Maximizing the Allowable Coverage Area of a Broadband Wireless Communication System that Utilizes an Occupied Frequency Band

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Presentation Outline

- Motivation
  - Explanation of the general problem and the approach taken in presenting the results
- Theoretical Formulas Used
  - Interference bound
  - Propagation model
  - Antenna gains and patterns
  - Transmit power level of the user antenna

Presentation Outline Cont.

- Algorithm For Computing the Forbidden Zone
- Results
  - Forbidden Area Ratio
  - Adjusting the azimuthal pointing of the AP Antenna
  - Adjusting the ground direction of the AP antenna

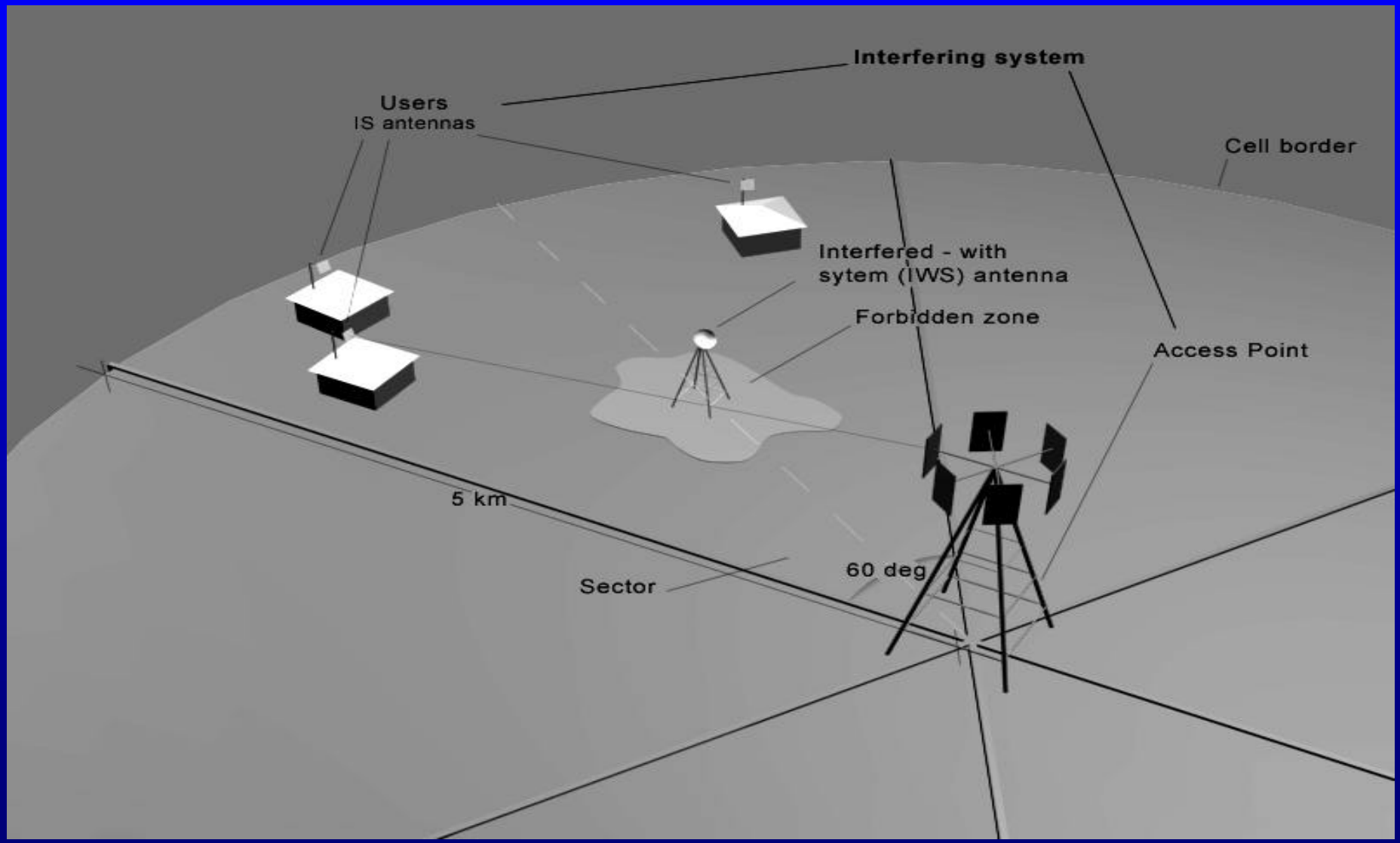
Presentation Outline Cont.

- Effects of adjusting the AP antenna height
- Effects of adjusting the AP antenna distance
- Effects of using power control
- Effects of increasing the gain of the user antenna
- Interference from the AP antenna

Presentation Outline Cont.

- Summary
  - Conclusions
  - Future Work
- Questions

Motivation

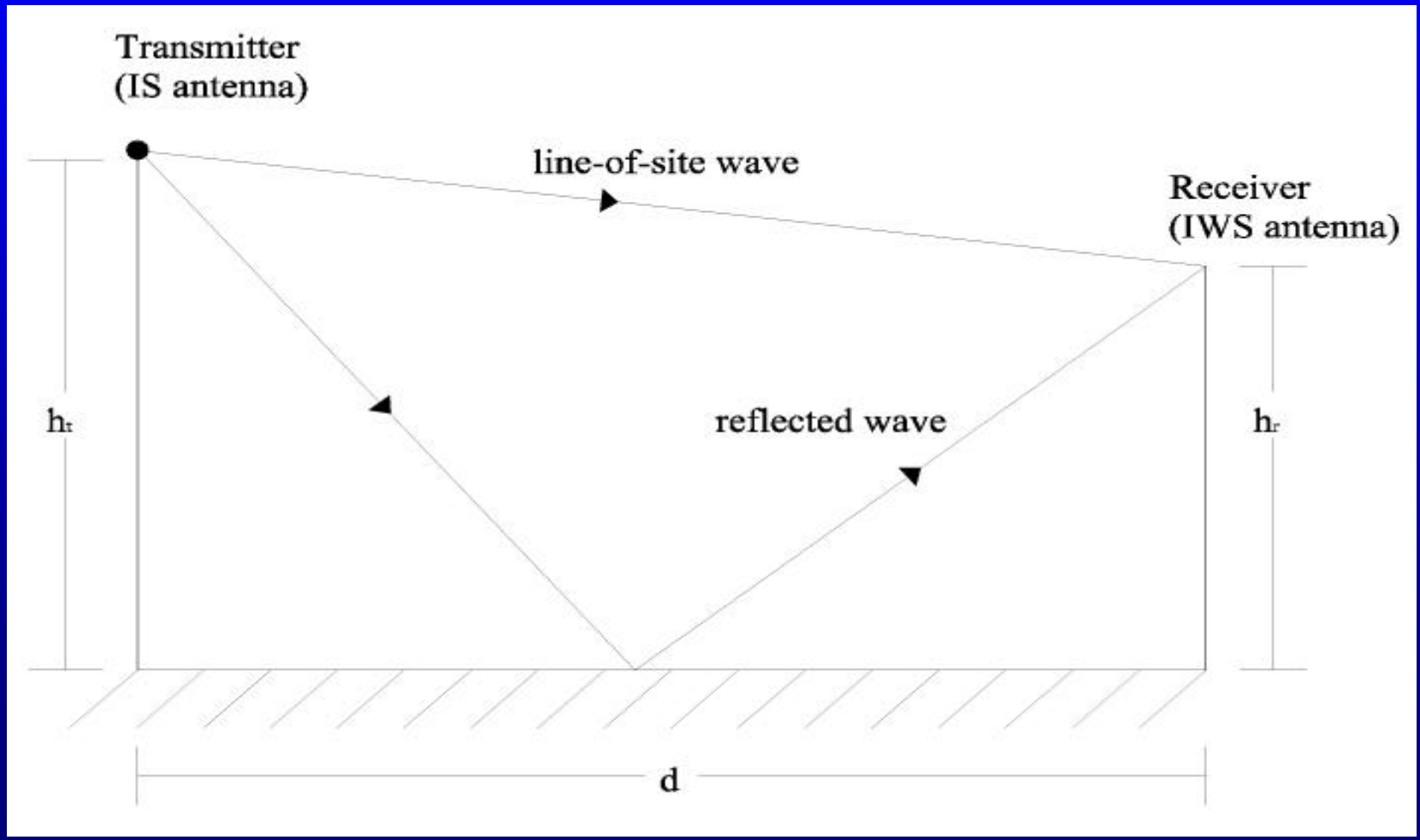

Interfering system
Users
IS antennas
Cell border
Interfered - with
sytem (IWS) antenna
Forbidden zone
Access Point
5 km
Sector
60 deg

Interference Bound

$$P_{received} \leq N(10^{M/10} - 1)$$

- M is the Margin
- N is the noise power

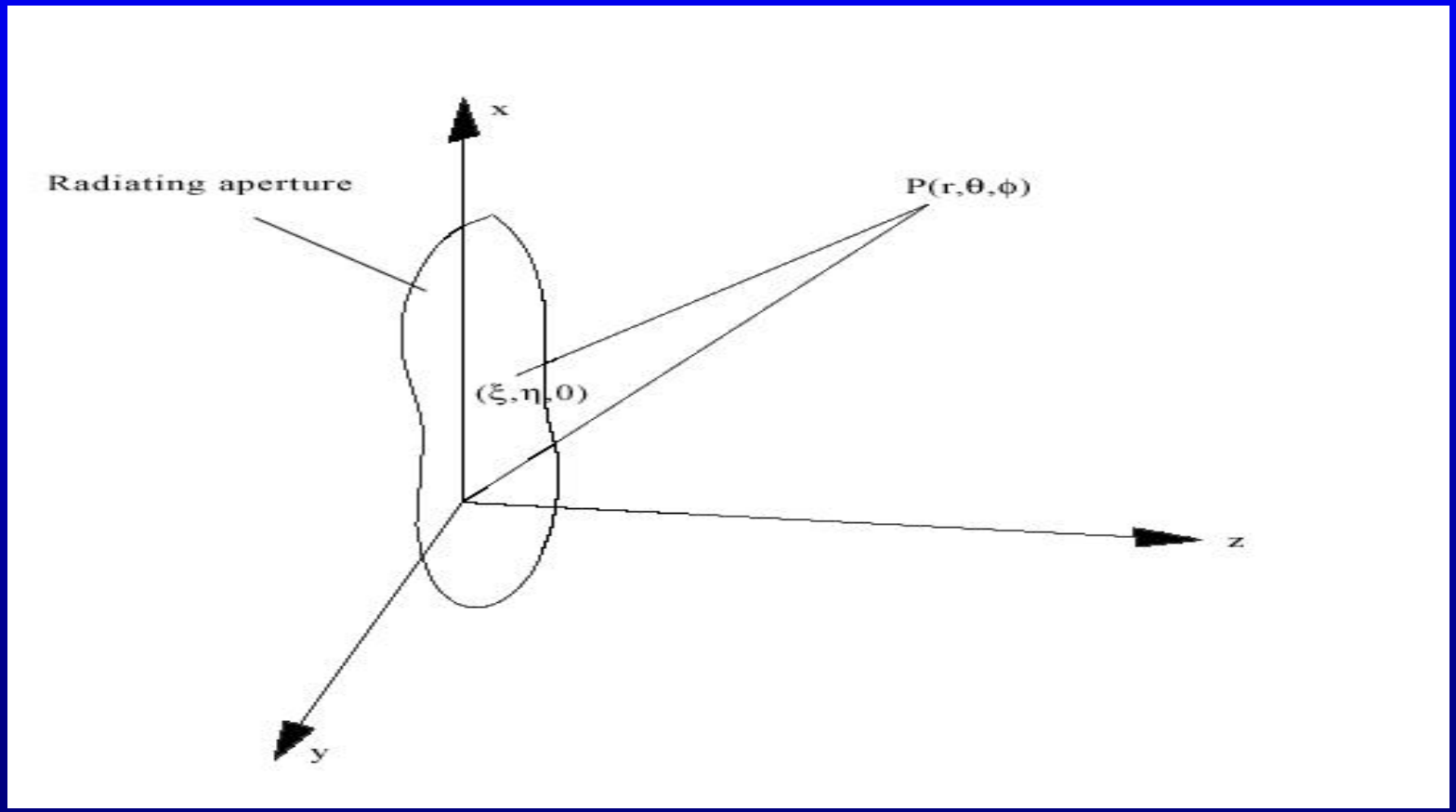
Propagation Model



Propagation Model

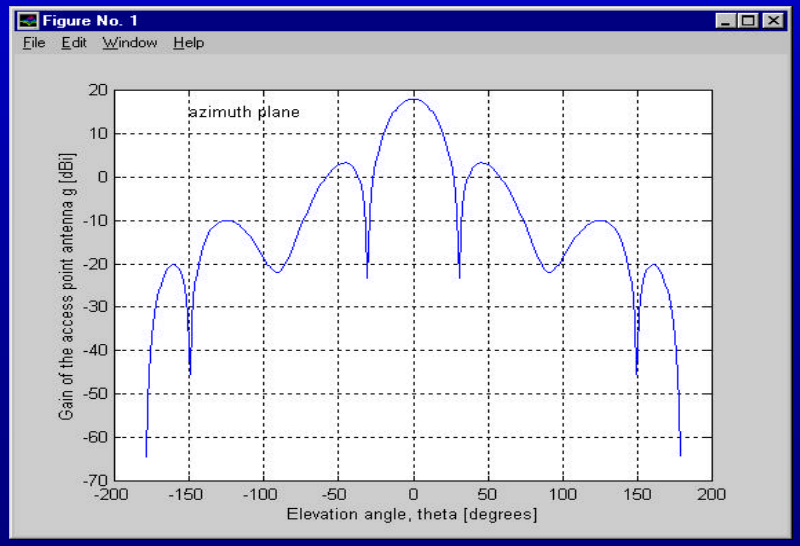
$$P_{received} \propto \frac{P_{transmitter} g_{IS\_IWS} g_{IWS\_IS} g_m}{\left(\frac{4\pi}{\lambda}\right)^2 ((h_r - h_t)^2 + d^2)}$$

