# MikroTik User Meeting 2016

Topic

# Quality Considerations in Wireless Networking


25-26 / 02 / 2016

Ljubljana, Slovenia

# Presented by

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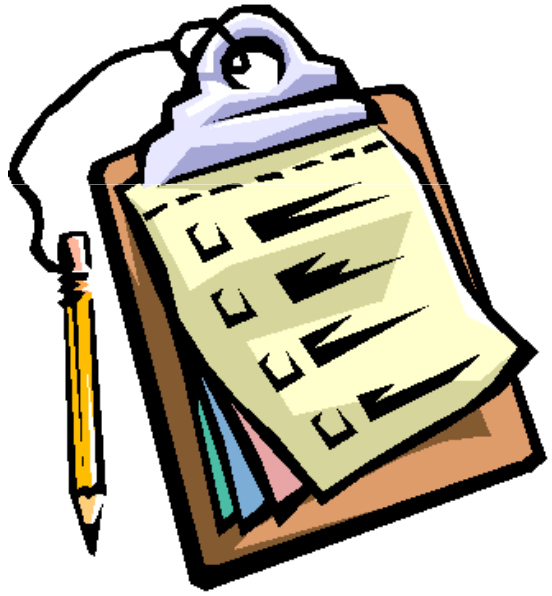
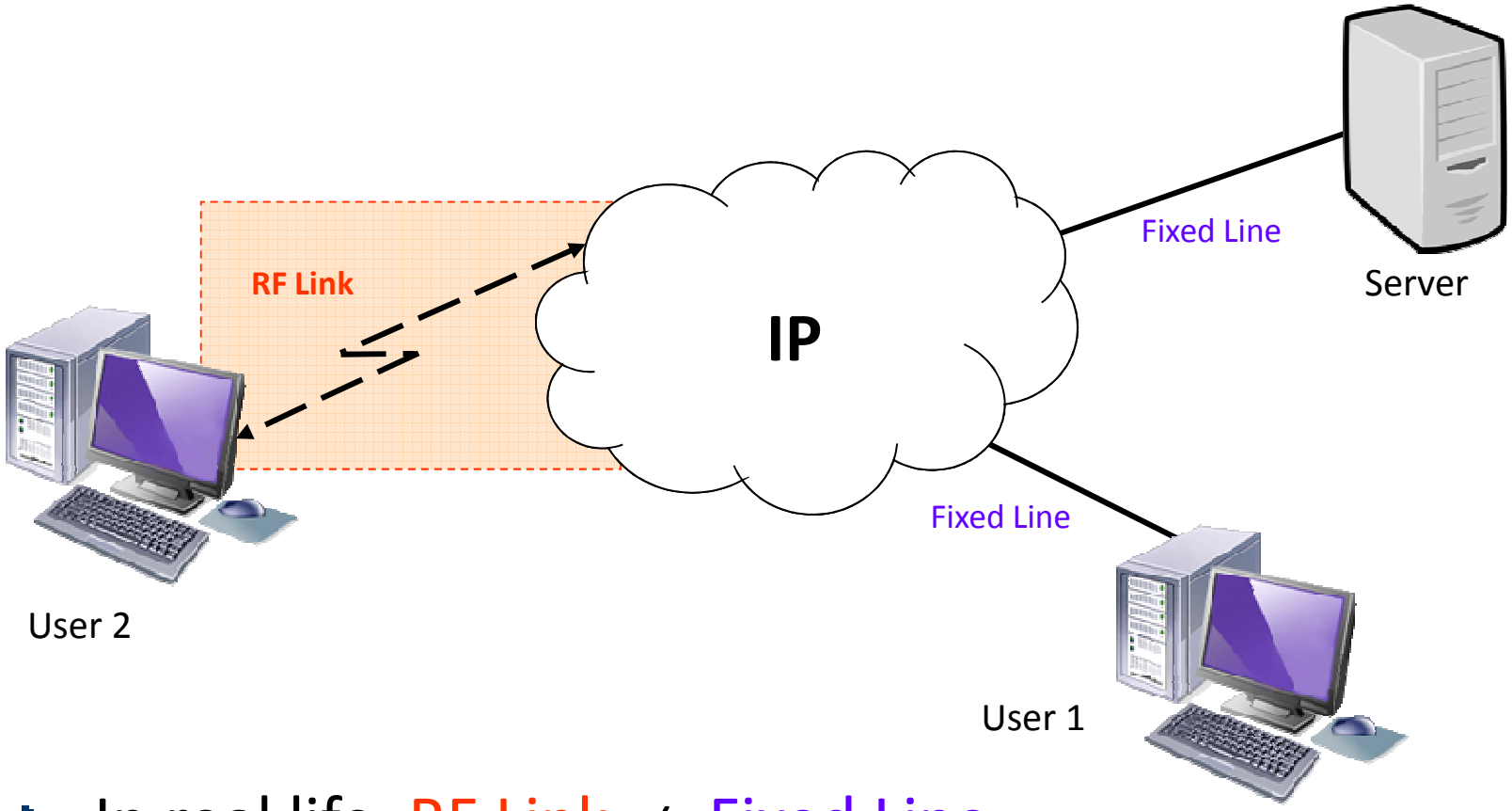
# Agenda

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

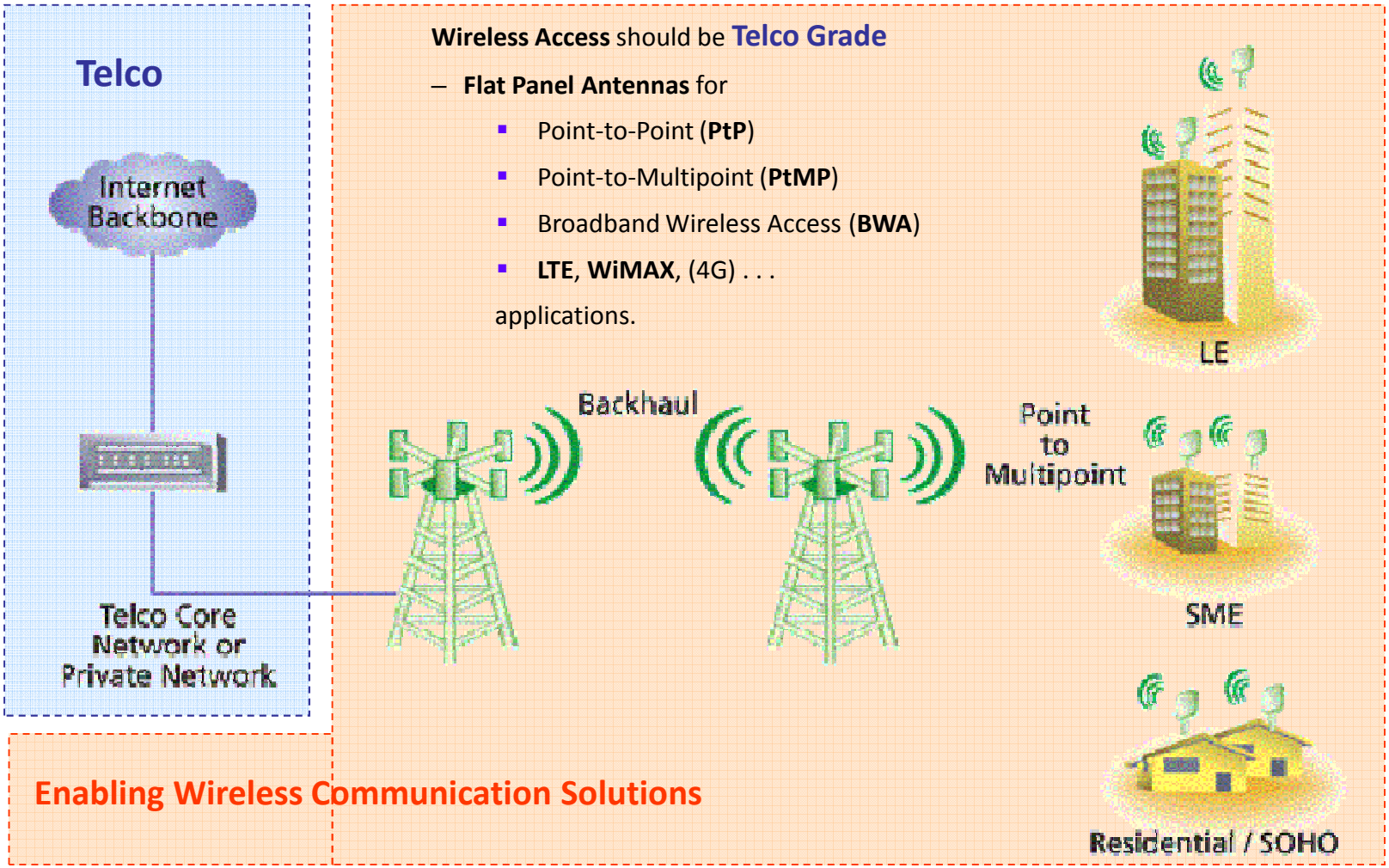


# Typical Network




- In real life, RF Link ≠ Fixed Line

# Broadband Wireless Access

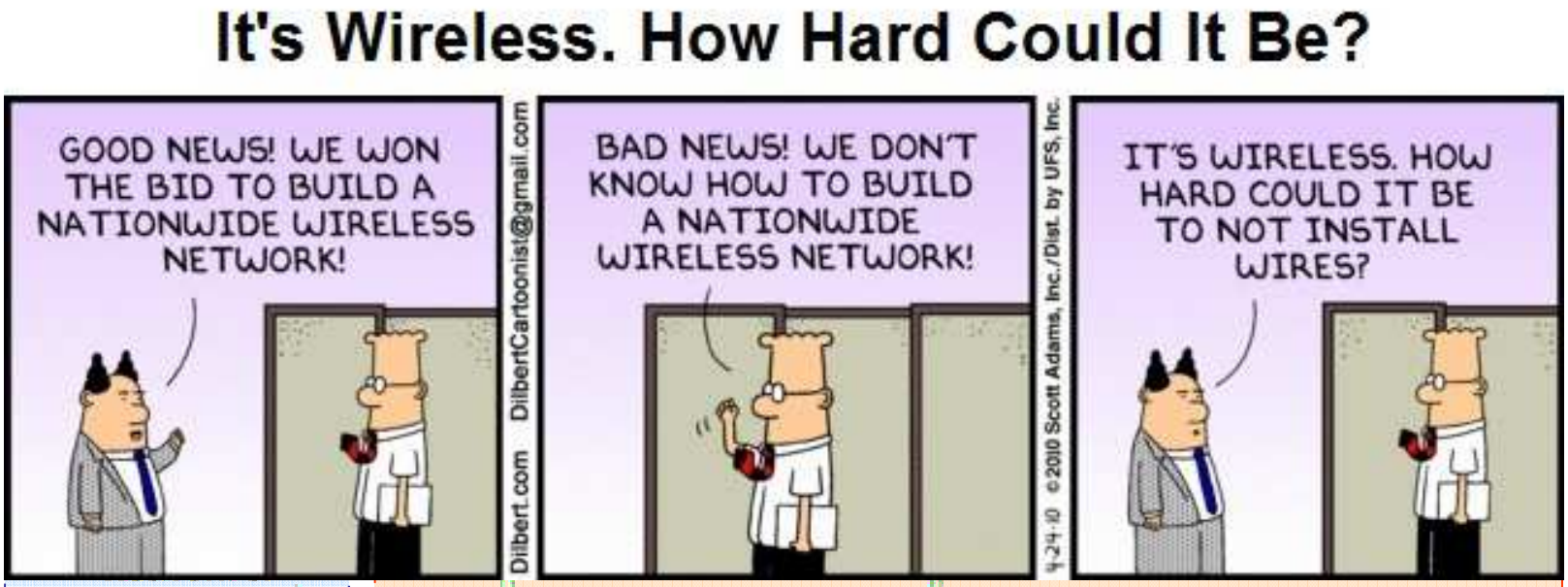


# Broadband Wireless Access

**Telco**

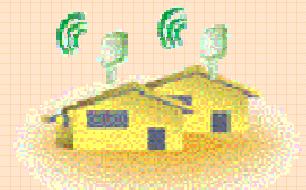
**Wireless Access** Should be **Telco Grade**

