Fax: (+972)-3-900 89 01

Mobile: (+972)-54-77 12 789

E-mail: michel.bodenheimer@mtiwe.com

Skype: michel.bodenheimer-mti

Thank You