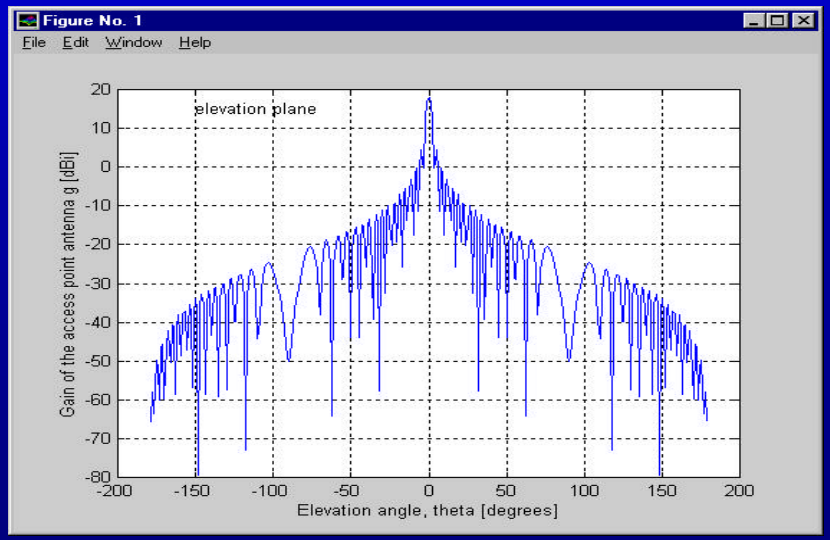
Antenna Gains and Patterns



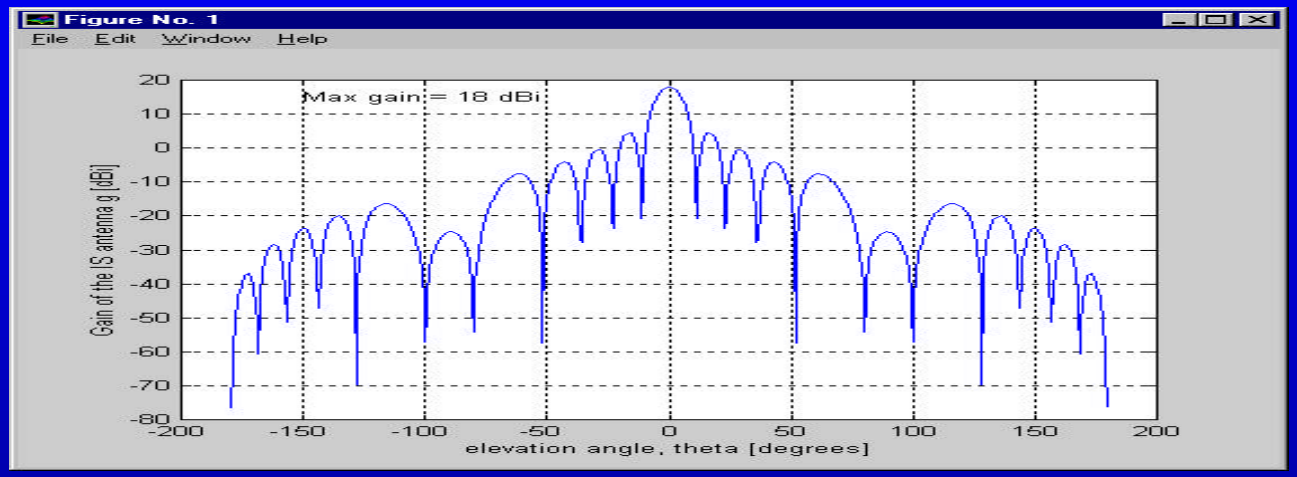
Antenna Gains and Patterns (AP antenna)

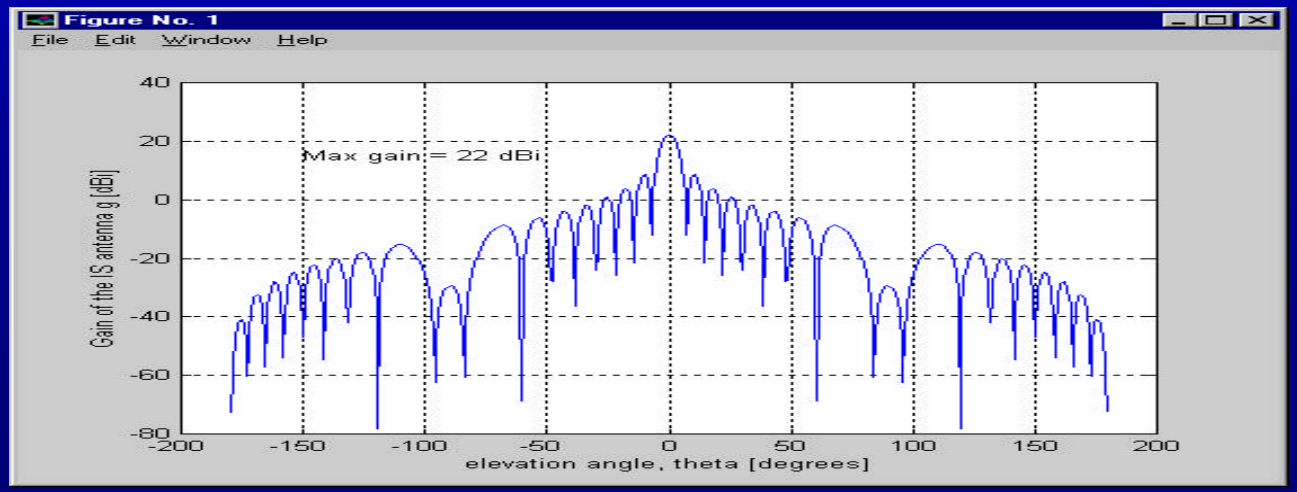
$$g(?,?) \; ? \; \frac{?ab}{?^2}(1 ? \cos ?)^2 \left| \frac{\sin(\frac{?a}{?}\sin ? \cos ?)}{\frac{?a}{?}\sin ? \cos ?} \; \frac{\sin(\frac{?b}{?}\sin ? \sin ?)}{\frac{?b}{?}\sin ? \sin ?} \right|^2$$





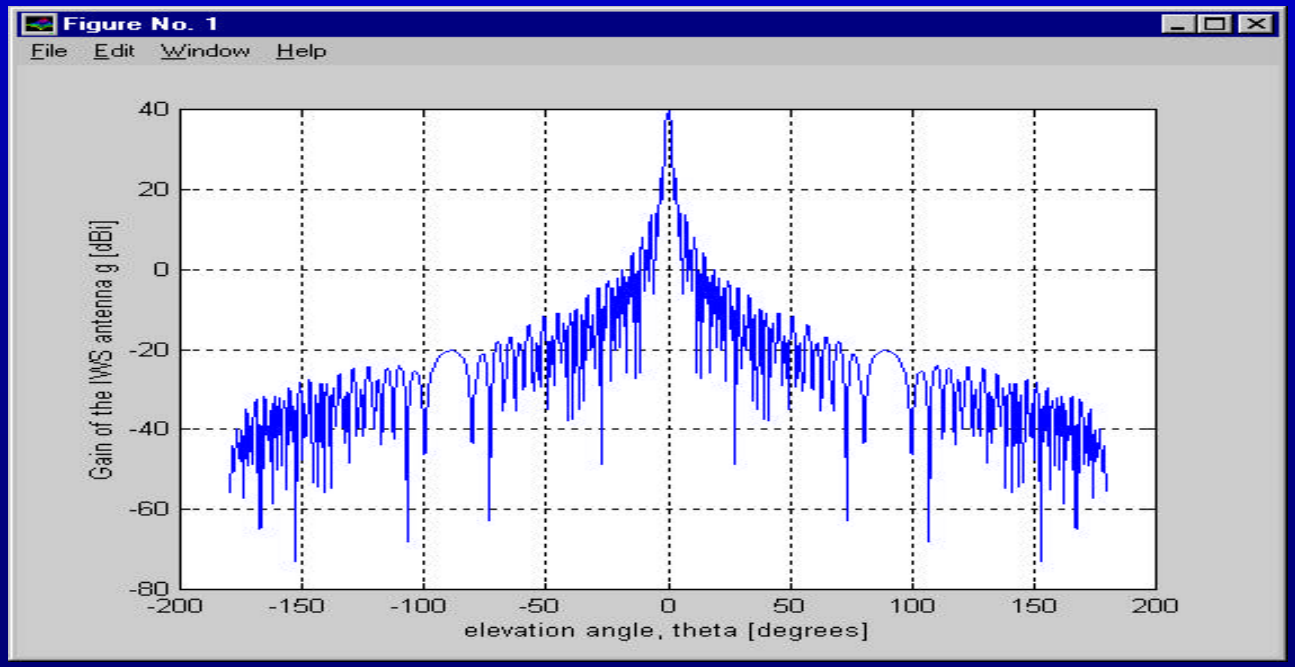
Antenna Gains and Patterns (IS antenna)





Antenna Gains and Patterns (IWS antenna)

$$g(?) ? \frac{? (1 ? \cos ?)^2}{?^2 a^2} \left| \frac{2? a^2 J_1(\frac{2? a}{?} \sin ?)}{\frac{2? a}{?} \sin ?} ? \frac{2? a_1 J_1(\frac{2? a_1}{?} \sin ?)}{\frac{2? a_1}{?} \sin ?} \right|^2$$



Transmit Level of the User Antenna

$$P_{IS\_antenna}(dBm) ? P_{received}(dBm) ? G_{IS}(dBi) ? G_{AP}(dBi) ? PathLoss(db) ? AddiLoss(dB)$$