– **Flat Panel Antennas** for




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**

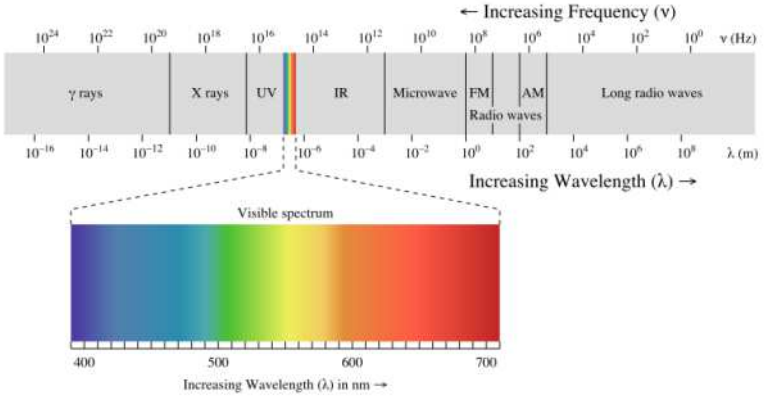
  Of any wireless system

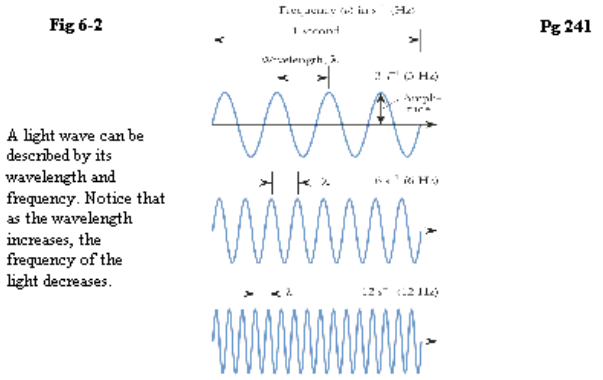
# Antenna Parameters

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

# Frequency [Hz]

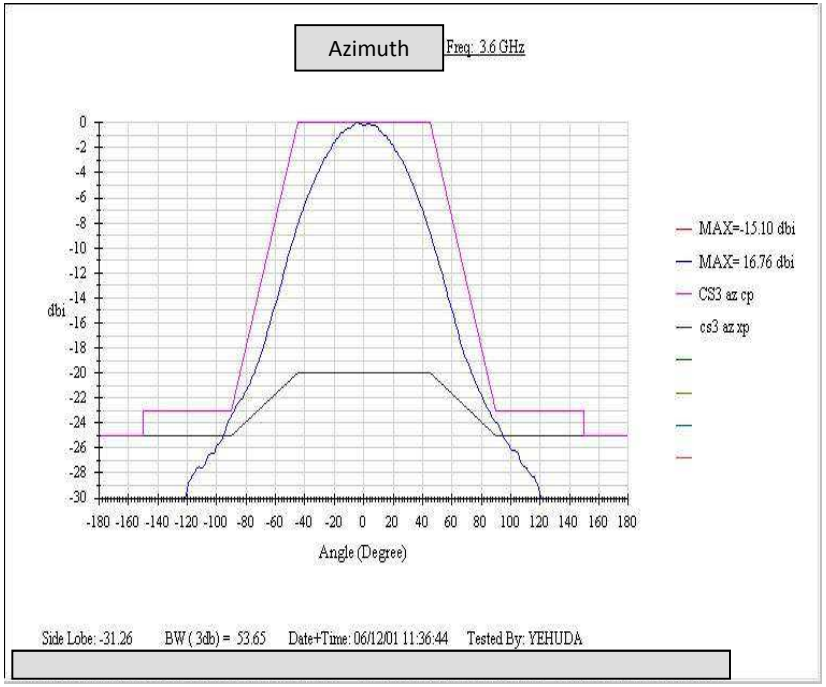
- **Frequency**
  - Frequency is the number of occurrences of a repeating event per time unit. The period is the duration of one cycle in a repeating event, so the period is the reciprocal of the frequency.
- **Radio Frequency**
  - That part of the electromagnetic spectrum, between about 3 kHz and 300 MHz, within which radio waves are transmitted.



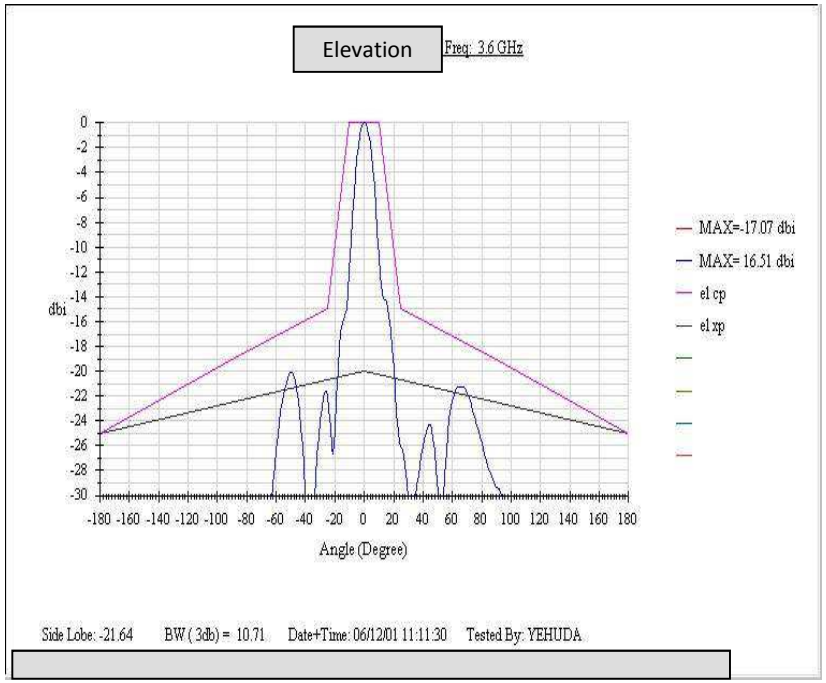



# Gain [dBi]

- **Azimuth**
  - Main Lobe
  - Side Lobe




- **Elevation**
  - Main Lobe
  - Side Lobe

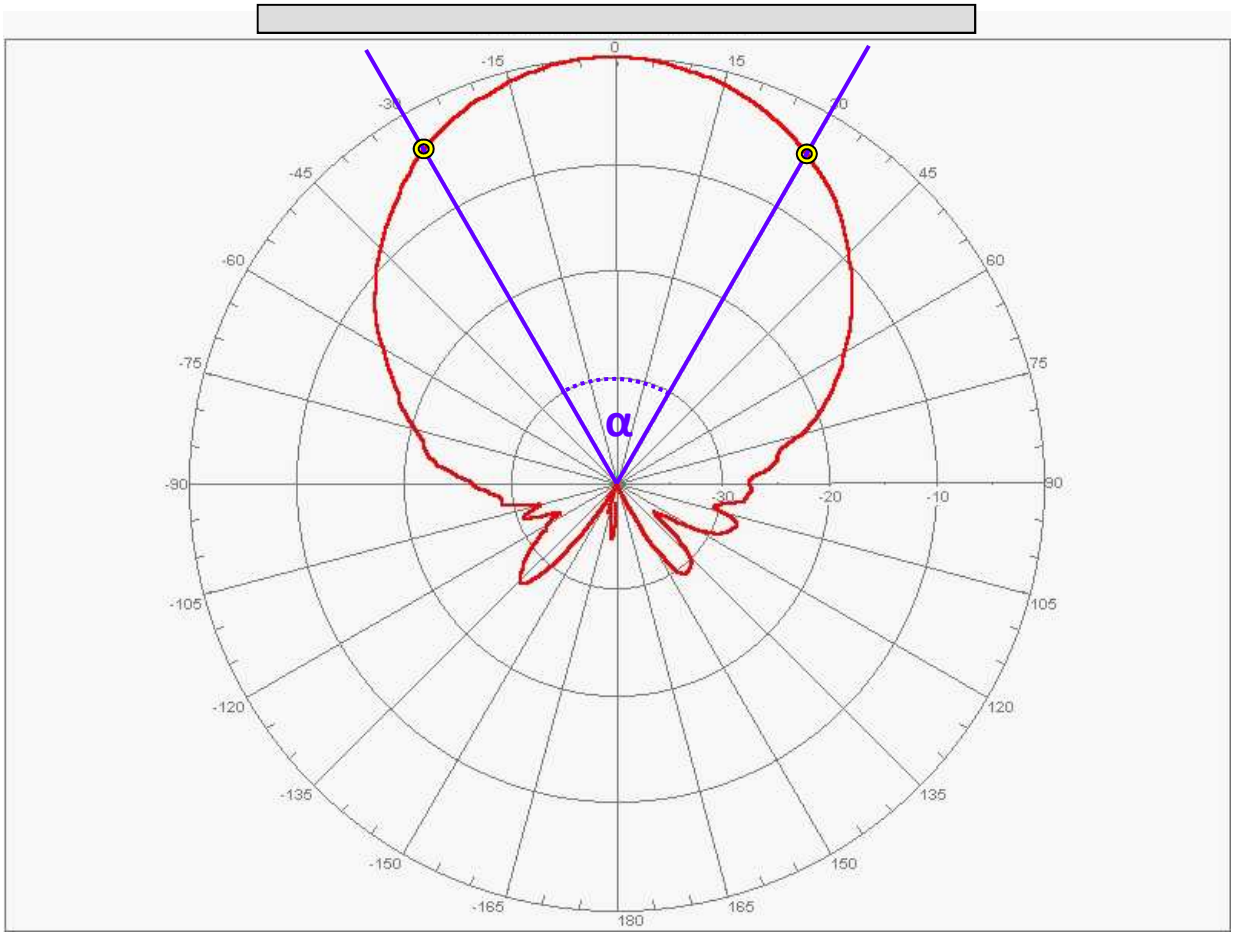


# Beam Width

***Defined*** at

- **- 3 dB**

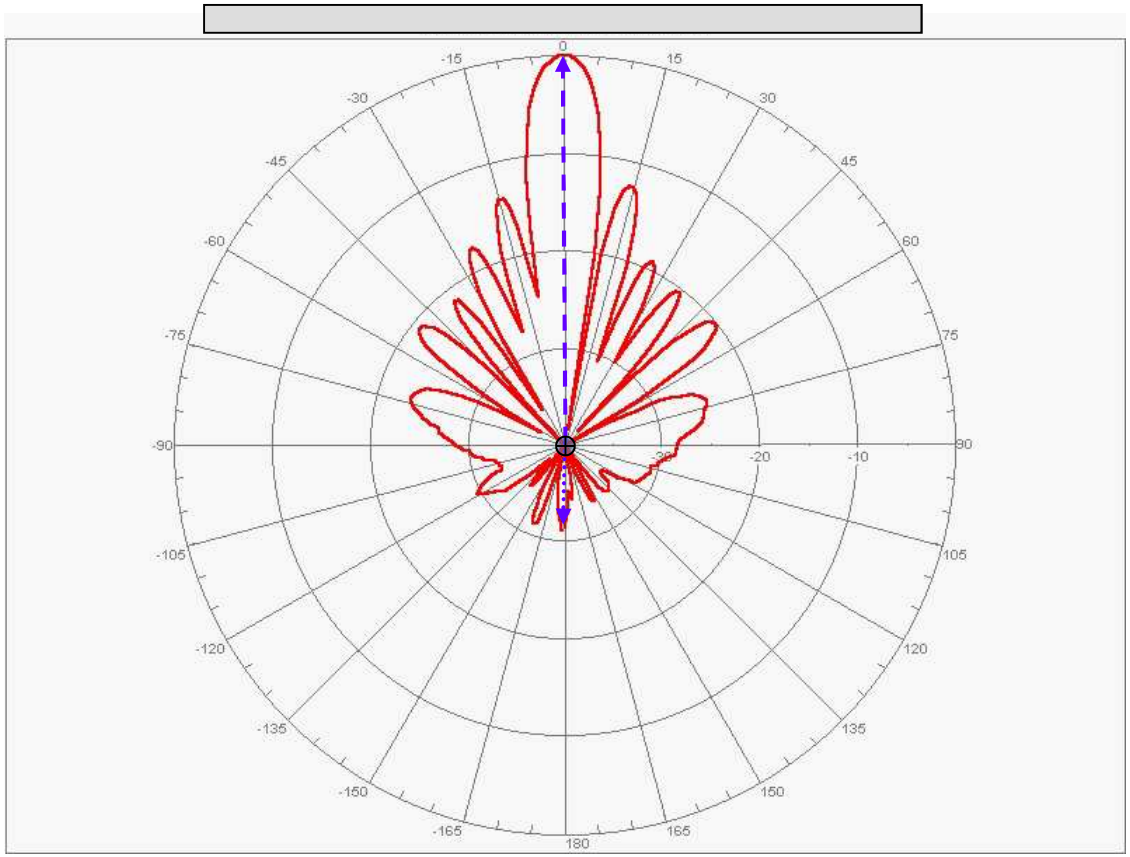
= Half Power




* **ETSI** EN 302 326-3

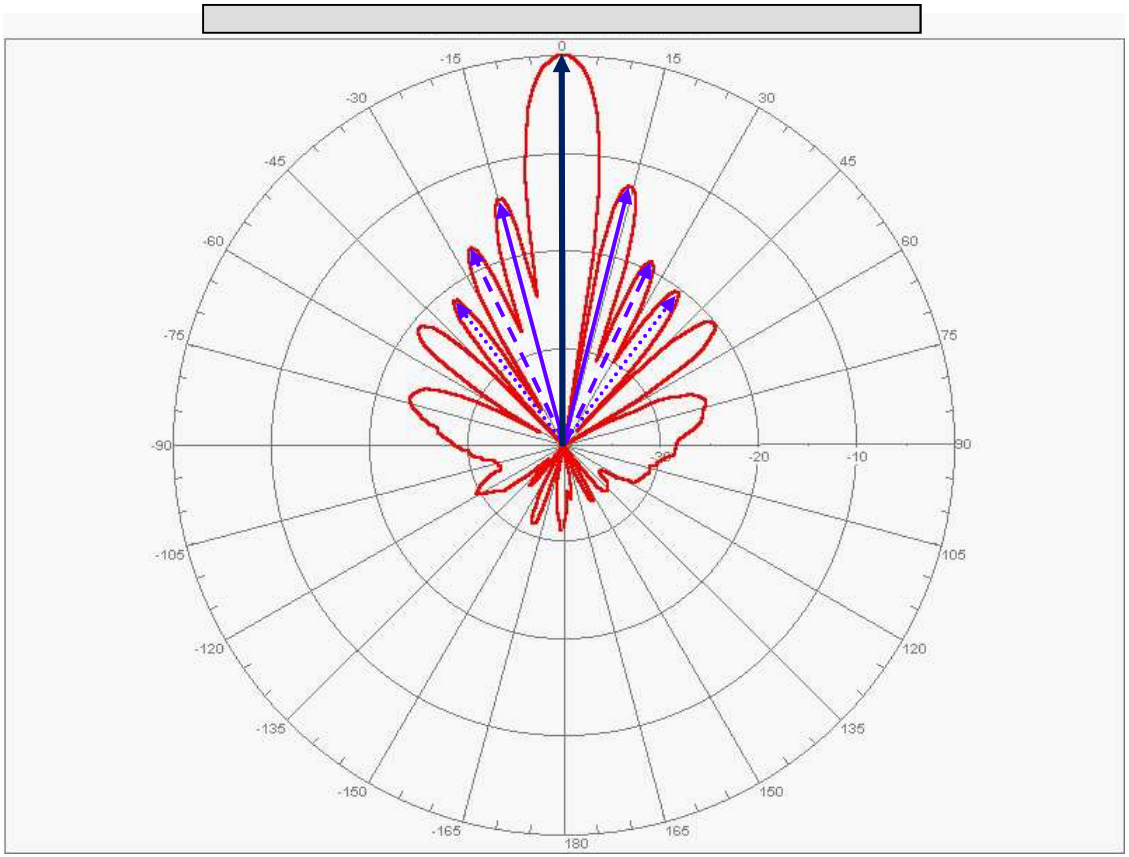
# Front to Back Ratio

- Front
- Back



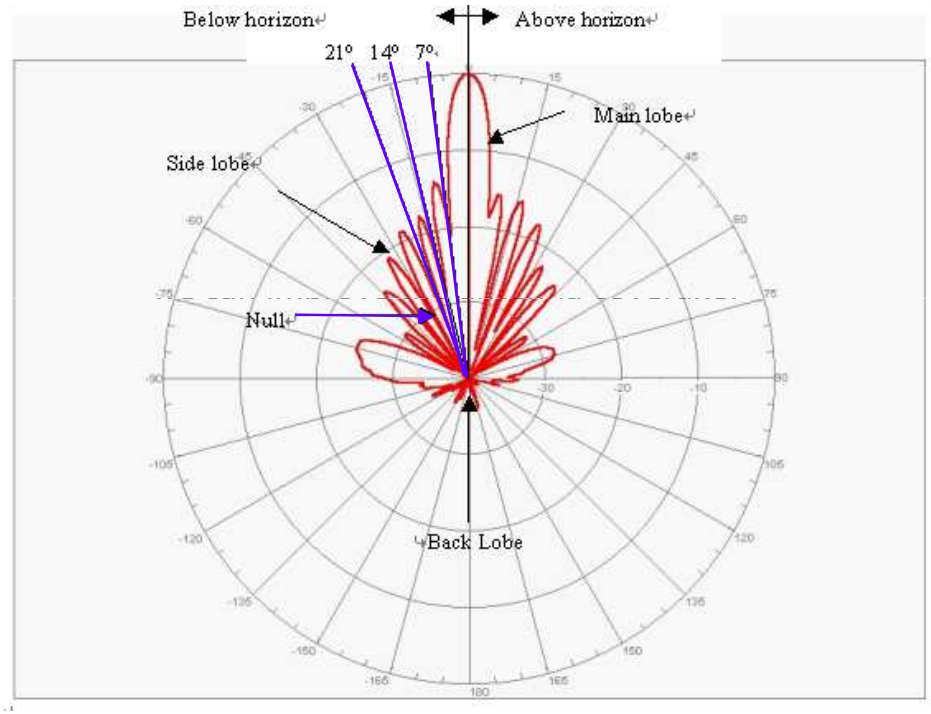
# Main Lobe & Side Lobes

- **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

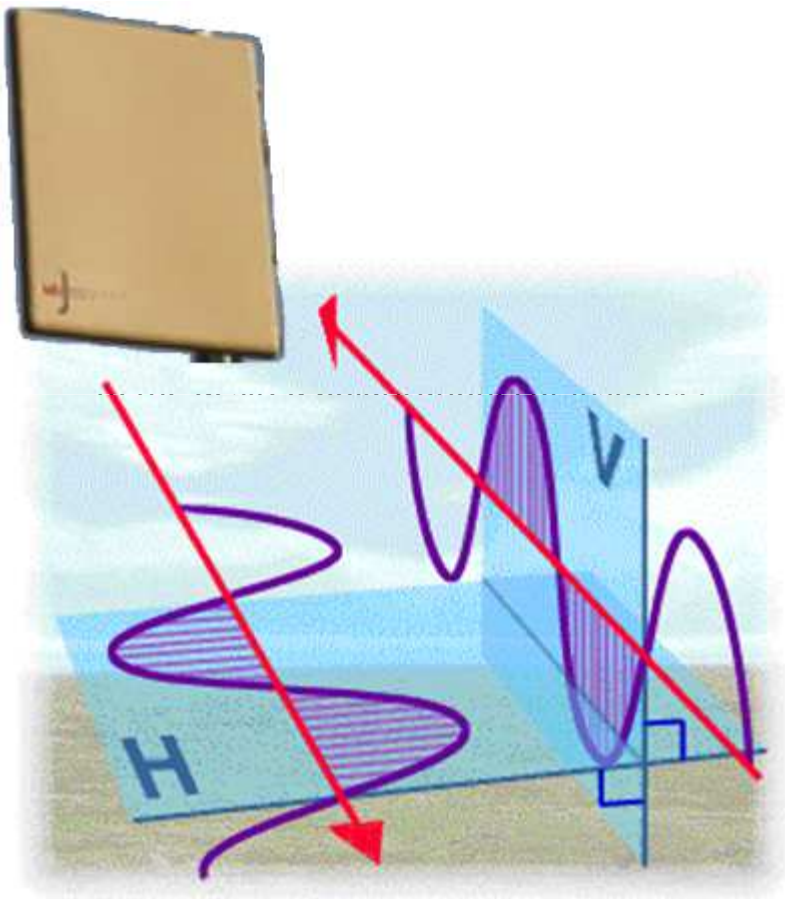
- Vertical

  X

- Horizontal

Often Cross Polarization is confused with

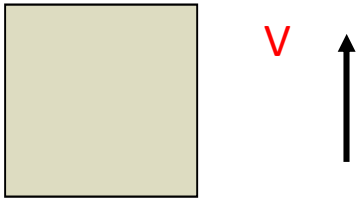
- **Dual Polarization** (V&H)
- **Dual Slant** (± 45 °)

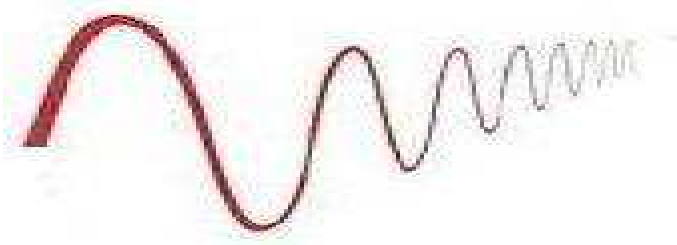


# Single Polarization

**Single Polarization**

- Vertical

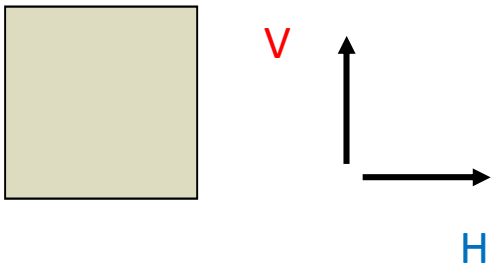


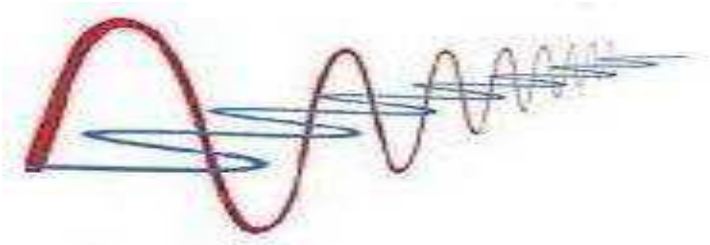



# Dual Polarization

**Dual Polarization** (DP)

- Vertical + Horizontal



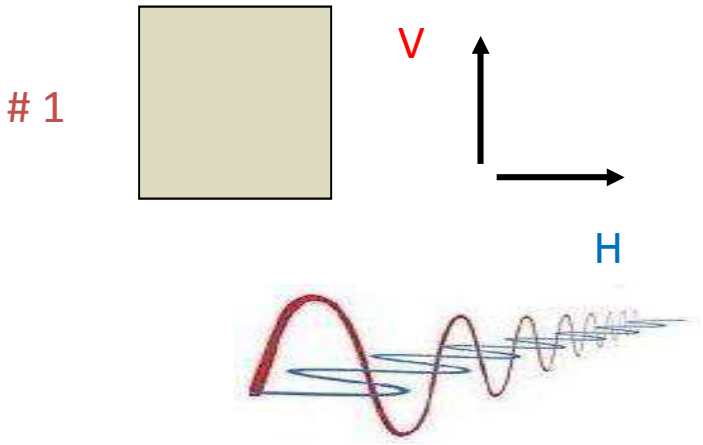
# Dual Polarization / Dual Slant

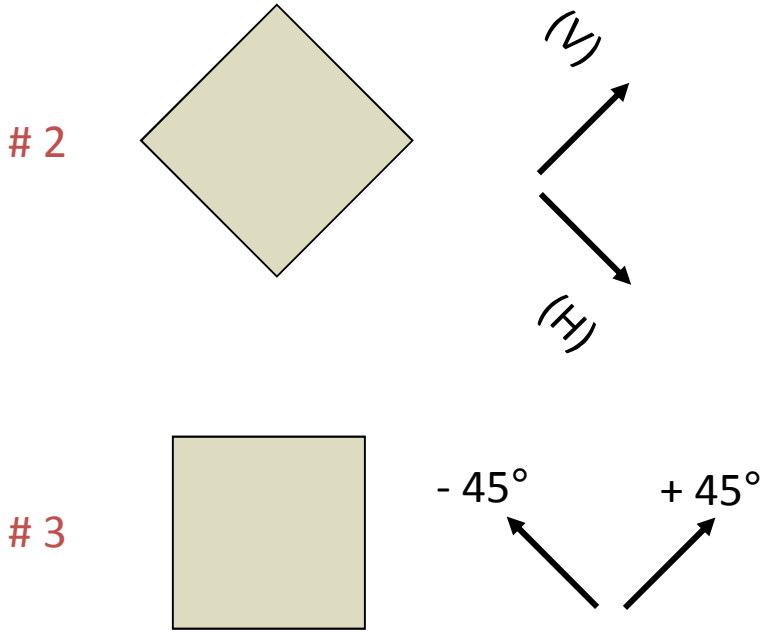
**Dual Polarization** (DP)