$$PathLoss(db) ? 40\log d ? 20\log h_{transmitter} ? 20\log h_{receiver}$$

$$P_{IS\_antenna}(dBm) ? ?81 ? G_{IS}(dBi) ? 18 ? 106 ? 20 ? 9$$

Algorithm for Computing the Forbidden Zone

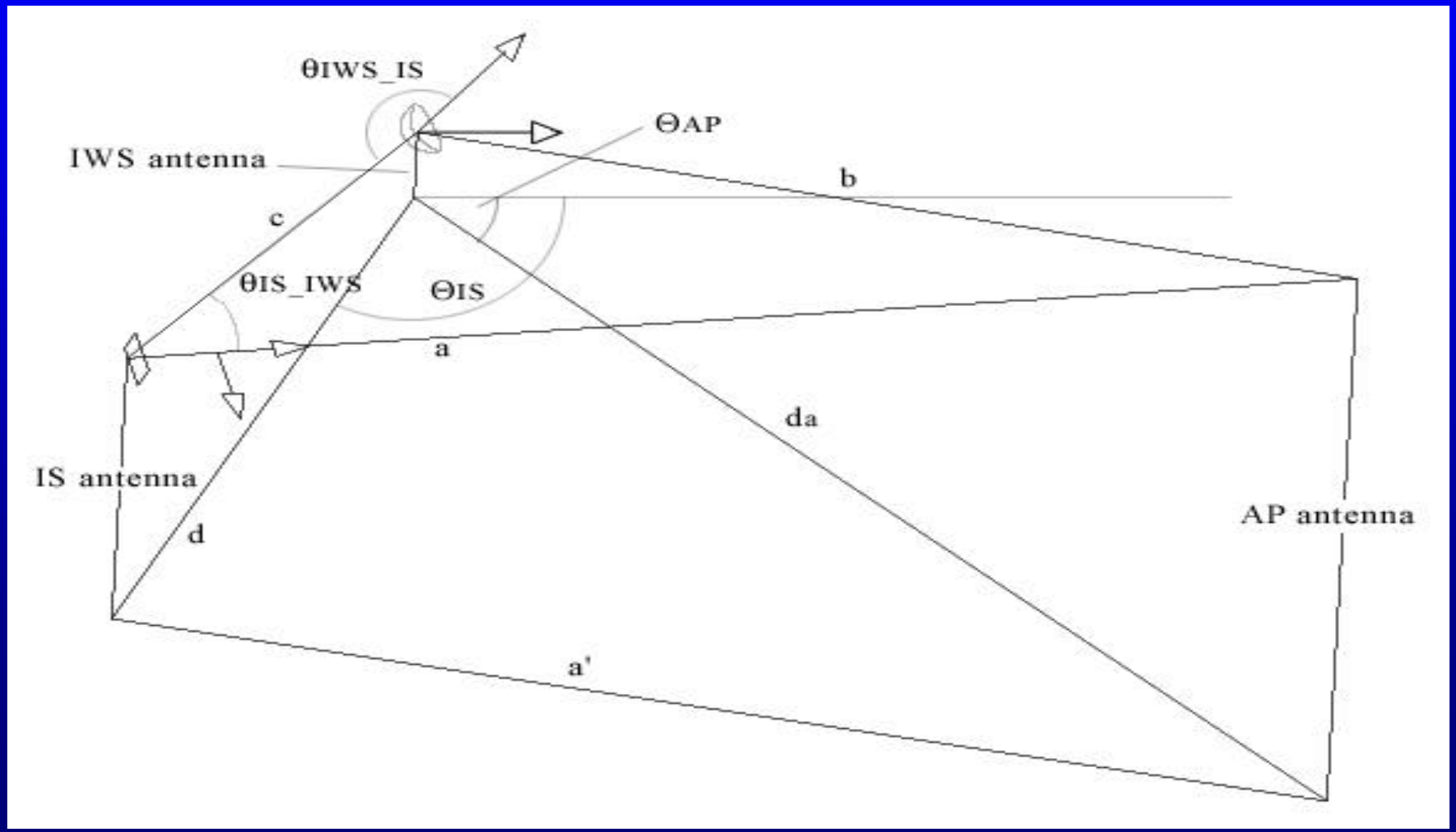
$$P_{received} \; ? \; \frac{P_{IS\_antenna}\, g_{IS\_IWS}(?_{IS\_IWS}, ?_{IS\_IWS})\, g_{IWS\_IS}(?_{IWS\_IS})\, g_m}{\left(\frac{4?}{? \; ?}\right)^2 ? \; ((h_{IS\_antenna} \; ? \; h_{IWS\_antenna})^2 \; ? \; d^2)}$$

$$?_{IS\_IWS} \; ? \; f_1(d, h_{IS\_antenna}, h_{IWS\_antenna}, h_{AP\_antenna}, ?_{AP}, ?_{IS}, d_a)$$

$$?_{IS\_IWS} \; ? \; f_2(d, h_{IS\_antenna}, h_{IWS\_antenna}, h_{AP\_antenna}, ?_{AP}, ?_{IS}, d_a)$$

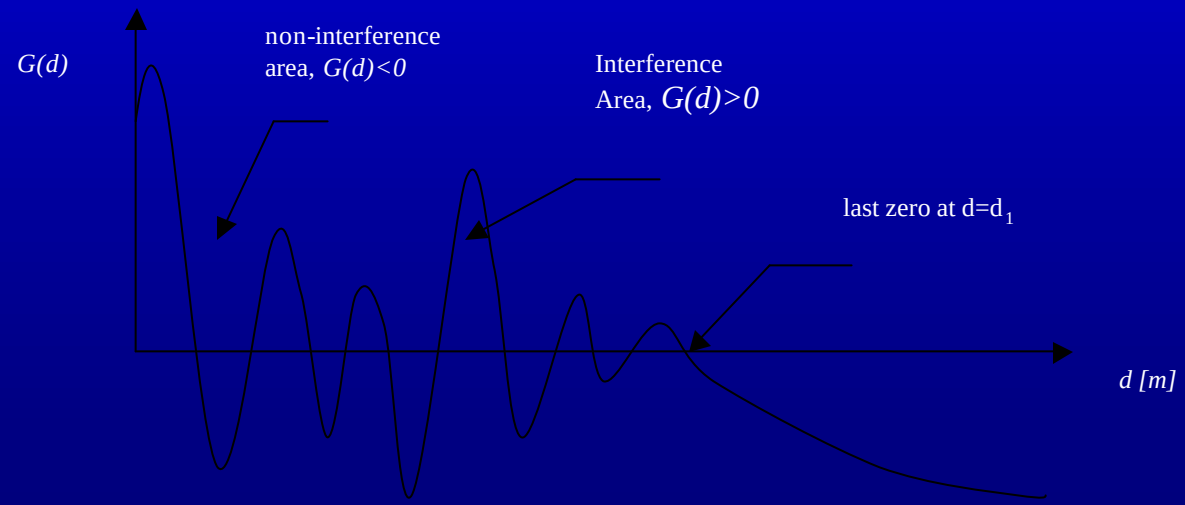
$$?_{IWS\_IS} \; ? \; f_3(d, h_{IS\_antenna}, h_{IWS\_antenna}, h_{AP\_antenna}, ?_{AP}, ?_{IS}, d_a)$$

Algorithm for Computing the Forbidden zone

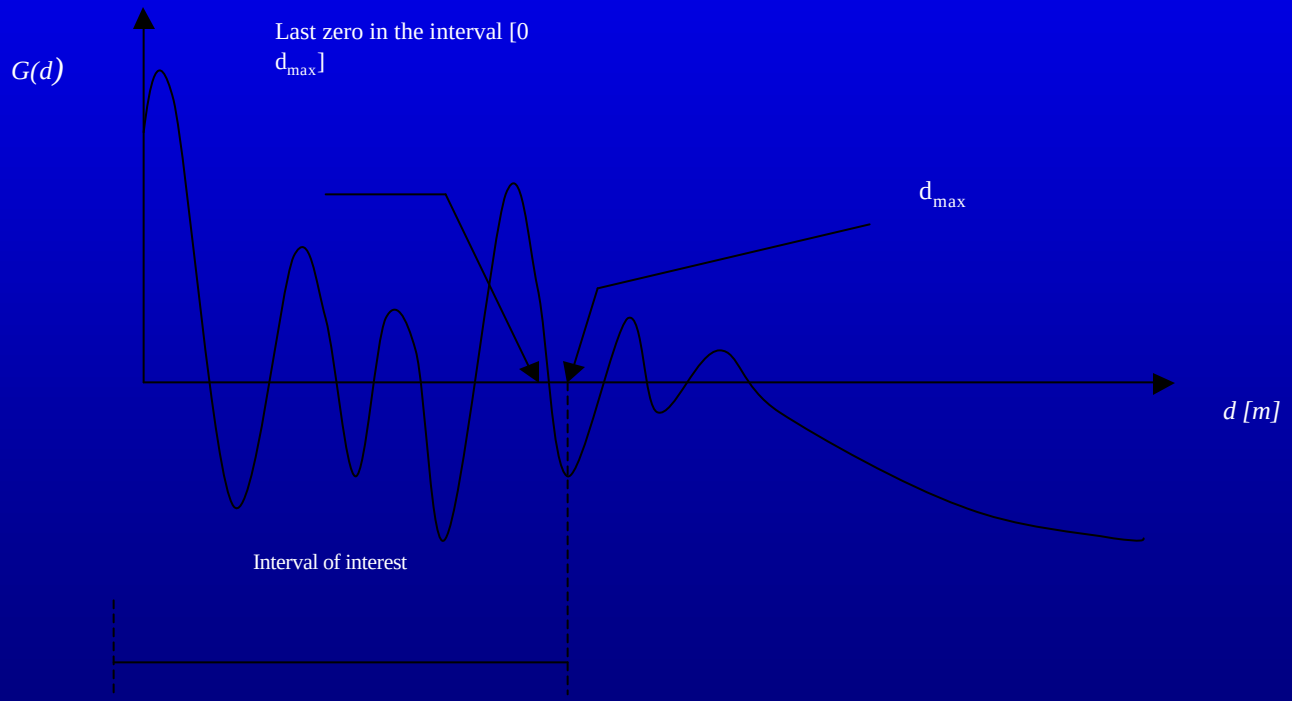


Algorithm for Computing the Forbidden Zone

$$G(d) ? \frac{P_{IS\_antenna} F(d)}{\left(? \frac{4?}{? \; ?} ? \right)^2 ((h_{IS\_antenna} ? h_{IWS\_antenna})^2 ? d^2)} ? N(10^{\frac{M}{10}} ? 1)$$