- Vertical + Horizontal

**Dual Slant** (DS)

- ± 45°

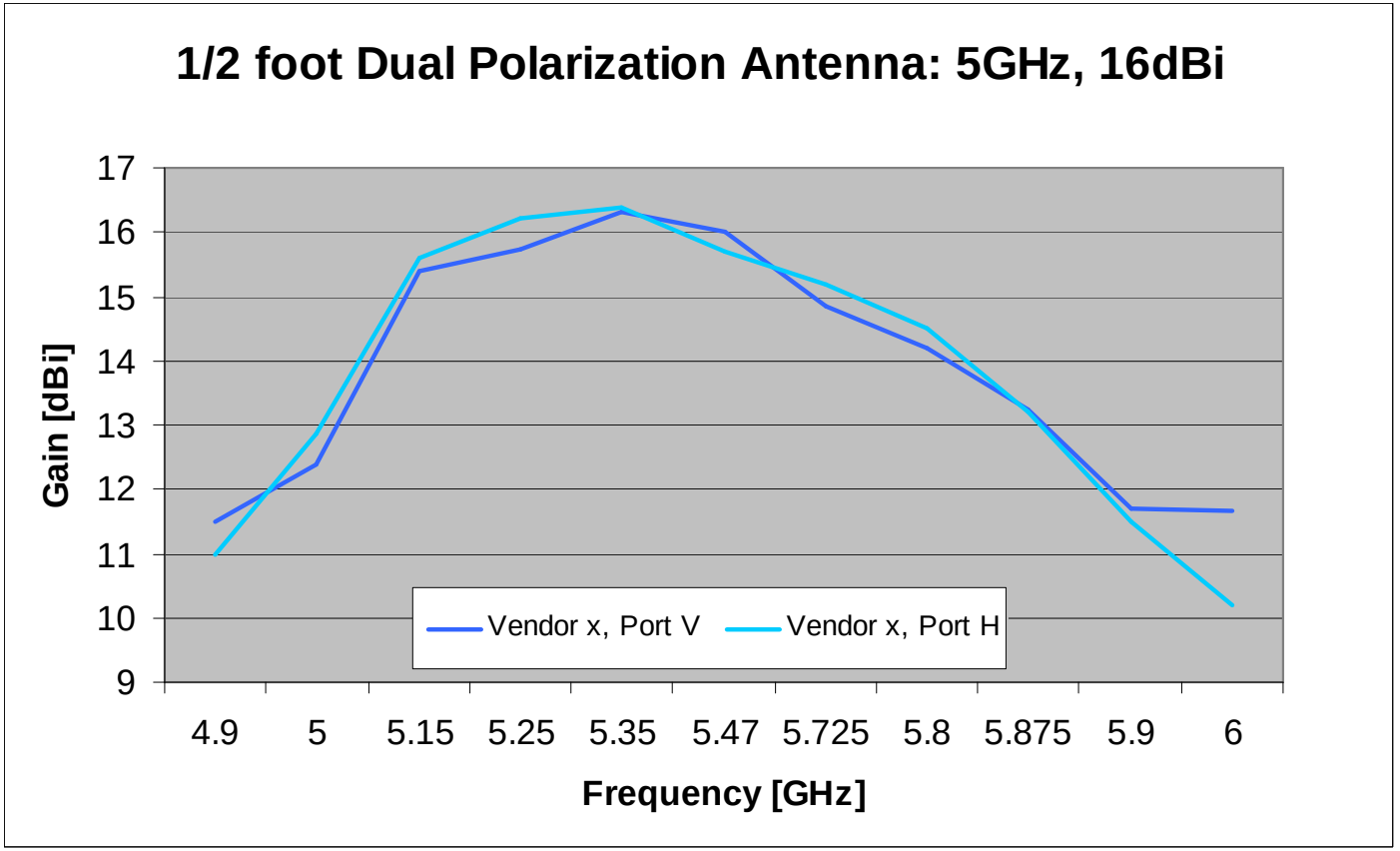


# Compare DP Antenna

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

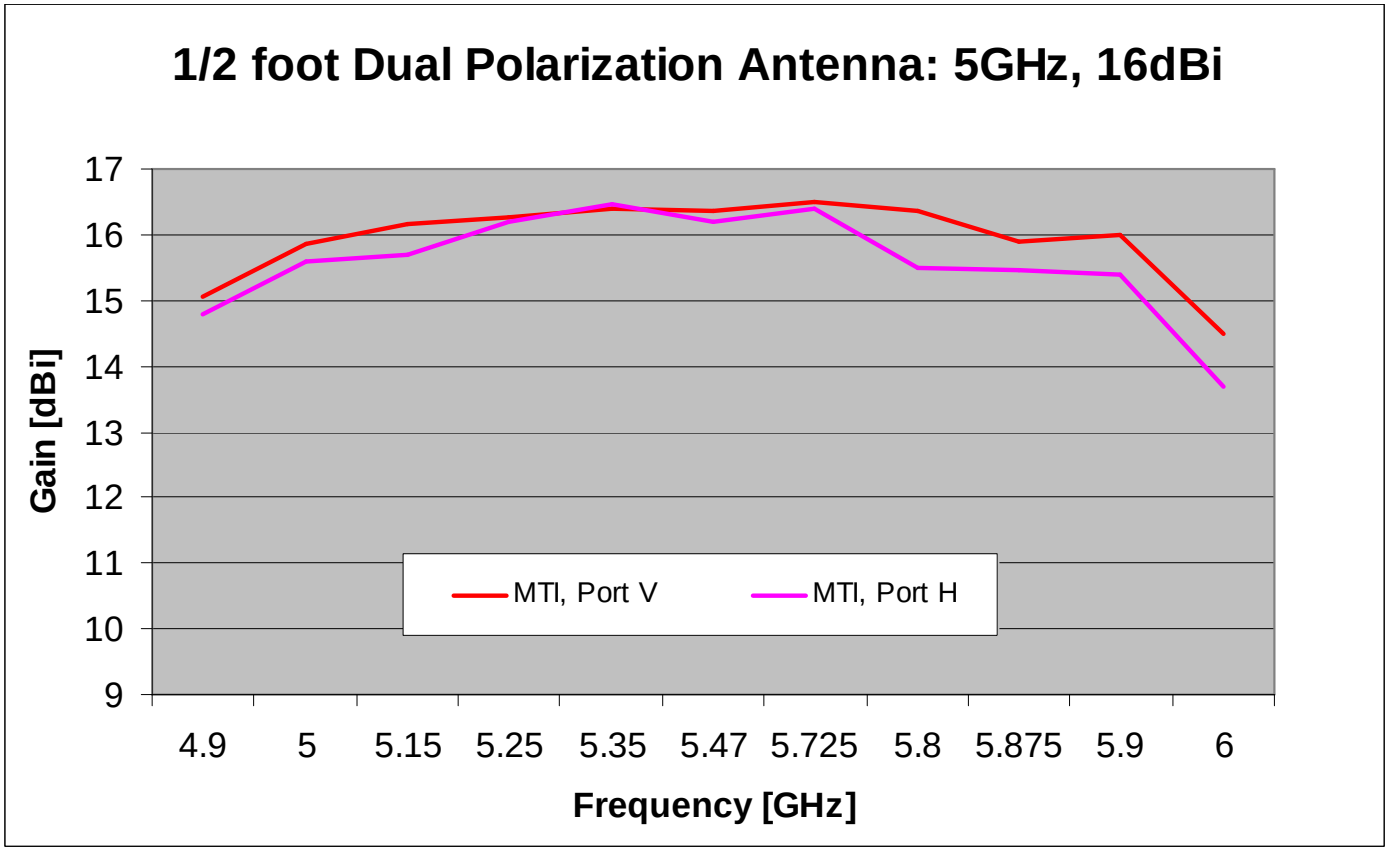
single PCB, FR-4



# Compare DP Antenna

- **5 GHz, 16 dBi:** Quality

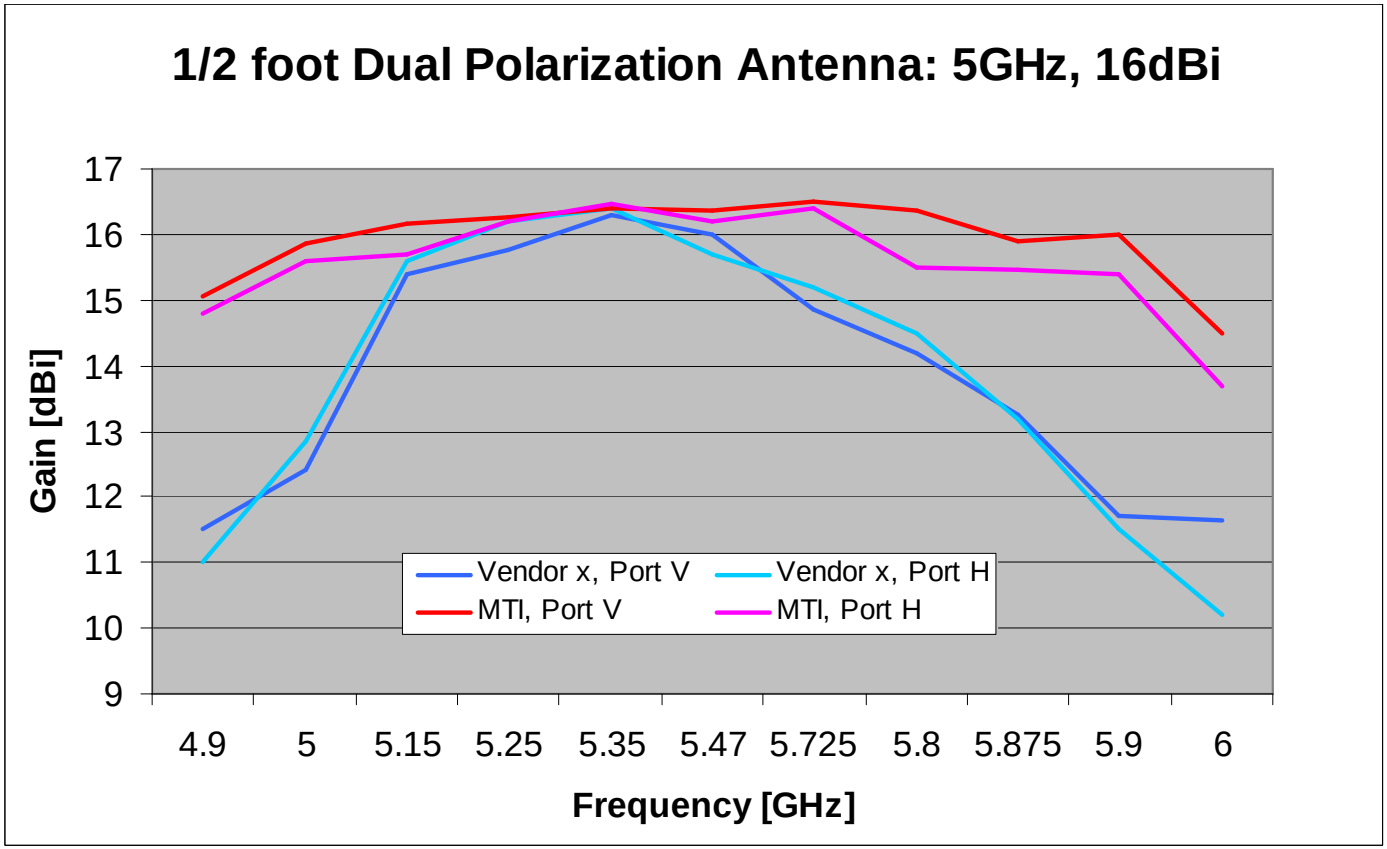
single PCB, FR-4



# 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

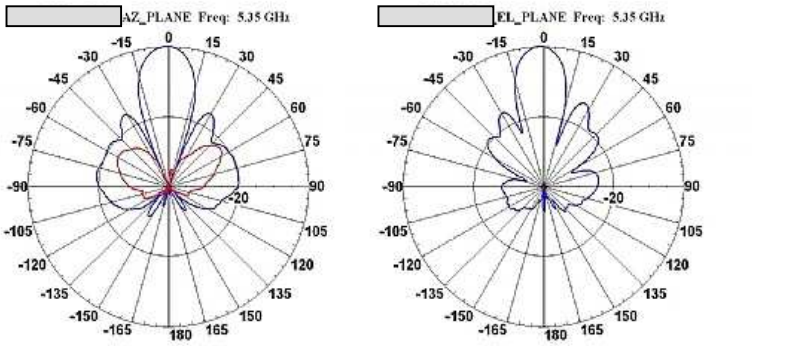
Each will have **different performance**, **different cost !**

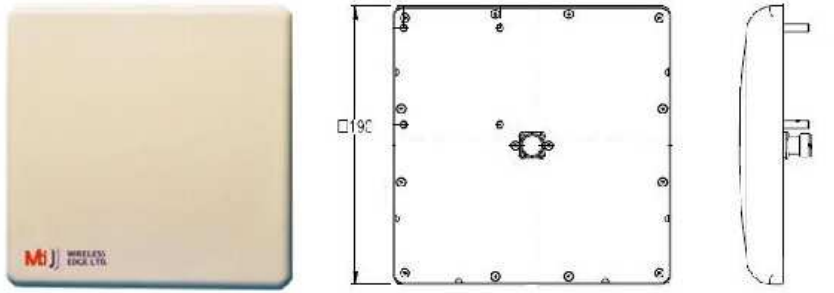
# Antennas may Outperform Specifications

[redacted] 5.15-5.875 GHz, 18 dBi, CPE antenna

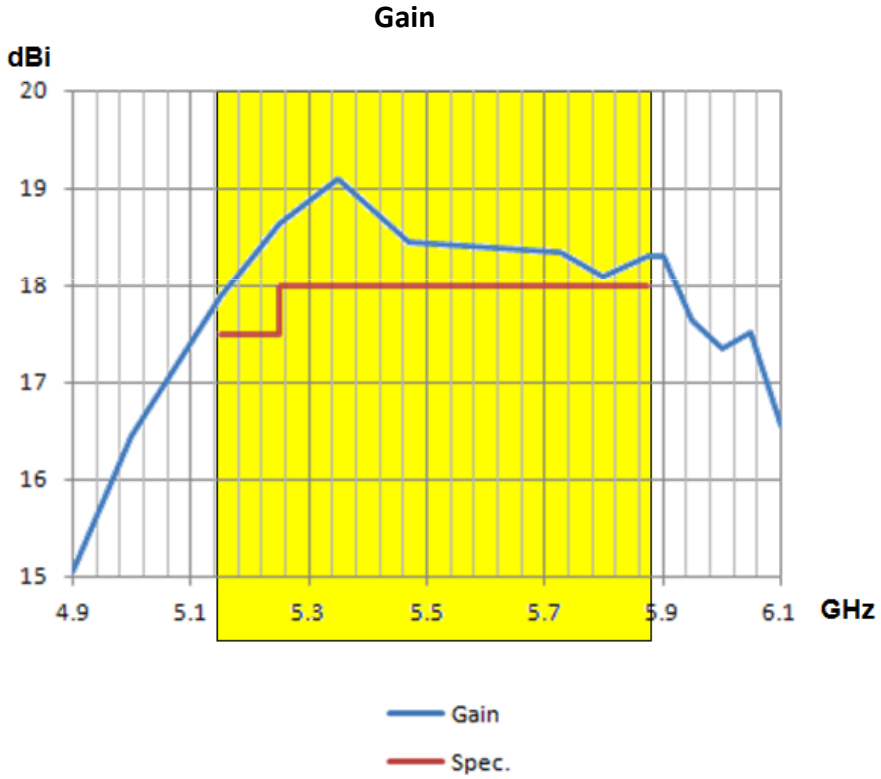
AZIMUTH RADIATION PATTERN MIDBAND FREQ. 5.35 GHZ

ELEVATION RADIATION PATTERN MIDBAND FREQ. 5.35 GHZ



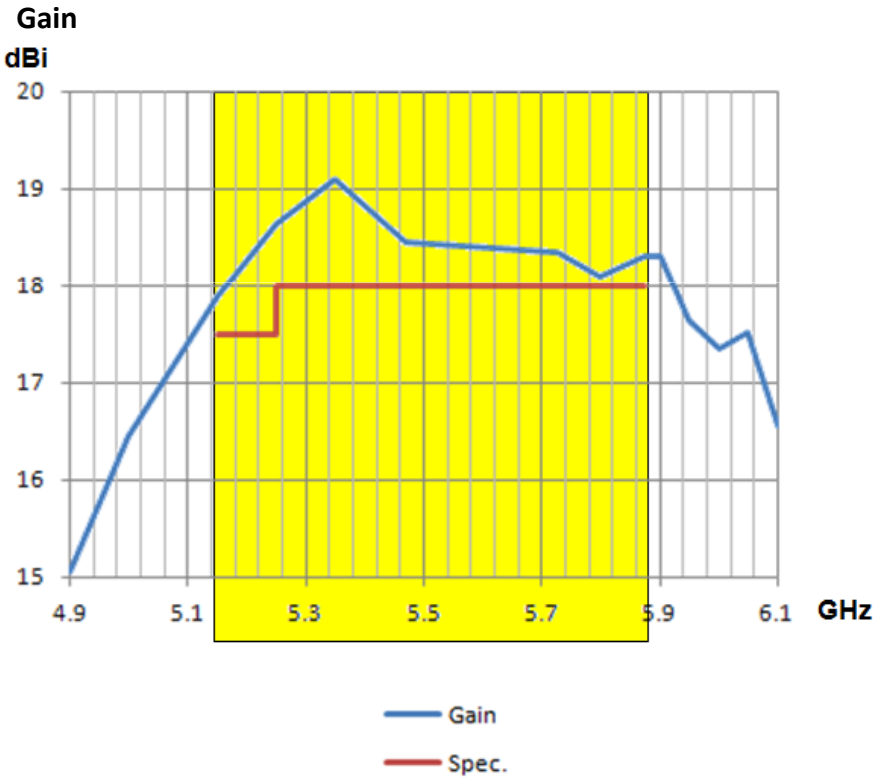



Specification vrs. Broadband performance

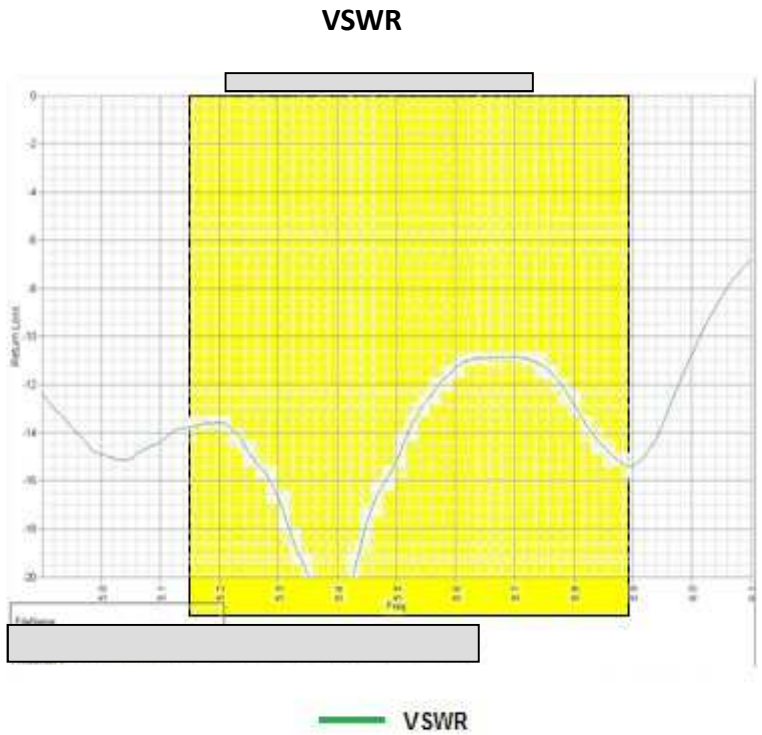


# Antennas performance out of specified bandwidth

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

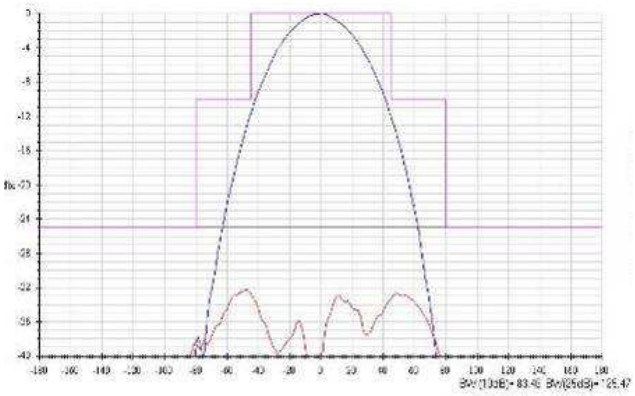
| | |
|---|---|
| • Operating Temperature | -40°C to +71°C |
| • Vibration | IEC 60721-3-4 Random 4M3 |
| • Mechanical Shock | IEC 60721-3-4 4M3 |
| • Humidity | ETSI EN300-2-4 T4.1E |
| • **Dust & Water Tightness** | IEC529, **IP67** |
| • **Salt Spray** | 500 hours per IEC 68 |
| • Solar Radiation | 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

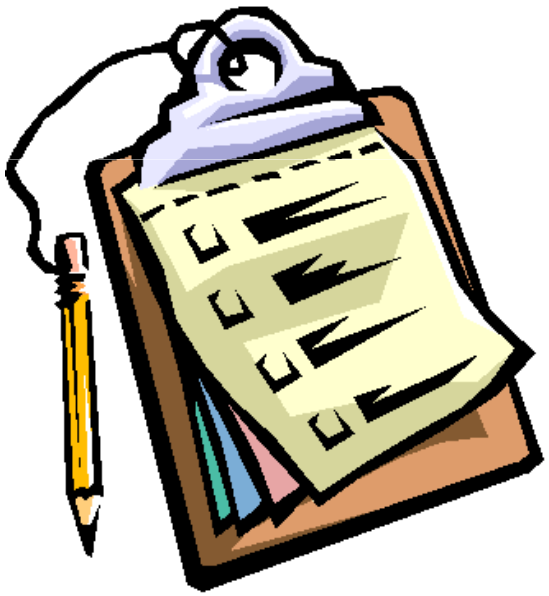
## Remarks

- 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**



- **. . .**

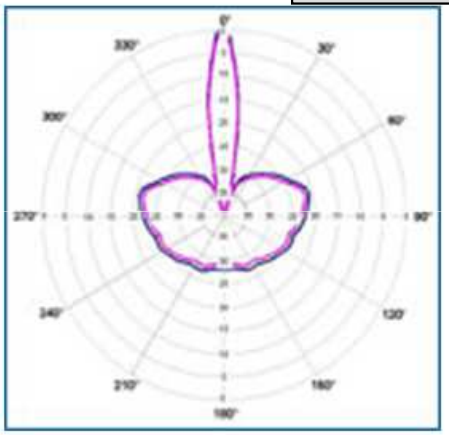
**Ramifications**

# Specification

**# 1.a.**

- **29 dBi Dual Polarization Dish Antenna**

| Category | Dual Polarization Dish Antenna |
|---|---|
| Ranges | 4.9 - 5.85 GHz |

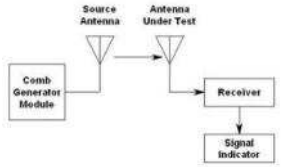


| ELECTRICAL SPECIFICATION | | |
|---|---|---|
| Parameters / Model No | [redacted]-29 | |
| Frequency (MHz) | 4900 - 5850 | 4900 - 5850 |
| Gain (dBi) | 29 | 29 |
| VSWR (Max) | 1.5 : 1 | 1.5 : 1 |
| Polarization Ports | Port 1 Horizontal | Port 2 Horizontal |
| H Plane BW (Degrees) | 6 | 6 |
| E Plane BW (Degrees) | 6 | 6 |
| Polarization | Linear Horizontal | Linear Vertical |
| Port to Port Isolation (dB) | > 30 dB | > 30 dB |

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 |

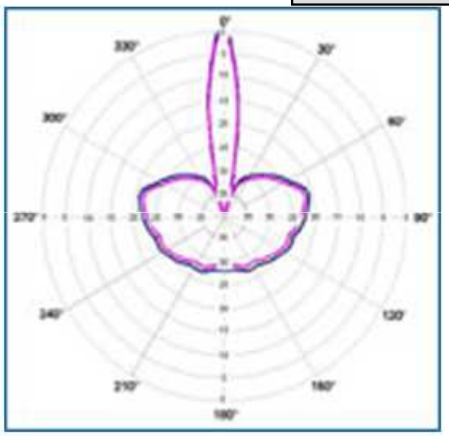
ELEVATION - PORT H

| 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** **!**

| Category | Dual Polarization Dish Antenna |
|---|---|
| Ranges | 4.9 - 5.85 GHz |



**ELECTRICAL SPECIFICATION**

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|---|---|---|
| Frequency (MHz) | 4900 - 5850 | 4900 - 5850 |
| Gain (dBi) | 29 | 29 |
| VSWR (Max) | 1.5 : 1 | 1.5 : 1 |
| Polarization Ports | Port 1 Horizontal | Port 2 Horizontal |
| H Plane BW (Degrees) | 6 | 6 |
| E Plane BW (Degrees) | 6 | 6 |
| Polarization | Linear Horizontal | Linear Vertical |
| Port to Port Isolation (dB) | > 30 dB | > 30 dB |

? ?

# "Cheap" Antenna

**# 1.a.**

- **You paid for a:**

  **29 dBi Dual Polarization Dish Antenna**

- **You received a:**

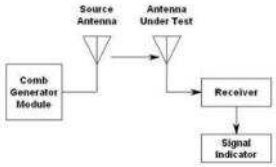
  **26 dBi Dual Polarization Dish Antenna**

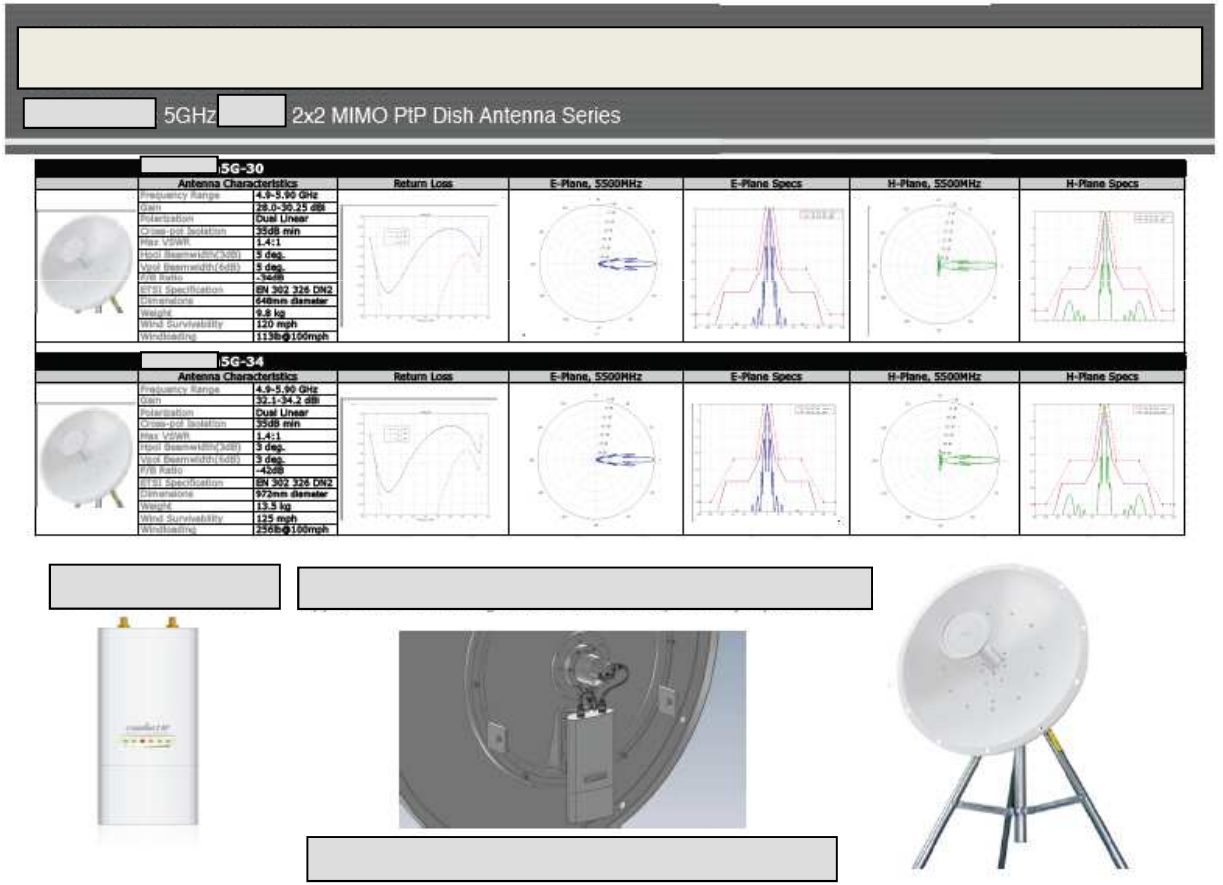
- **Value for money?**

# Specification

**# 1.b.**

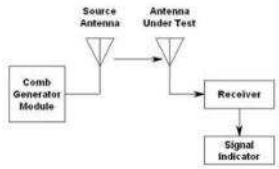
- **5 GHz, Dual Polarization Dish Antenna**