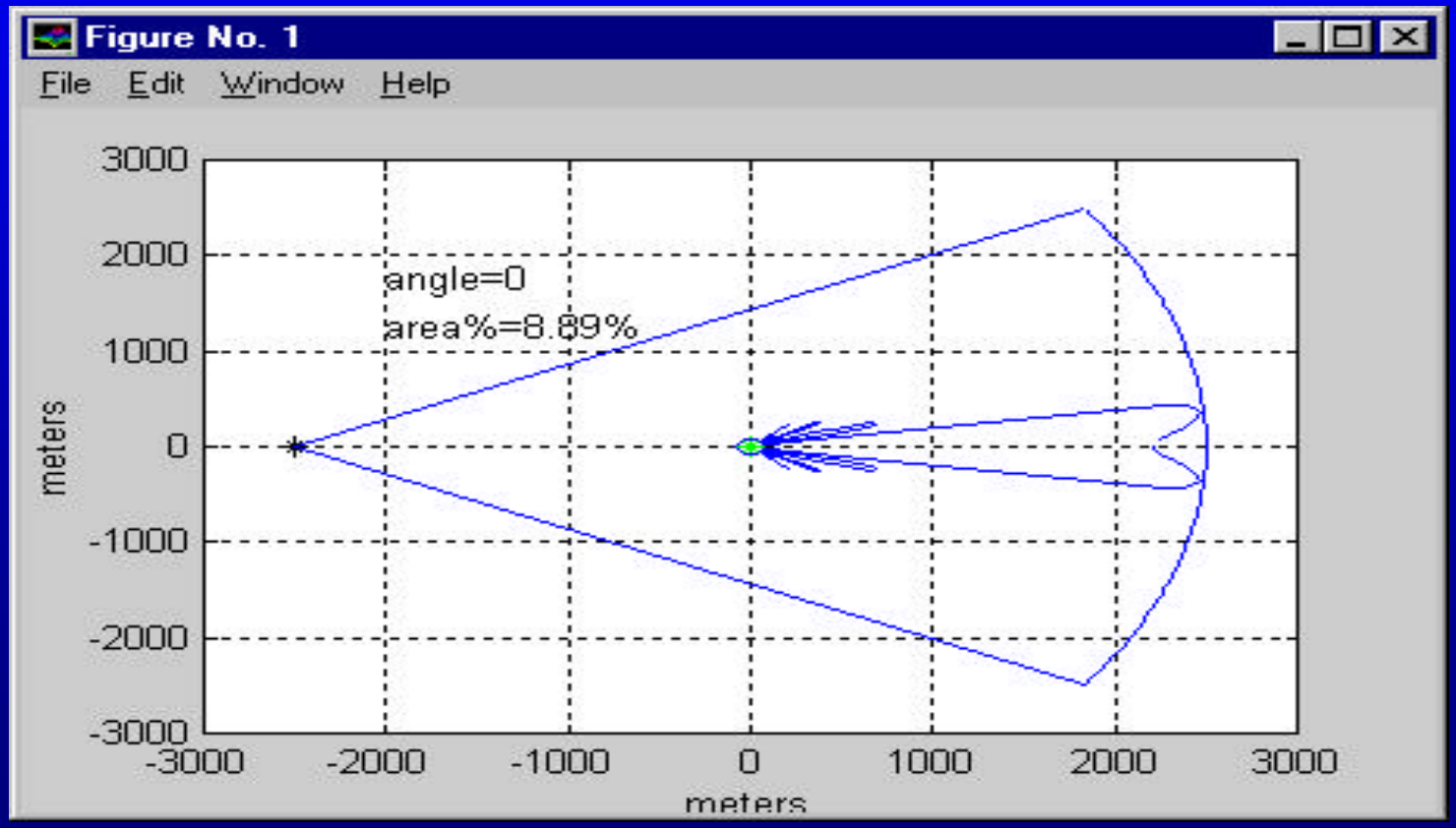


Algorithm for Computing the Forbidden Zone



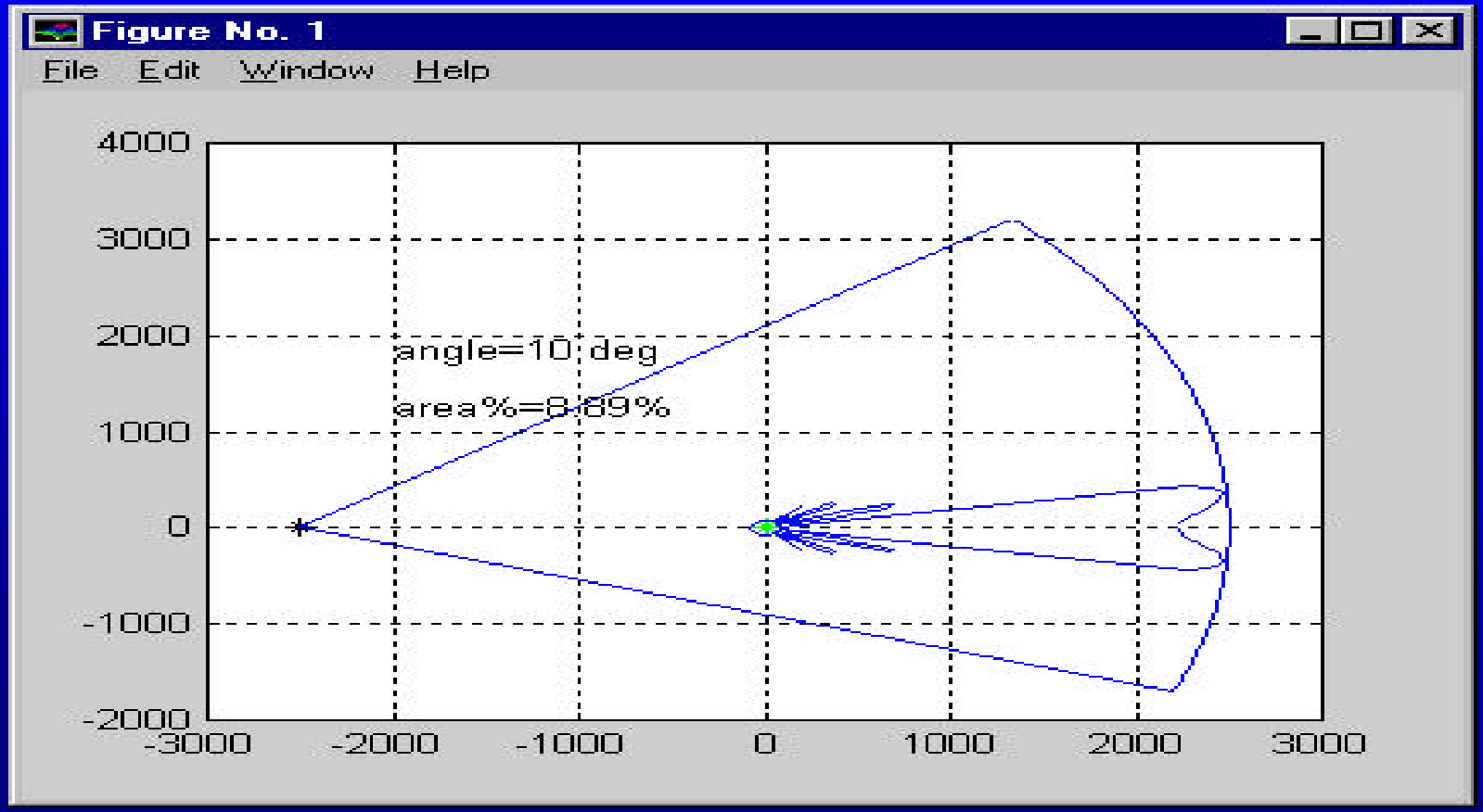
Azimuthal Pointing Adjustment

y-axis direction



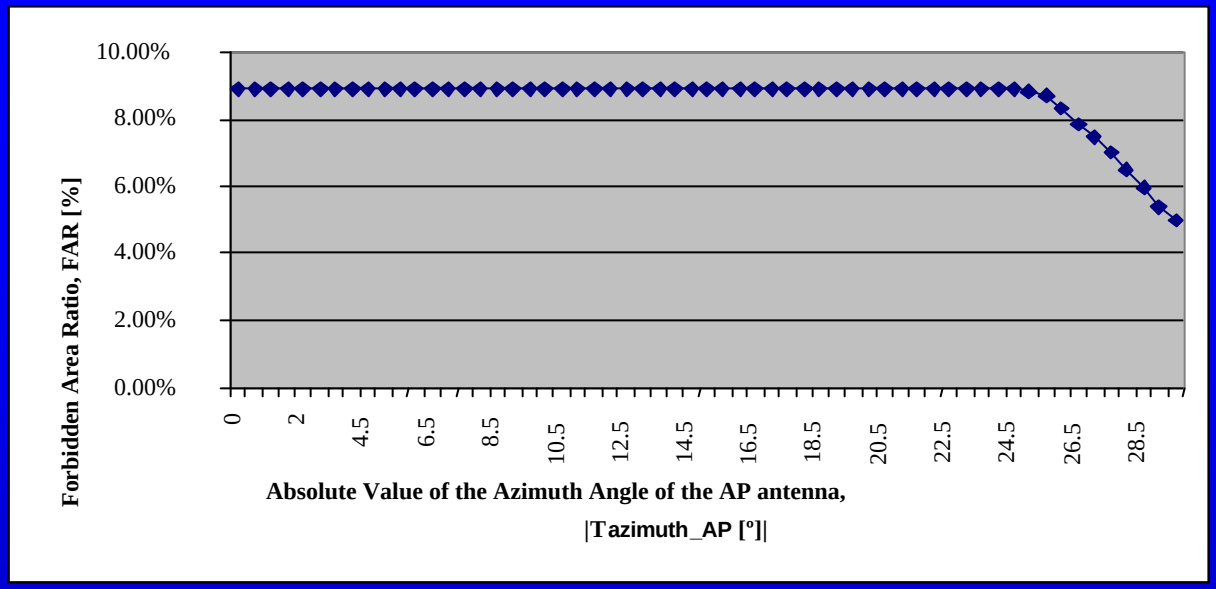
Distance form the IWS antenna in the x- direction,d[meters]

Azimuthal Pointing Adjustment

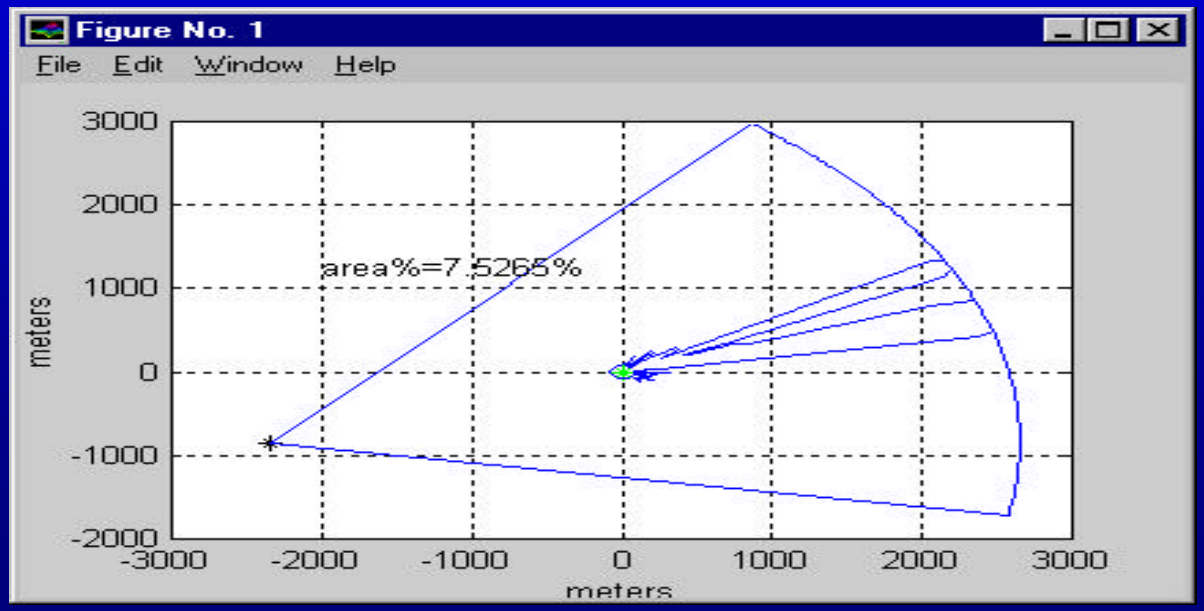


y-axis direction

Distance form the IWS antenna in the x- direction,d[meters]