# 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**

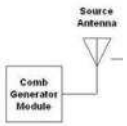
| Freq(Ghz) | Gain - measured (dBi) | Gain - Spec (dBi) |
|---|---|---|
| 4.9 | 25.7 | 28 - 30.25 |
| 5 | 26.69 | 28 - 30.25 |
| 5.15 | 27.07 | 28 - 30.25 |
| 5.25 | 27.29 | 28 - 30.25 |
| 5.35 | 27.48 | 28 - 30.25 |
| 5.47 | 27.64 | 28 - 30.25 |
| 5.625 | 28.28 | 28 - 30.25 |
| 5.725 | 28.74 | 28 - 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**



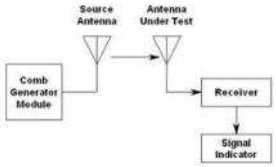

| Freq (Ghz) | Ant B Gain (dBi) | HQ Gain (dBi) | HQ Extra Gain (dBi) |
|---|---|---|---|
| 4.9 | 26.54 | 28.20 | 1.66 |
| 5 | 27.67 | 28.11 | 0.44 |
| 5.15 | 27.69 | 28.42 | 0.73 |
| 5.25 | 27.99 | 28.78 | 0.79 |
| 5.35 | 27.97 | 28.82 | 0.85 |
| 5.47 | 28.04 | 29.20 | 1.16 |
| 5.625 | 28.53 | 29.41 | 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?**

# Reading Specifications

**# 2.**


Revolutionary Cost/Performance Carrier Class 3GHz MIMO BaseStation Antenna

MIMO TDMA Protocol System

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

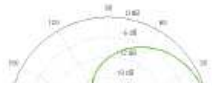
**- 6 dB ? ? ?**

Hi-Gain Sector 3G-120-18

| Antenna Characteristics | |
|---|---|
| Frequency Range | 3.3-3.8 GHz |
| Gain | 17.3-18.2 dBi |
| Polarization | Dual Linear |
| Cross-pol Isolation | 28dB min. |
| Max VSWR | 1.5:1 |
| Weight | 5.9 kg |
| Windloading | 160 mph |

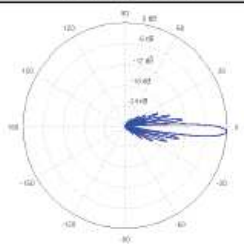
Return Loss

V-Pol Azimuth

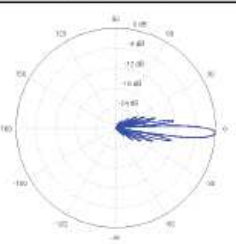


| | |
|---|---|
| Hpol Beamwidth (6dB) | 118 deg. |
| Vpol Beamwidth (6dB) | 121 deg. |

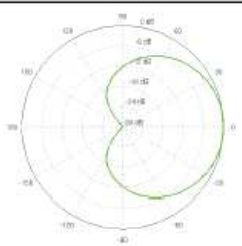
V-Pol Elevation



H-Pol Elevation



H-Pol Azimuth



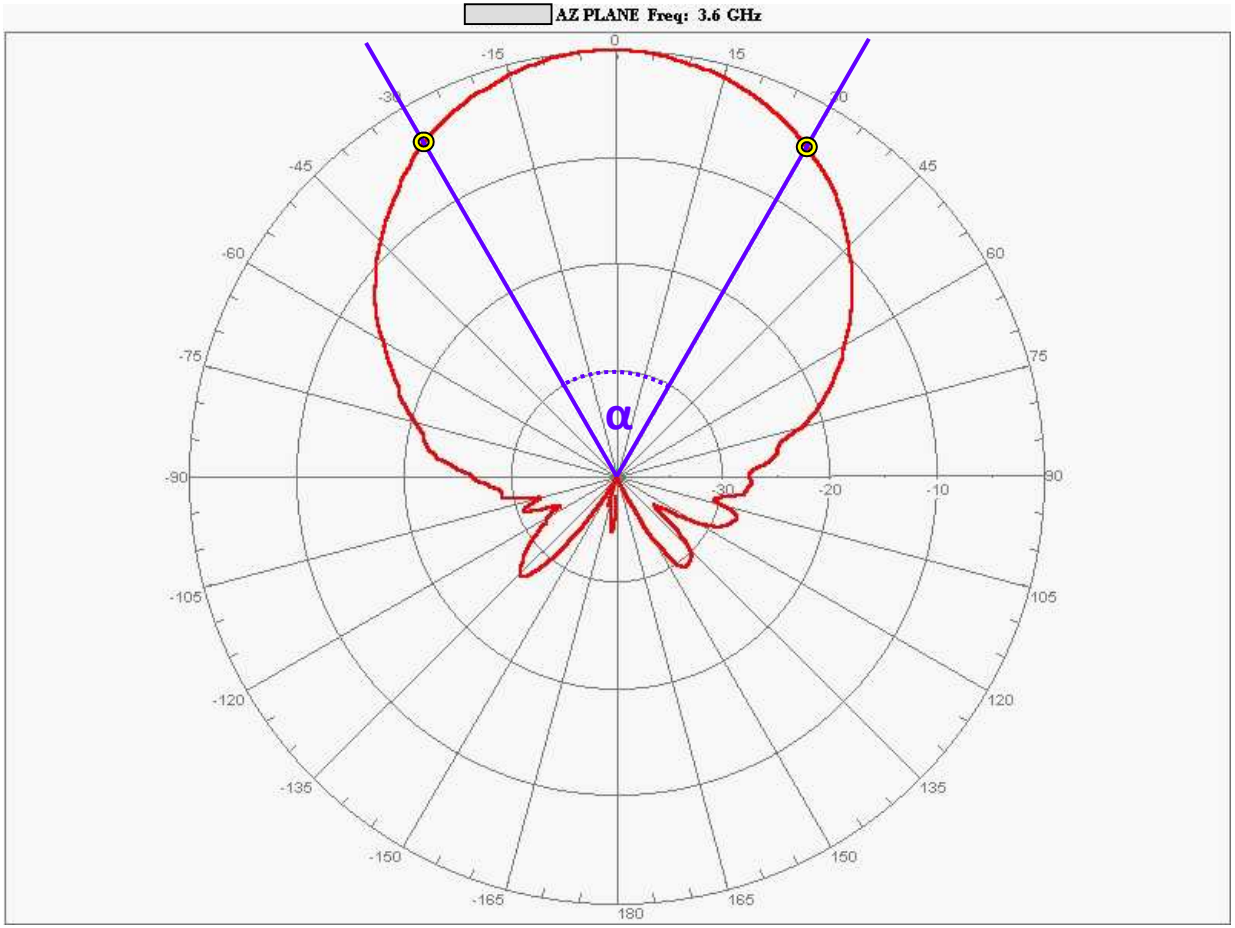
# Beam Width

***Defined*** at

- **- 3 dB**

= Half Power

* **ETSI** EN 302 326-3



# Reading Specifications (2)


Revolutionary Cost/Performance Carrier Class 3GHz MIMO BaseStation Antenna

MIMO TDMA Protocol System

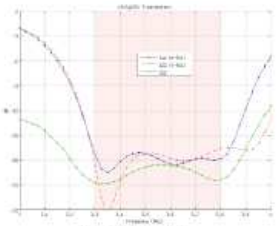
| | |
|---|---|
| Hpol Beamwidth (6dB) | 118 deg. |
| Vpol Beamwidth (6dB) | 121 deg. |

- 6 dB ? ? ?

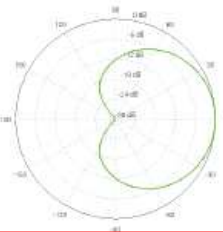
Hi-Gain Sector 3G-120-18

| Antenna Characteristics | |
|---|---|
| Frequency Range | 3.3-3.8 GHz |
| Gain | 17.3-18.2 dBi |
| Polarization | Dual Linear |
| Cross-pol Isolation | 28dB min. |
| Max VSWR | 1.5:1 |
| Hpol Beamwidth (6dB) | 118 deg. |
| Vpol Beamwidth (6dB) | 121 deg. |
| Elevation Beamwidth | 6 deg. |
| Electrical Downtilt | 2 deg. |
| ETSI Specification | EN 302 326 DN2 |
| Dimensions | 700x145x93mm |
| Weight | 5.9 kg |
| Windloading | 160 mph |

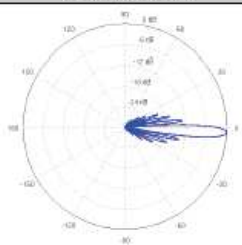
Return Loss



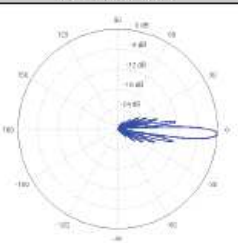
V-Pol Azimuth



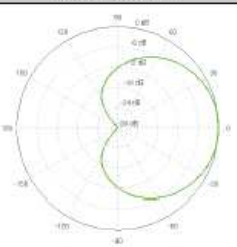
V-Pol Elevation



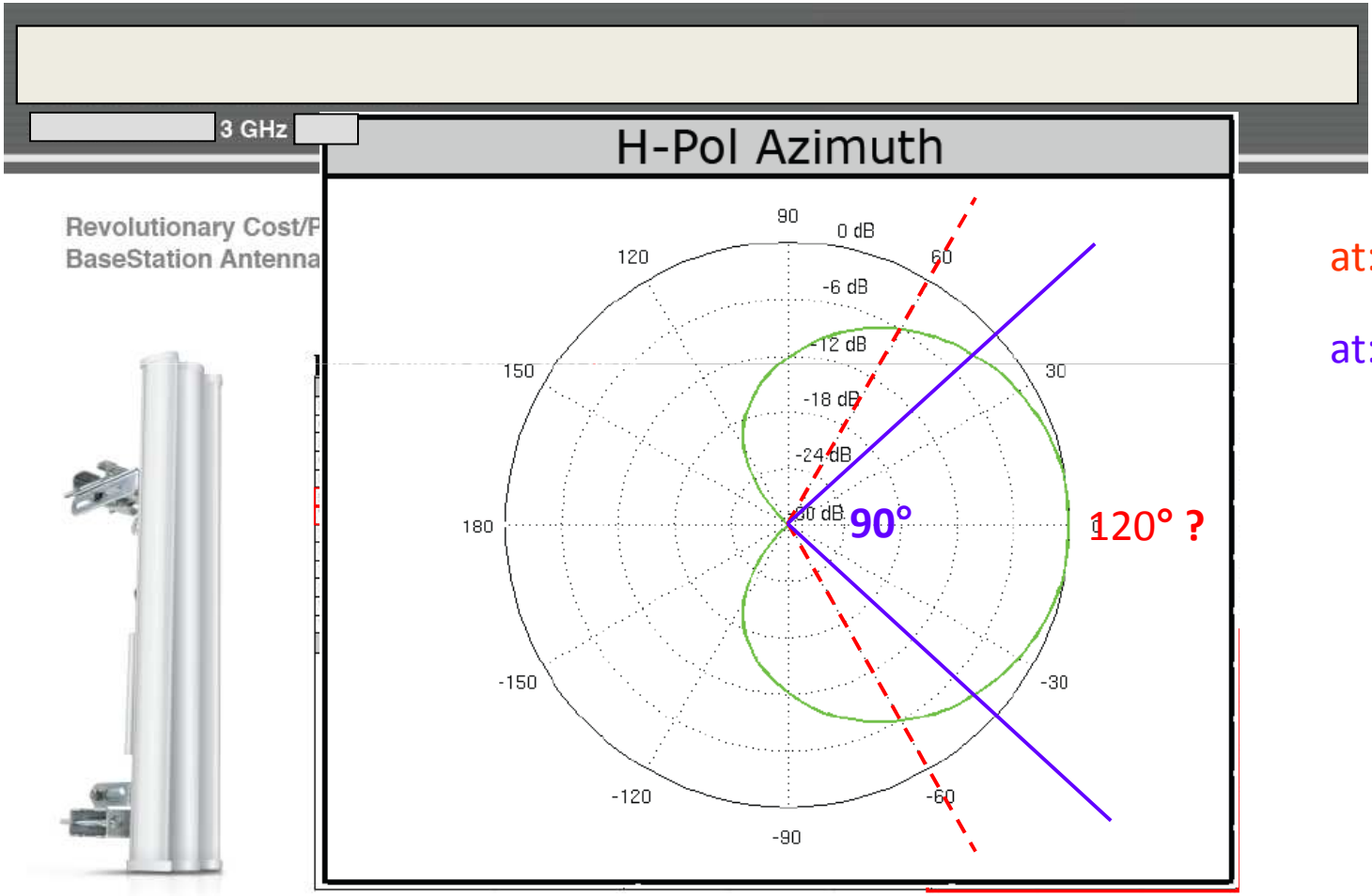
H-Pol Elevation



H-Pol Azimuth



# Reading Graphs




at: **- 6 dB**

at: **- 3 dB**

# Reading Specifications (3)

[redacted] 3 GHz [redacted] 2x2 MIMO Basestation Sector Antenna

Revolutionary Cost/Performance Carrier Class 3GHz MIMO BaseStation Antenna

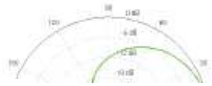
[redacted]
MIMO TDMA Protocol System

Hi-Gain [redacted] Sector 3G-120-18

| Antenna Characteristics | |
|---|---|
| Frequency Range | 3.3-3.8 GHz |
| Gain | 17.3-18.2 dBi |
| Polarization | Dual Linear |
| Cross-pol Isolation | 28dB min. |
| Max VSWR | 1.5:1 |
| Weight | 5.9 kg |
| Windloading | 160 mph |