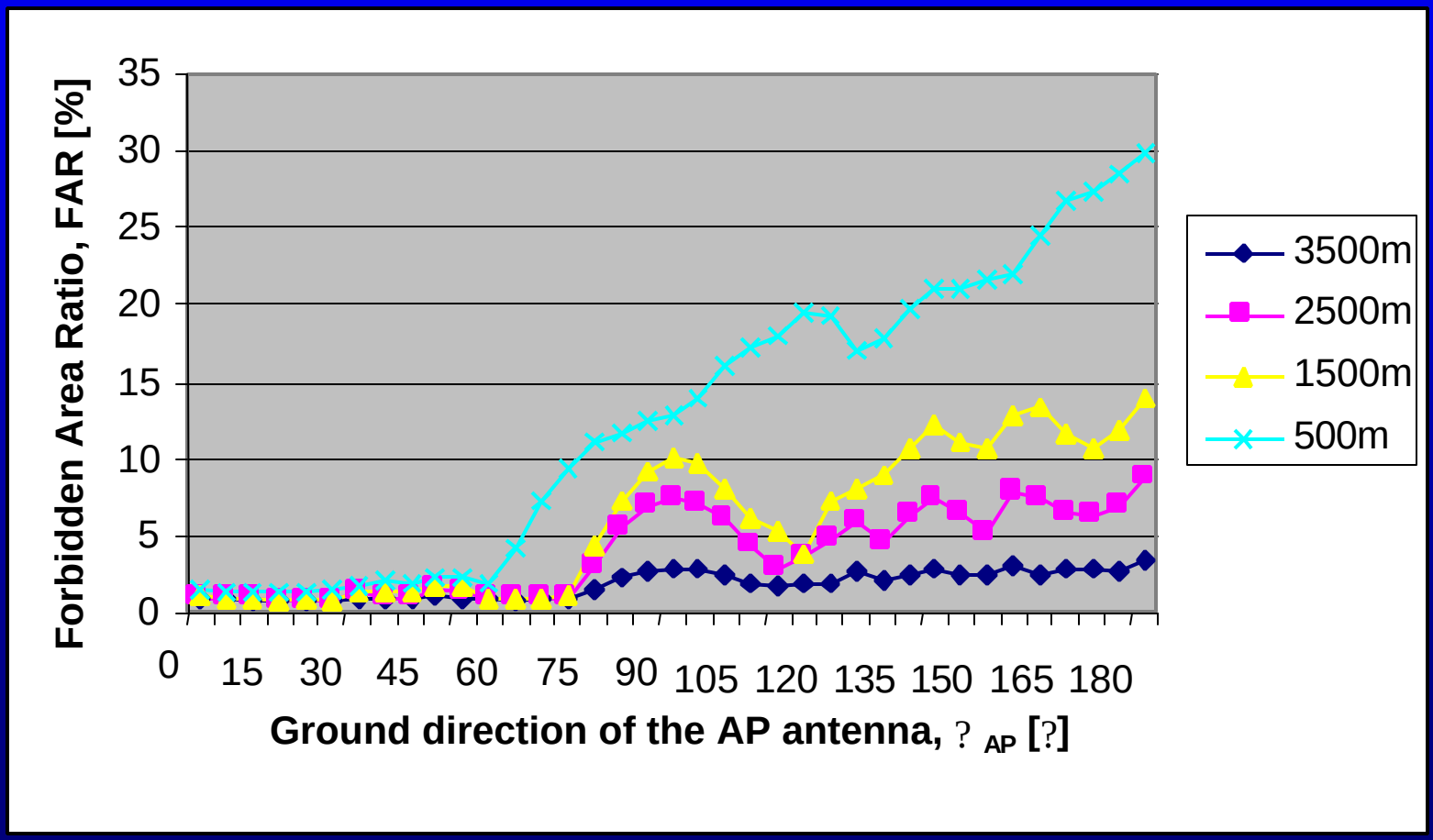


y-axis direction

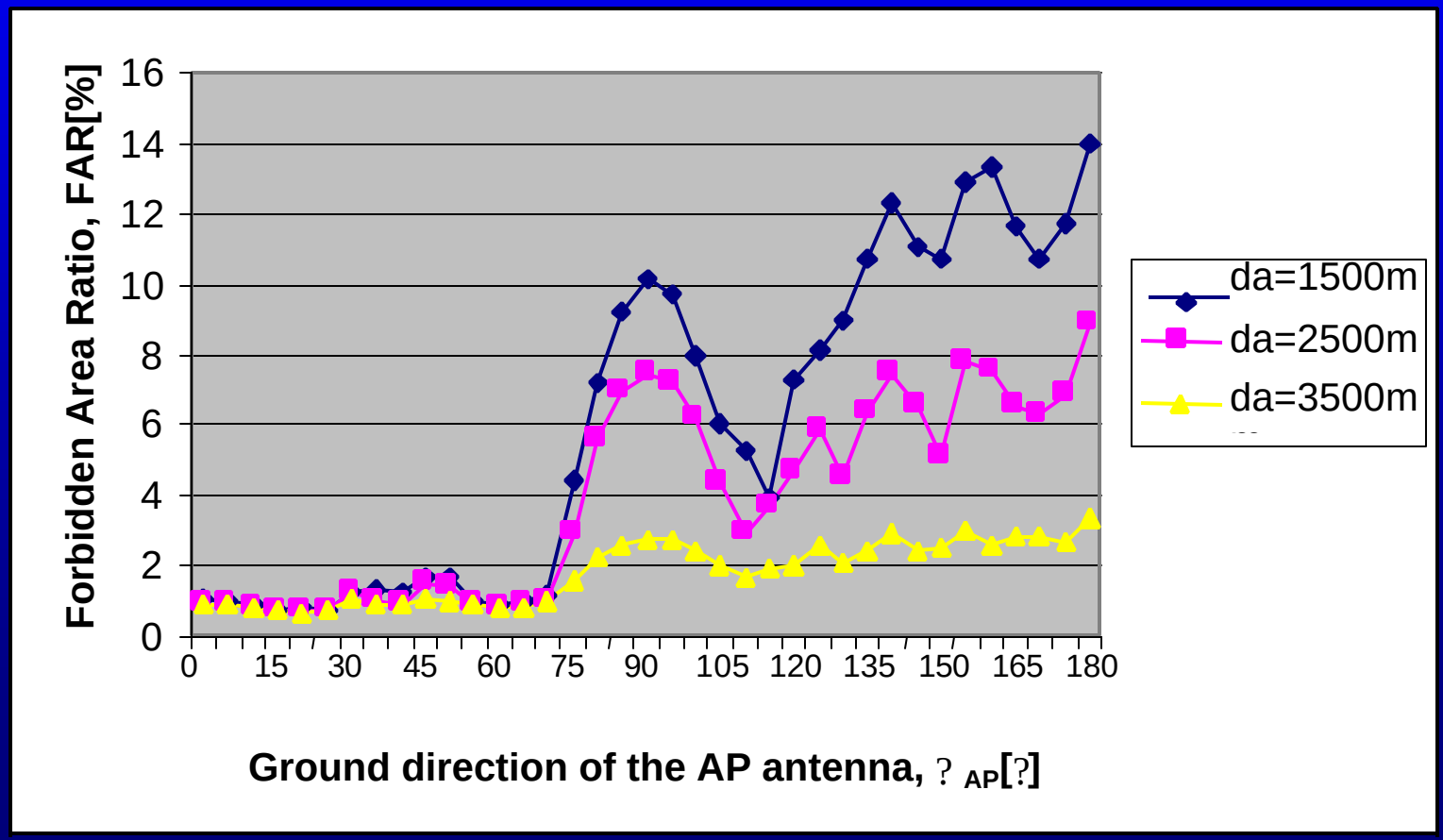


Distance form the IWS antenna in the x- direction,d[meters]

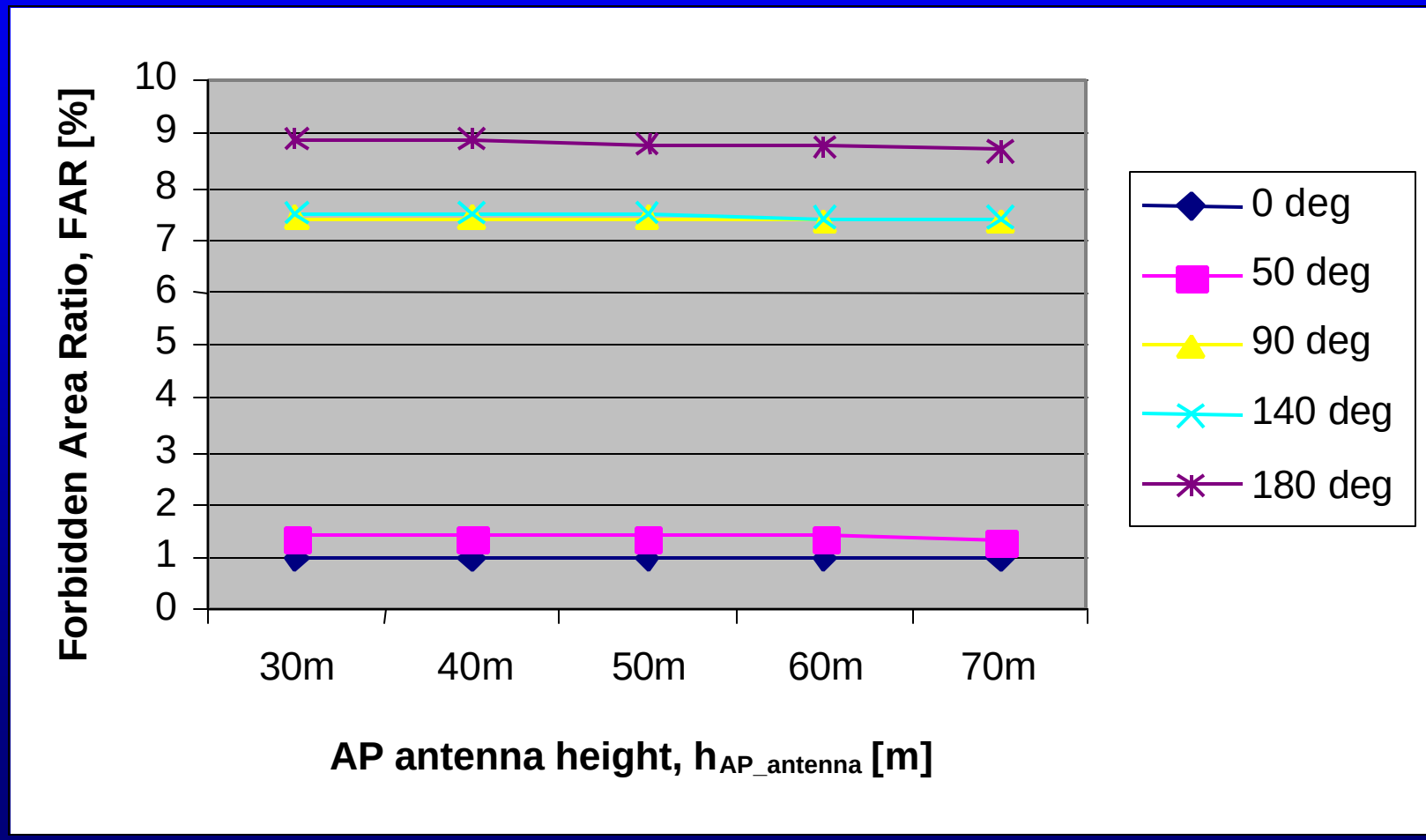
Adjusting the Ground Direction of the AP Antenna



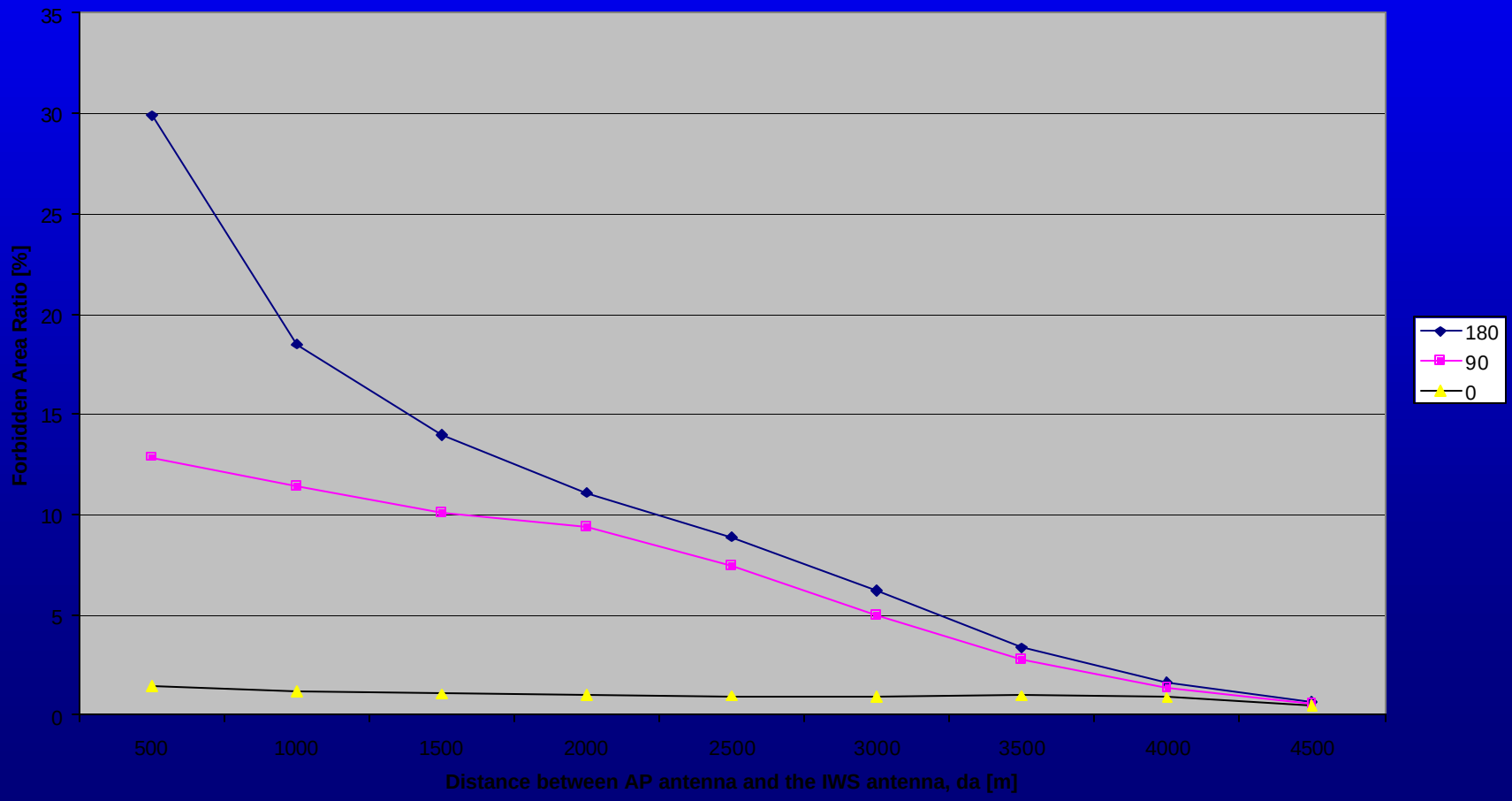
Adjusting the Ground Direction of the AP Antenna



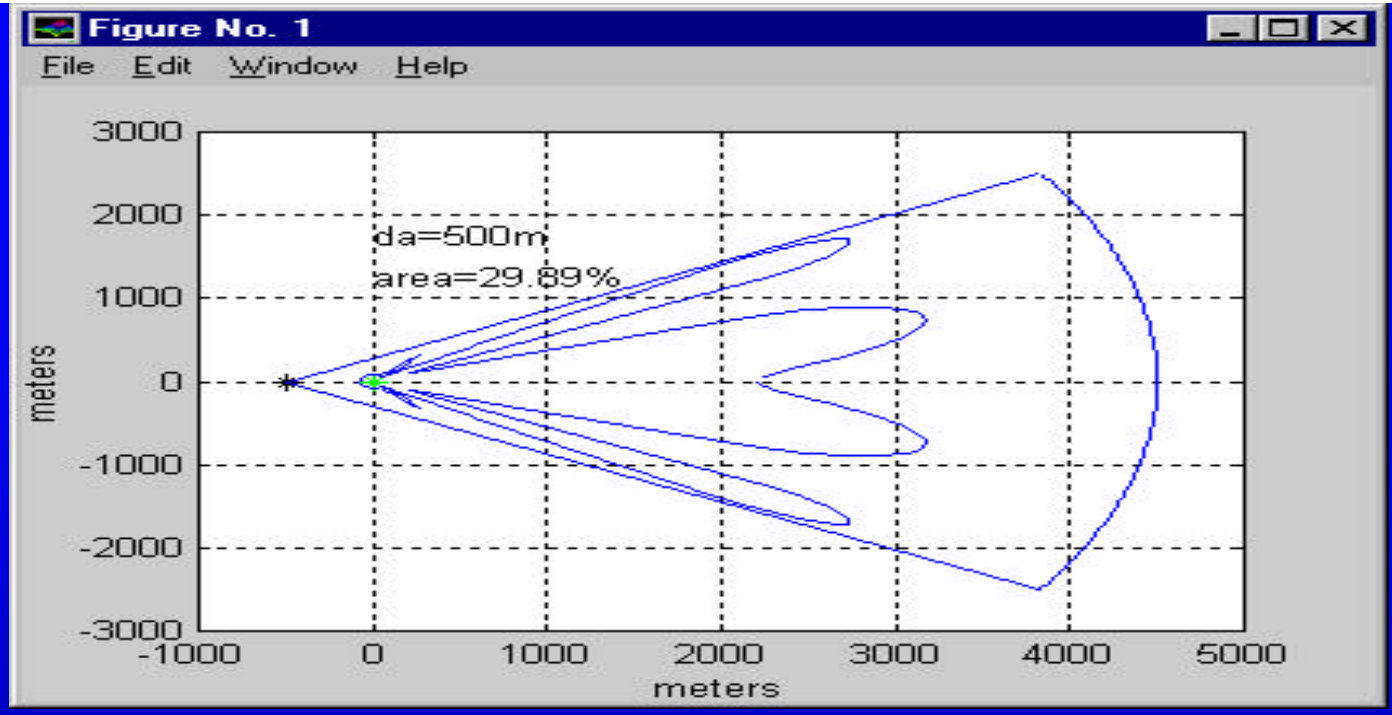
Effects of the AP Antenna Height



Coverage Dependence on the AP Antenna Distance

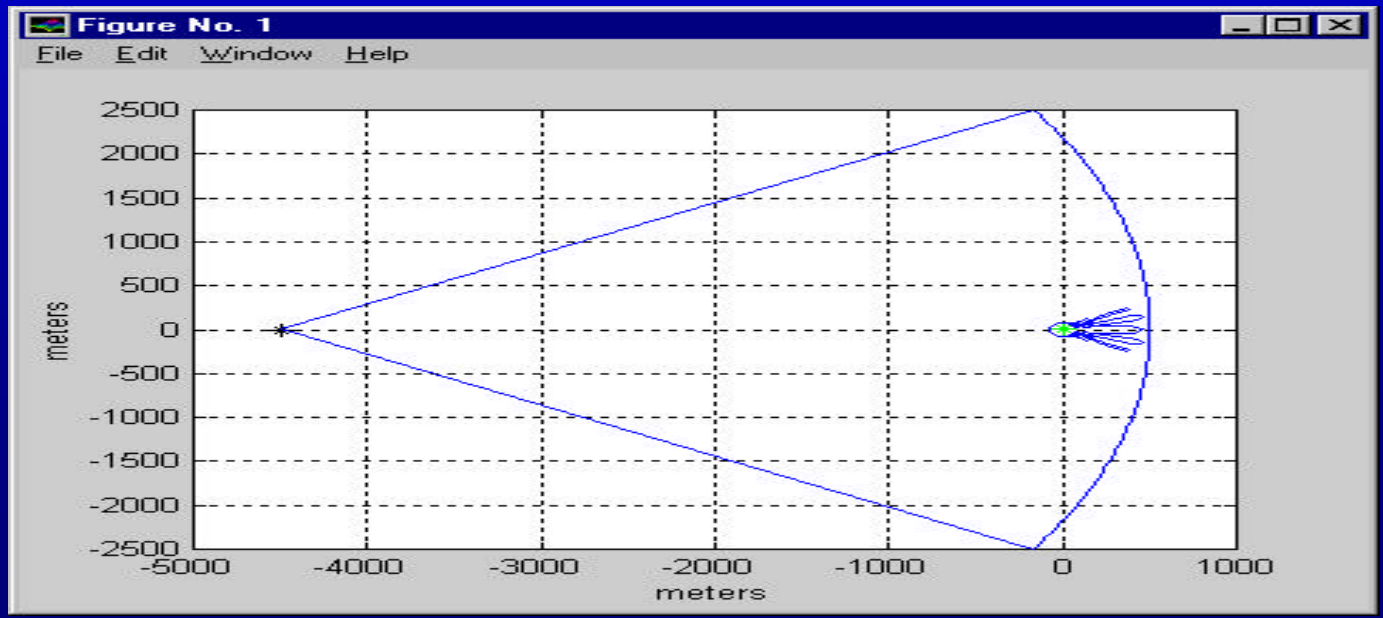


y-axis direction d[meters]



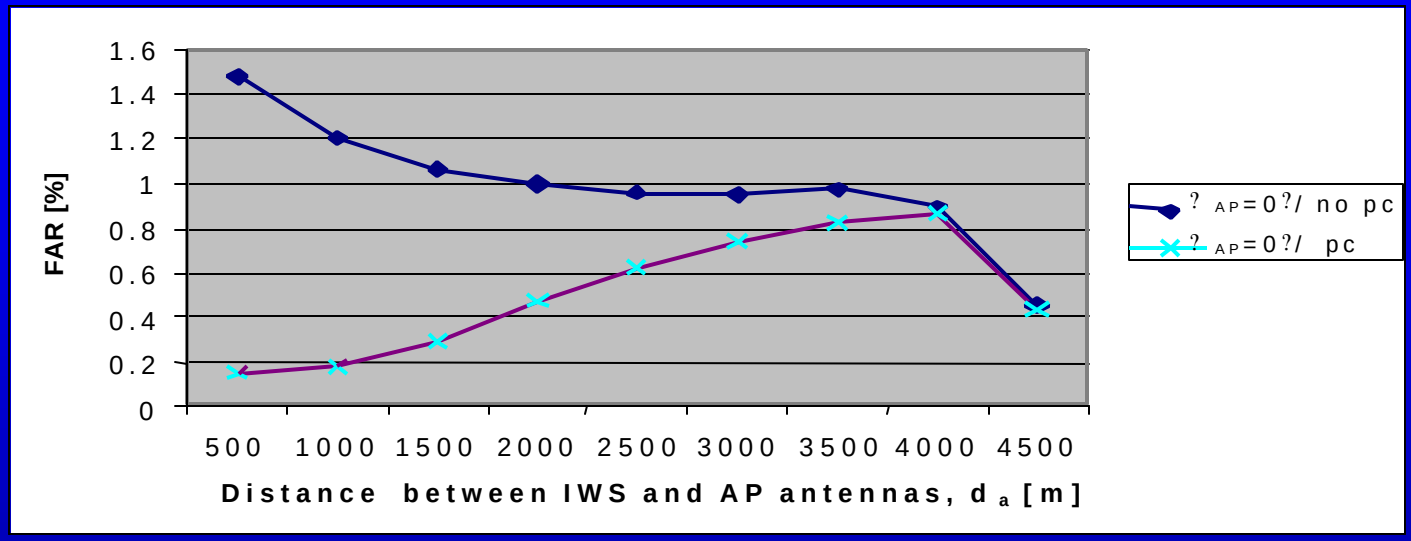
Distance form the IWS antenna in the x- direction,d[meters]

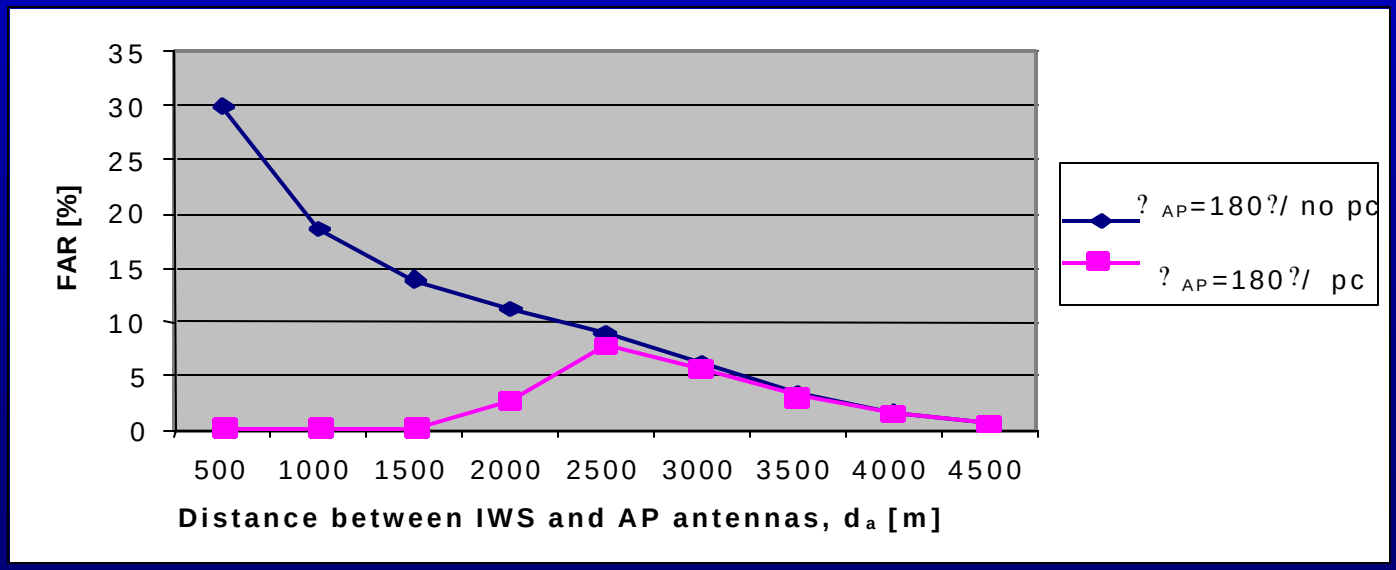
y-axis direction d[meters]



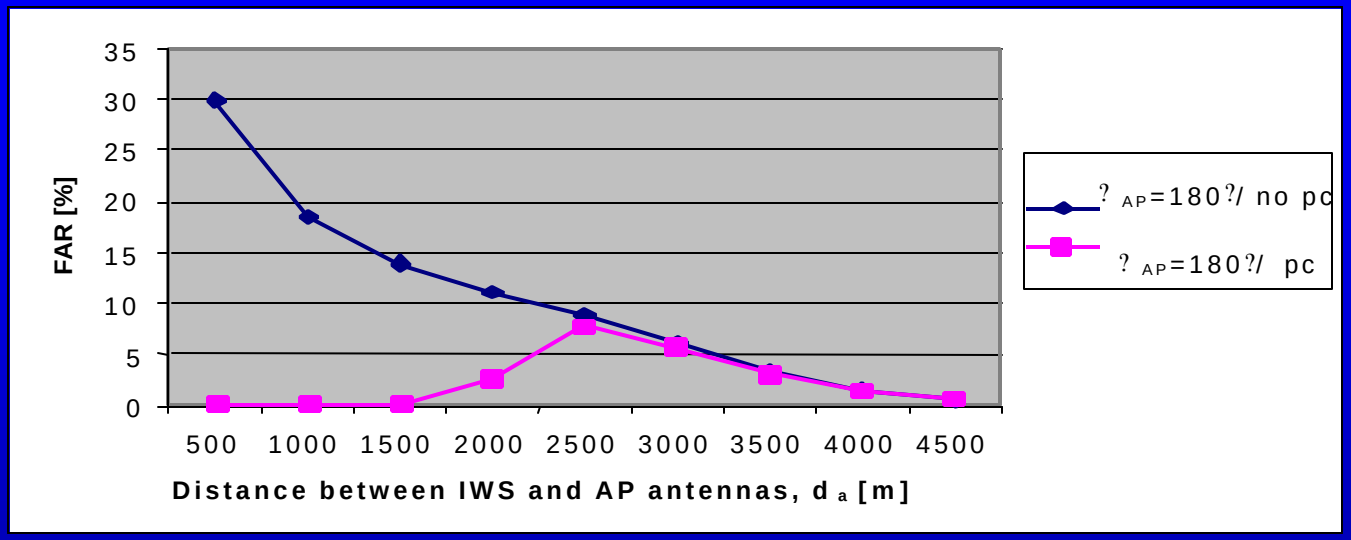
Distance form the IWS antenna in the x- direction,d[meters]