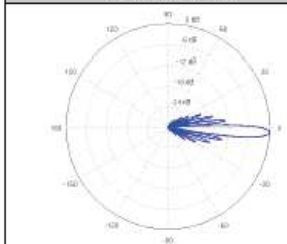
Return Loss

V-Pol Azimuth

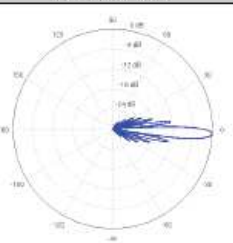


| | |
|---|---|
| Hpol Beamwidth | 90 deg. |
| Vpol Beamwidth | 90 deg. |

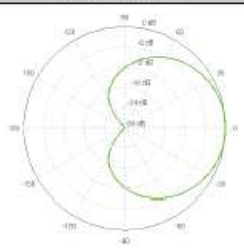
V-Pol Elevation



H-Pol Elevation



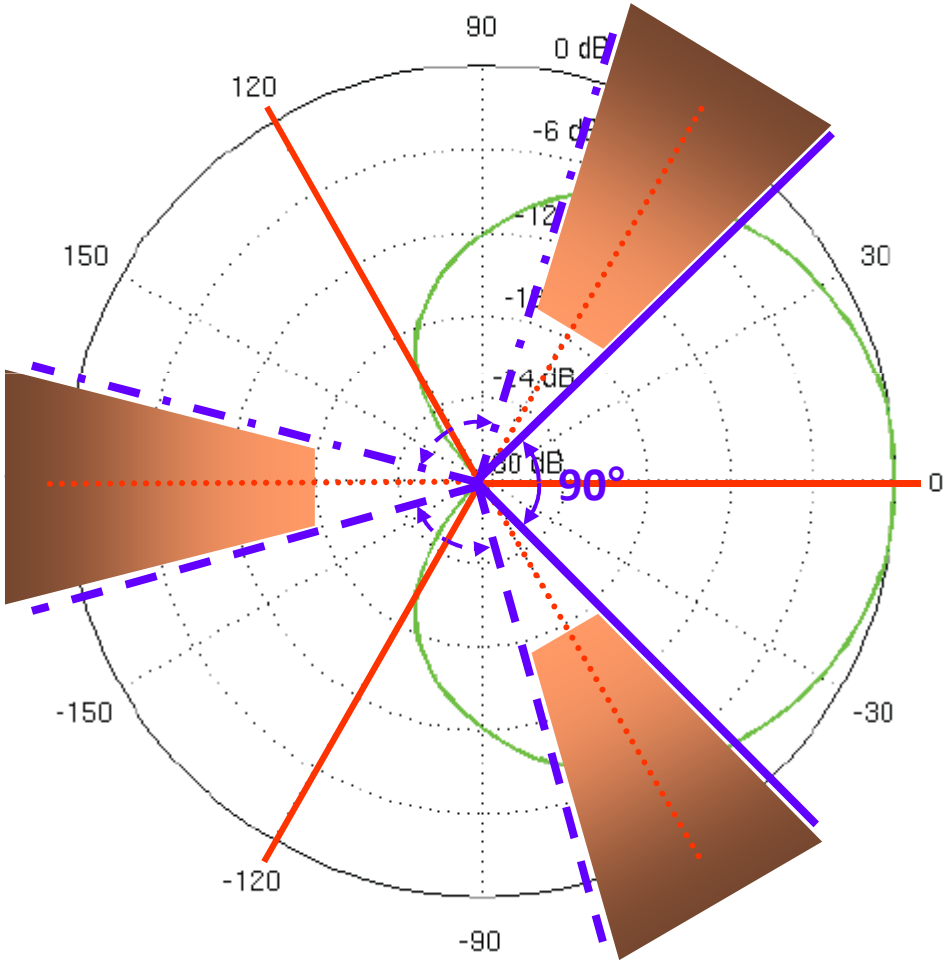
H-Pol Azimuth



# It’s not only Specifications !

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

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



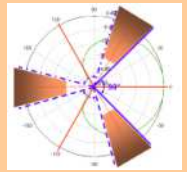
# Return on Investment (ROI)

**# 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.

# Throughput

**# 3.**


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**

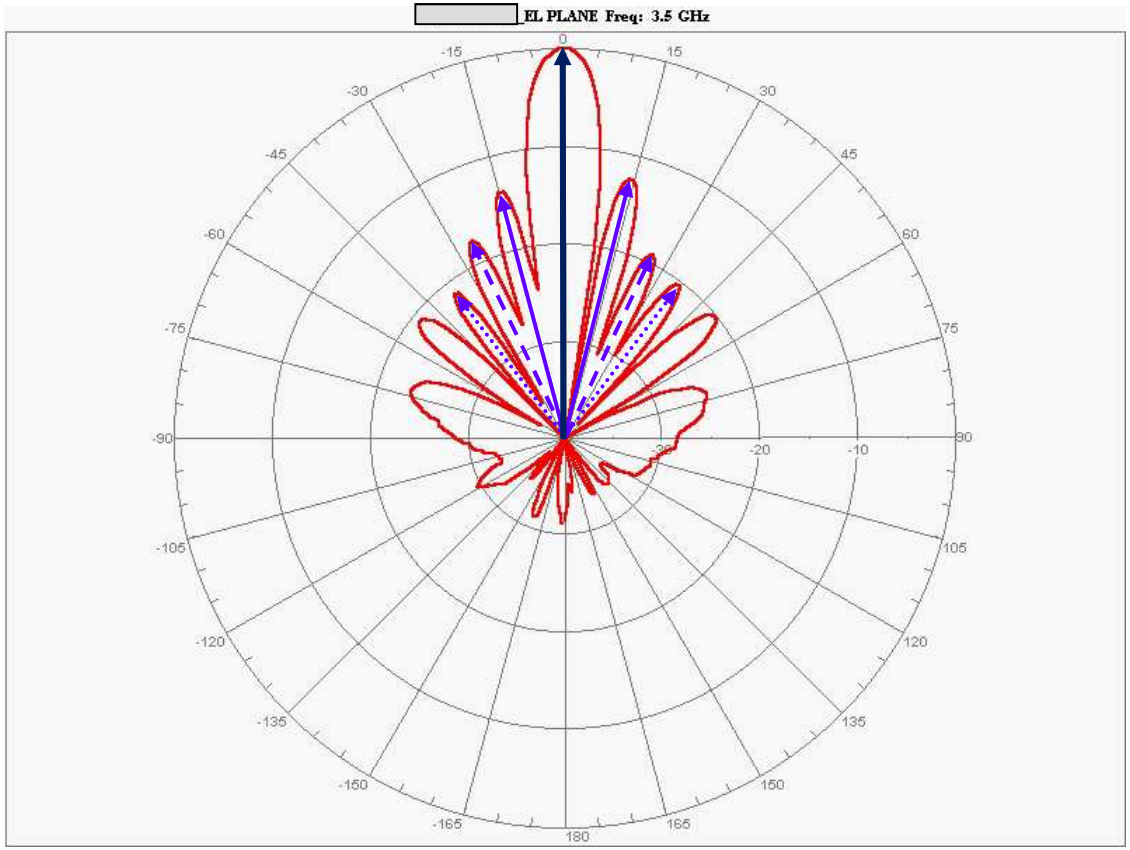
**Note: Throughput**

- 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).