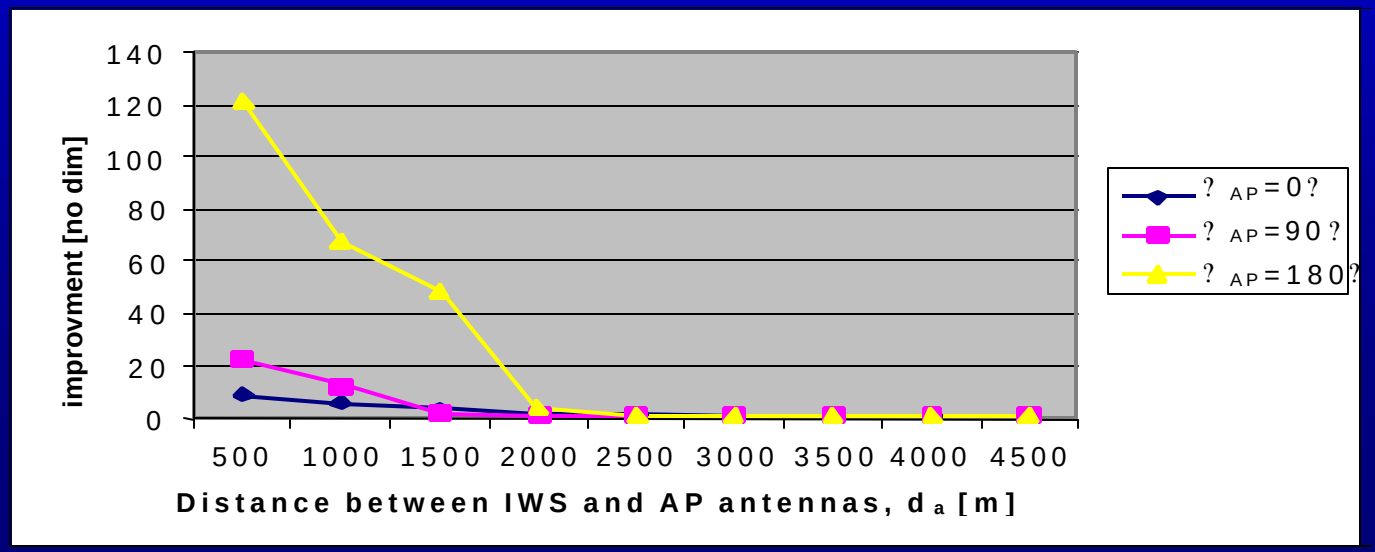
Effects of Power Control



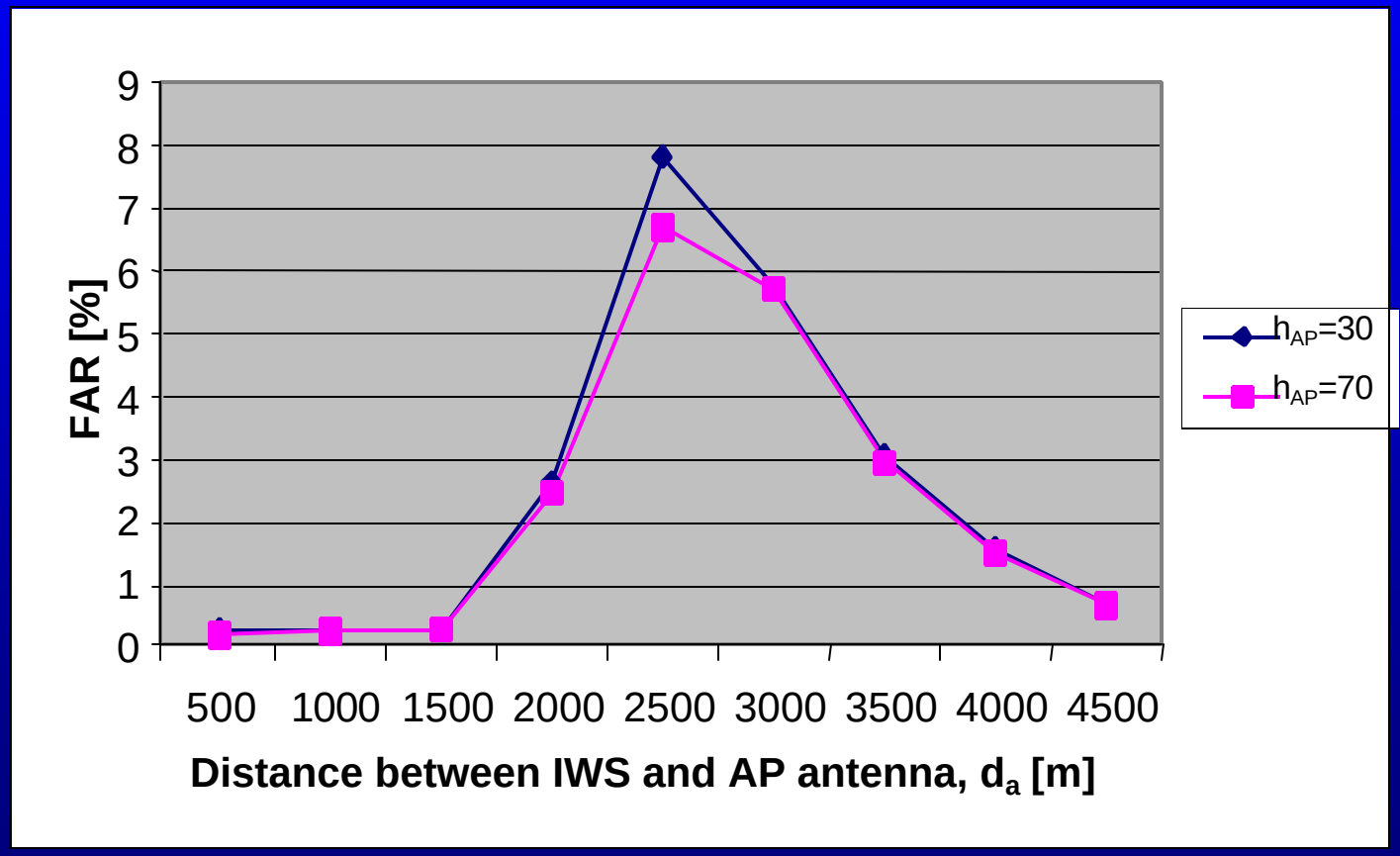


Effects of Power Control

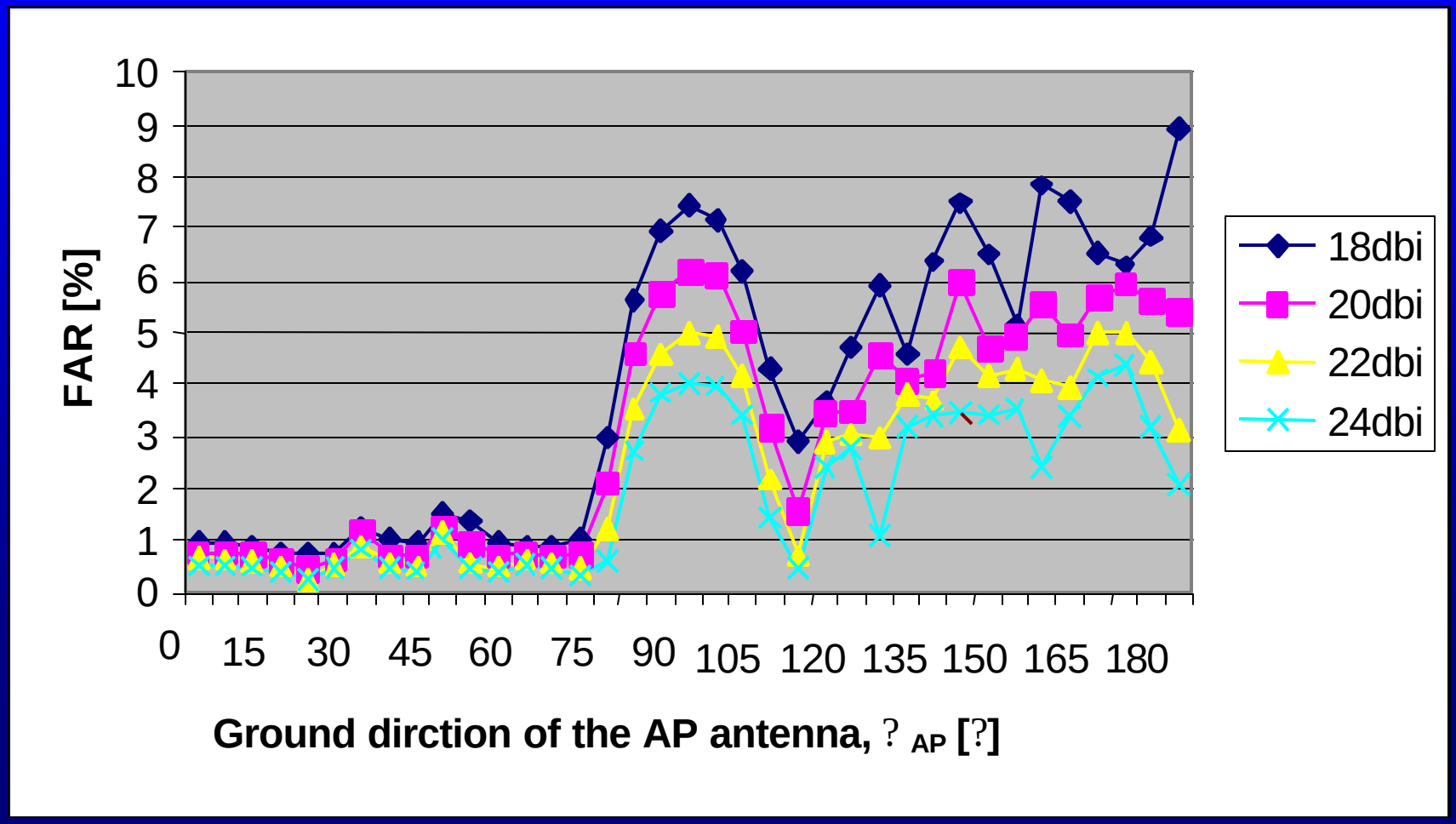




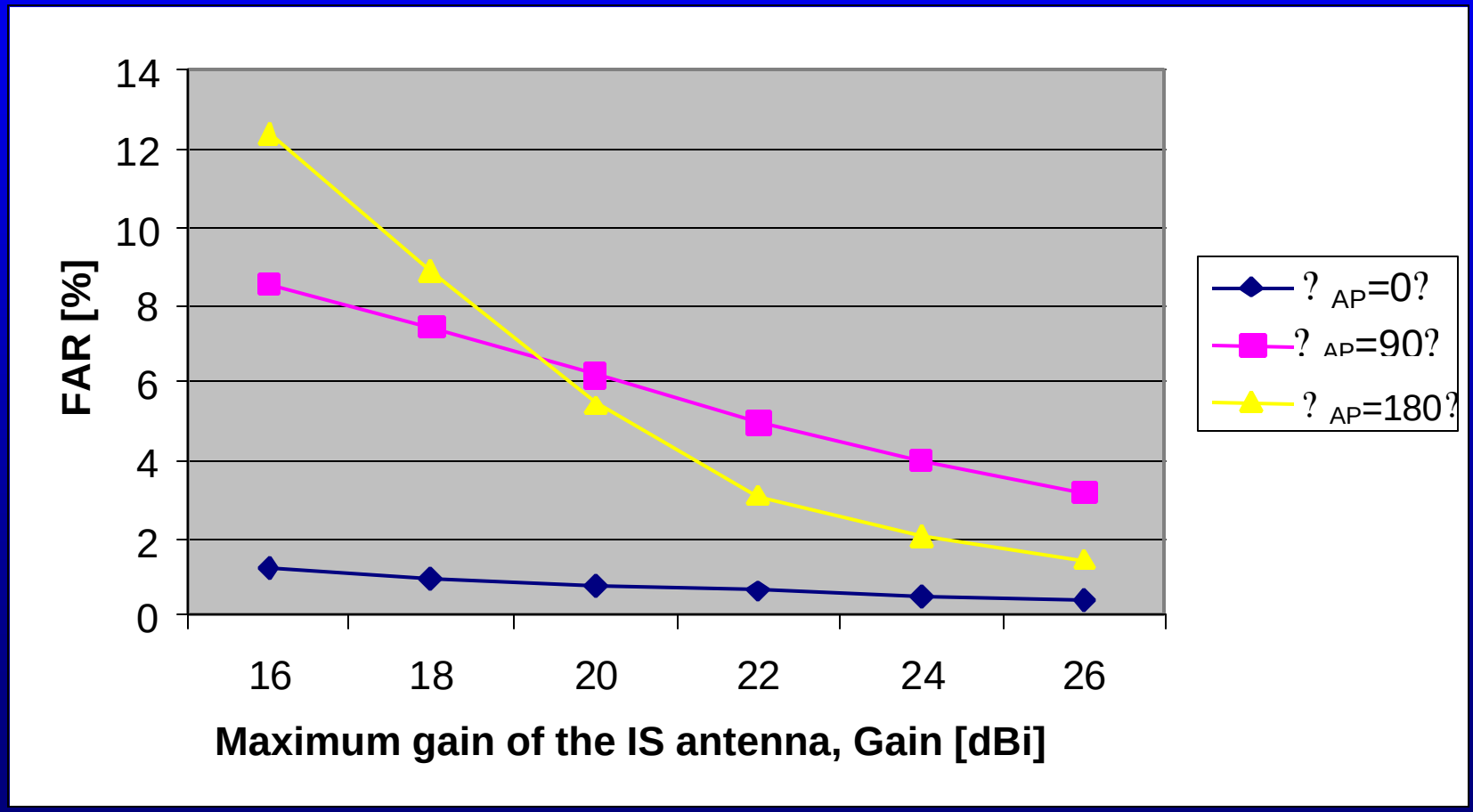
Effects of Power Control

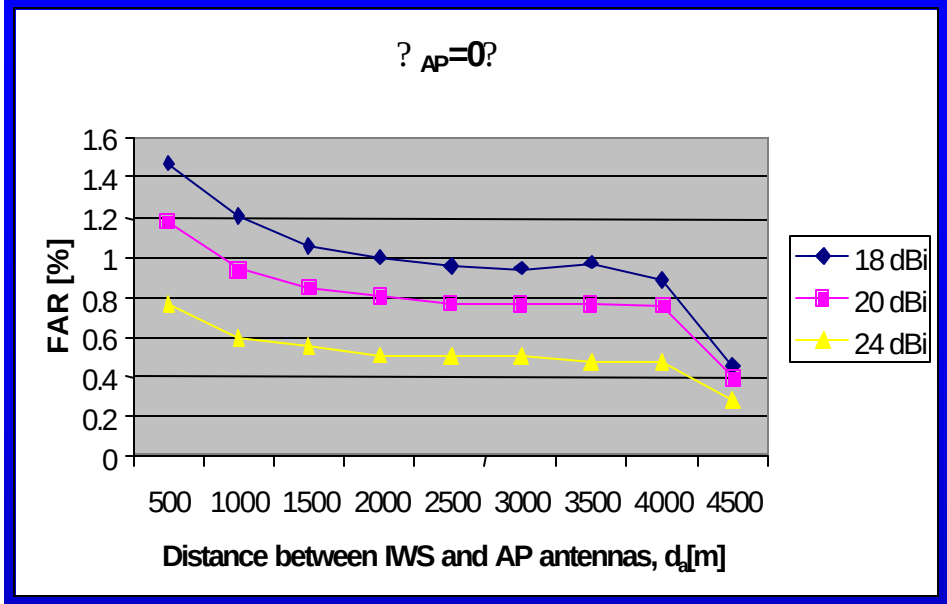


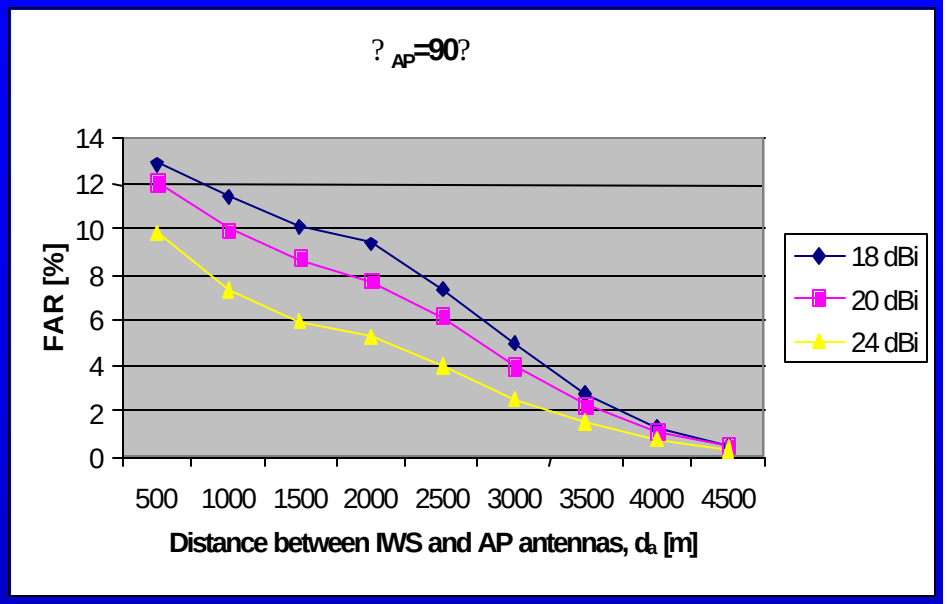
Effects of the Antenna Gain Increase

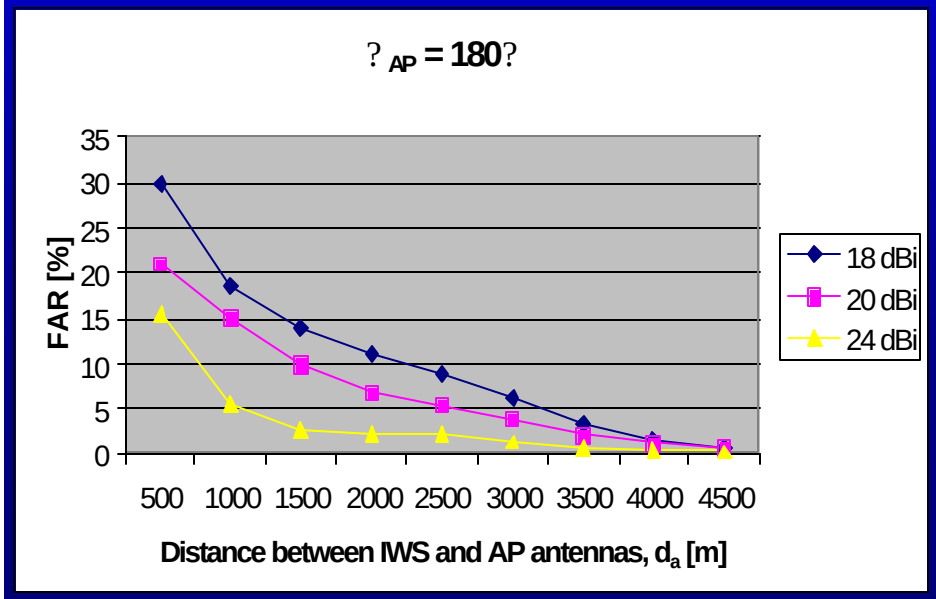