# Main Lobe & Side Lobes

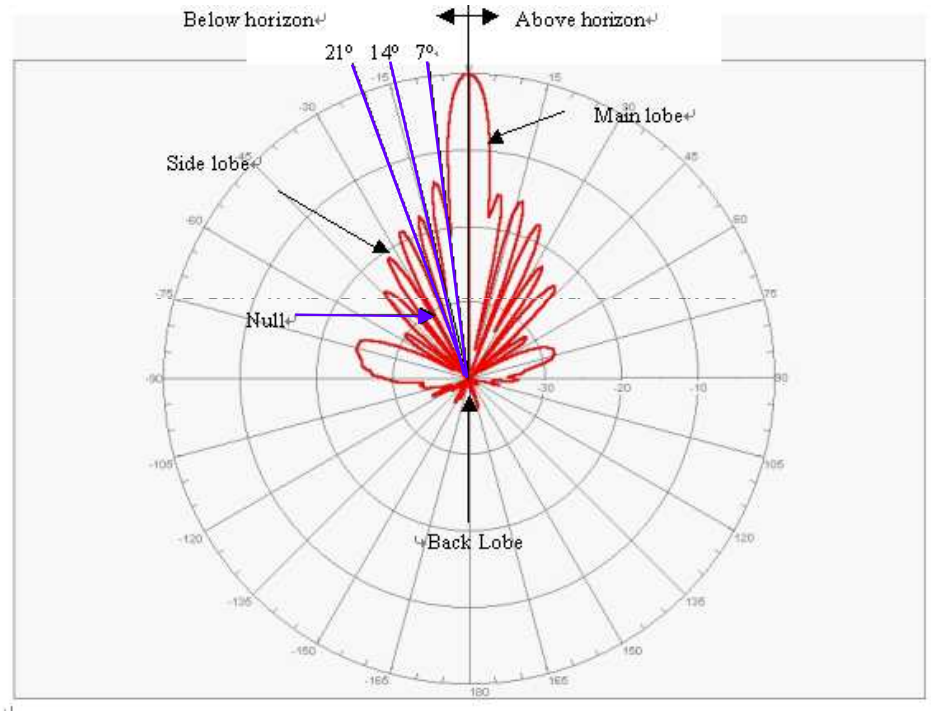
**# 4.**

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



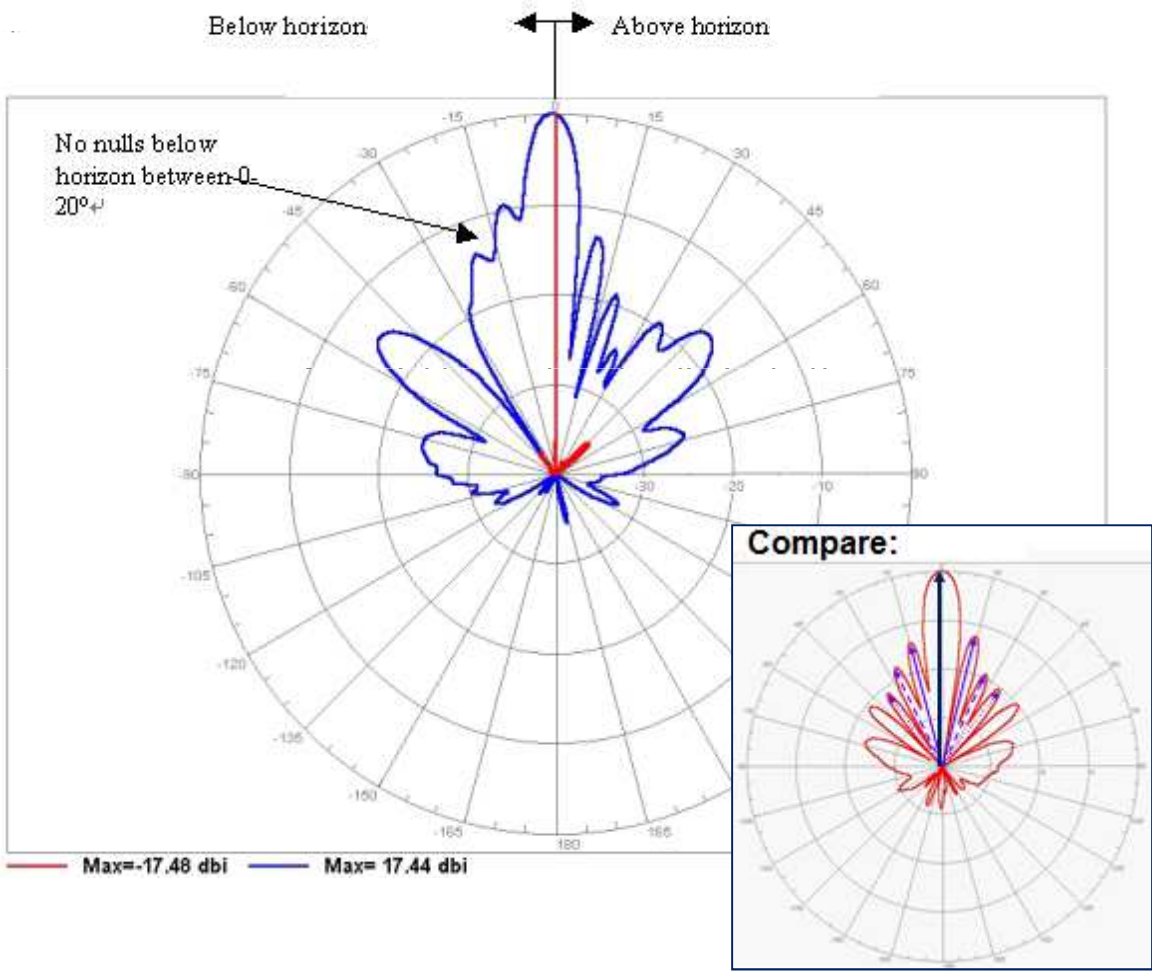
# Nulls

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



# Null Fill

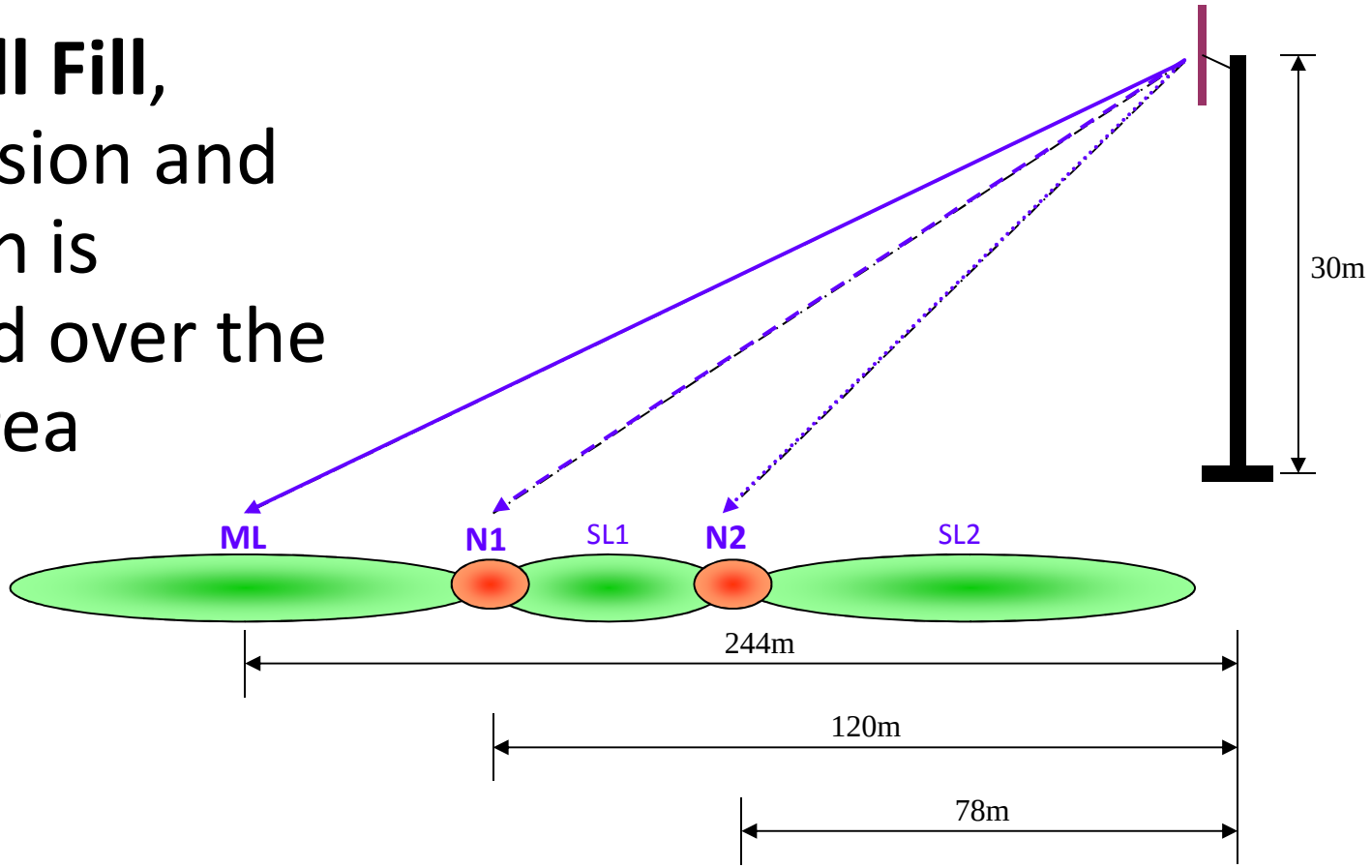
- Special technology to **eliminate Nulls** below horizon



# Main Lobe & Side Lobes

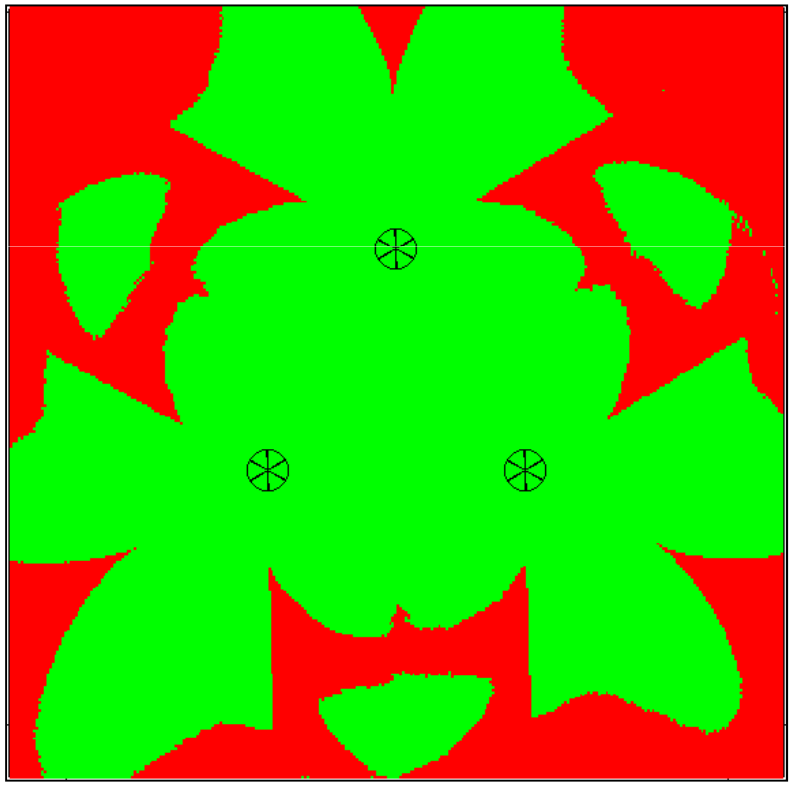
**Nulls** in between

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

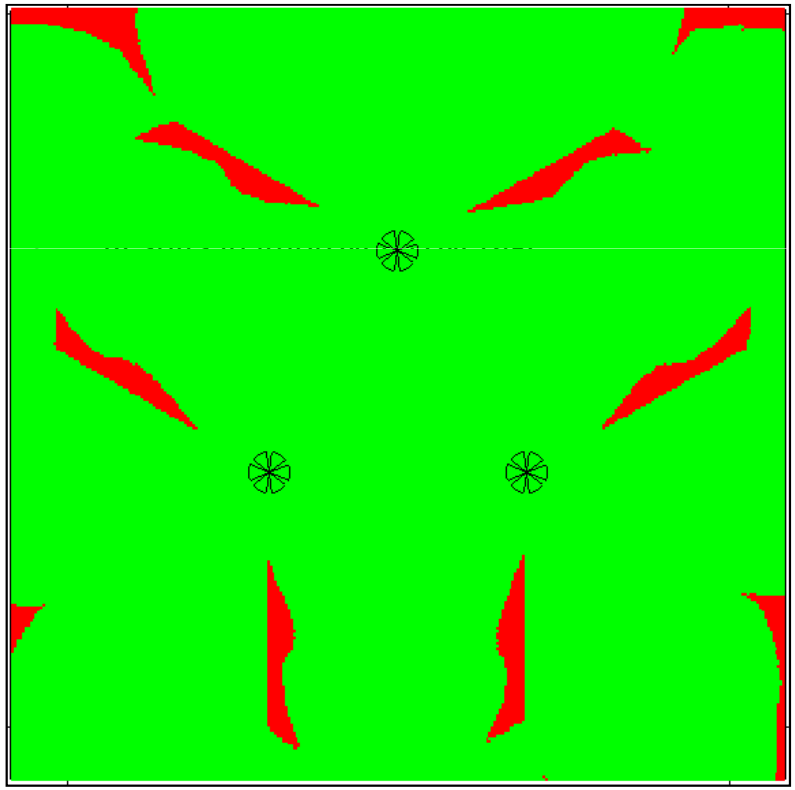


# Result of Null-Fill (Simulation)

- Improved Coverage!
- Increased ROI



Coverage **without** Null Fill



Coverage **with** Null Fill

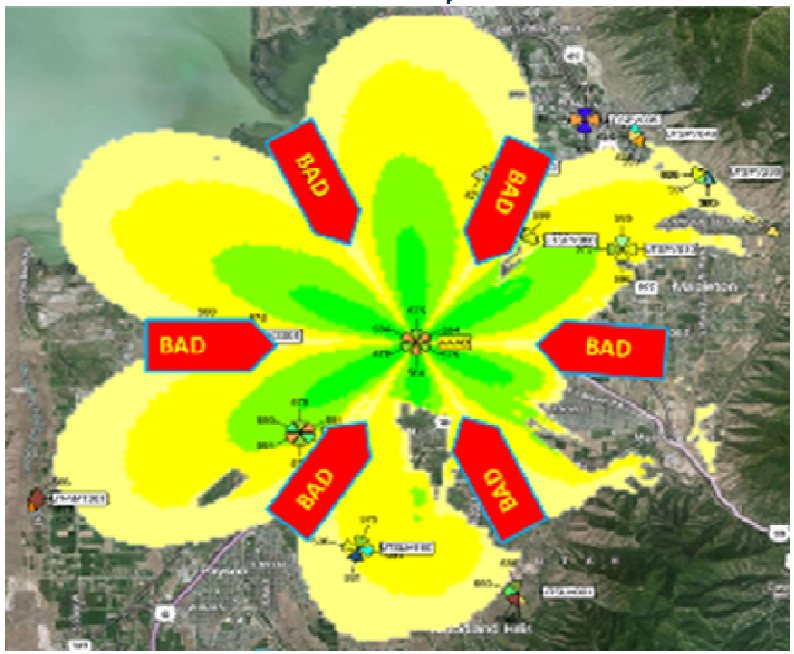
Result of Null-Fill

# Real Life Example

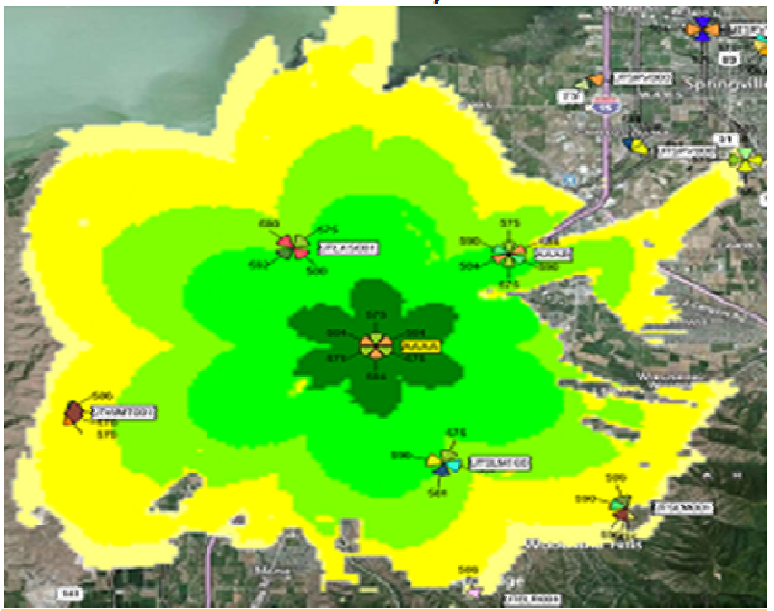
This is how customer dramatically improved performance of their network by switching to High Quality Base Station Antennas HQ-x, 5.15-5.875 GHz, 16 dBi, 60°, Dual Polarization **Antenna with Null Fill**.

Shown with **Collocation Channels Performance**.

450 Antenna
with 2 channels, 6 sectors




HQ HQ-x
with 2 channels, 6 sectors

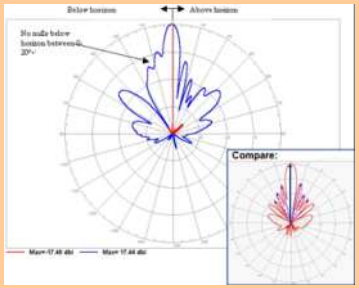


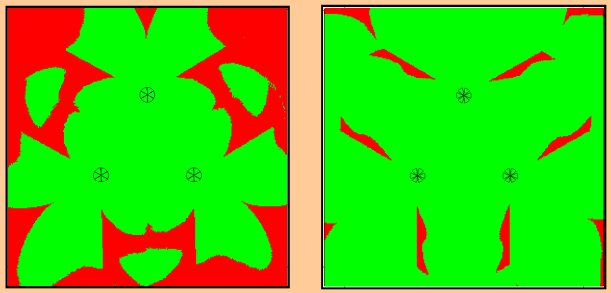
Improved network **coverage**, **throughput** and **capacity** of cell sites!

# 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


mum
Ljubljana, Slovenia, Feb. 25-26, 2016

Powered by MikroTik

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

E-mail: michel.bodenheimer@mtiwe.com
Skype: michel.bodenheimer-mti

# Thank You