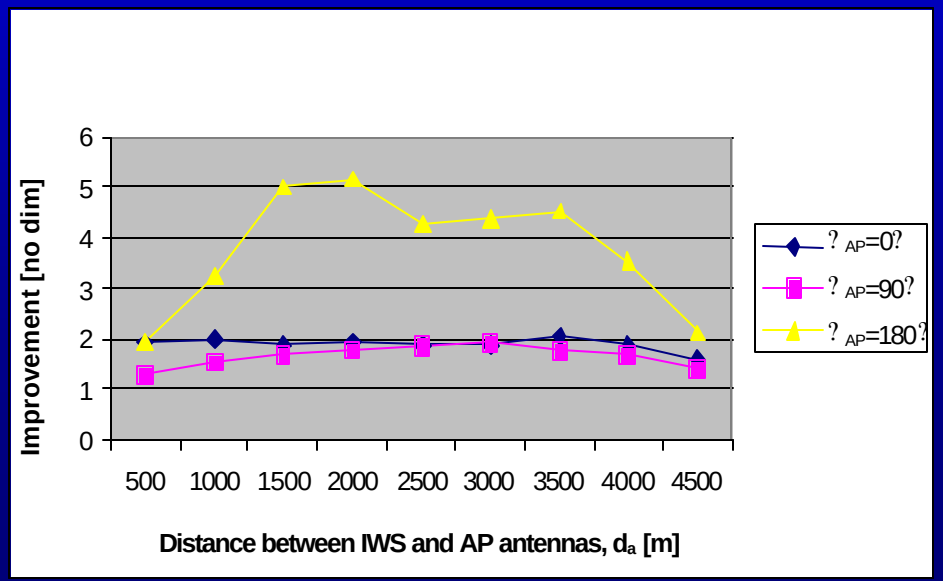
Effects of the Antenna Gain Increase



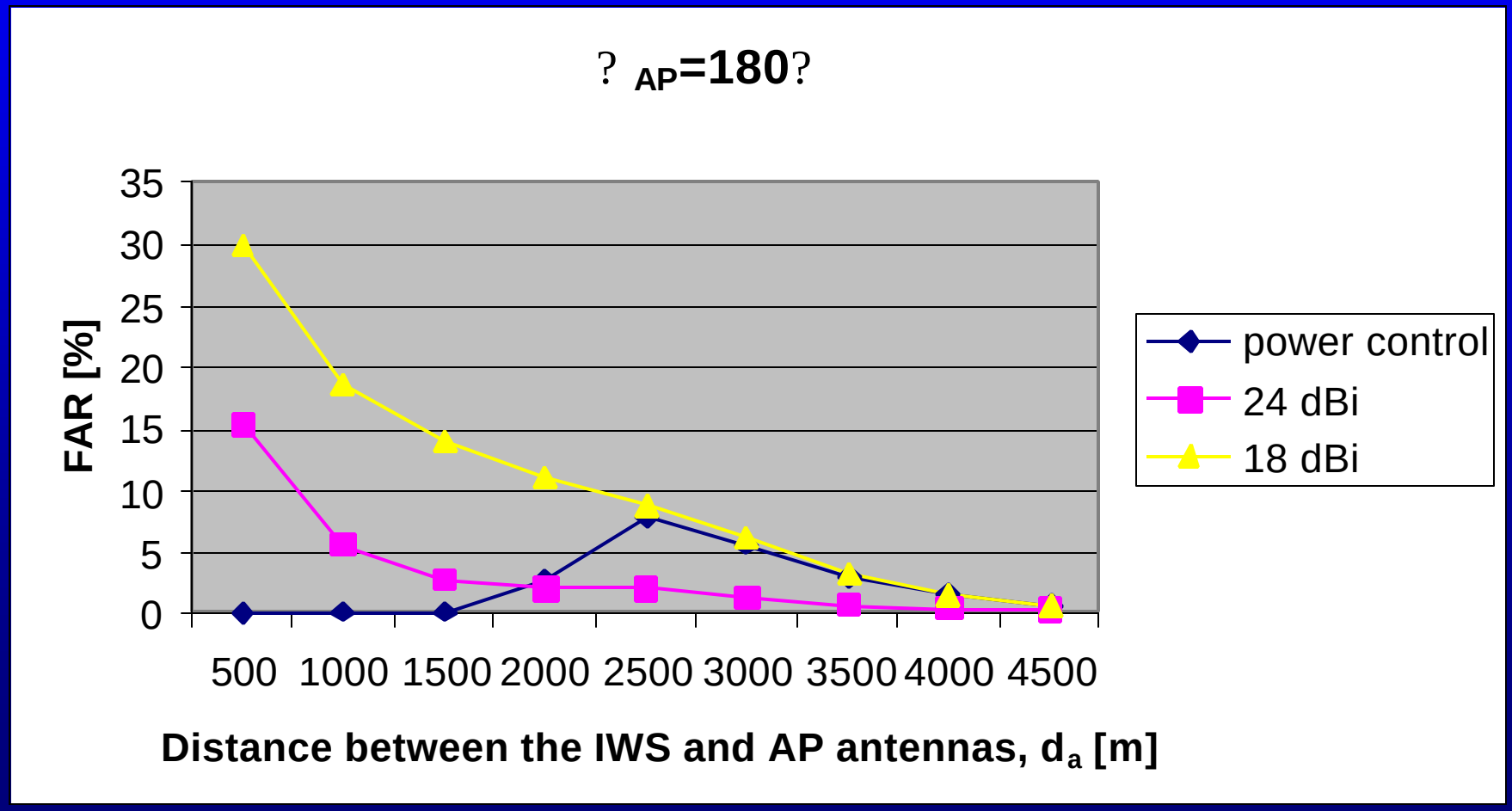

? AP=0?
FAR [%]
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
500 1000 1500 2000 2500 3000 3500 4000 4500
Distance between IWS and AP antennas, da[m]
18 dBi
20 dBi
24 dBi


? AP=90?
FAR [%]
14
12
10
8
6
4
2
0
500 1000 1500 2000 2500 3000 3500 4000 4500
Distance between IWS and AP antennas, da [m]
18 dBi
20 dBi
24 dBi

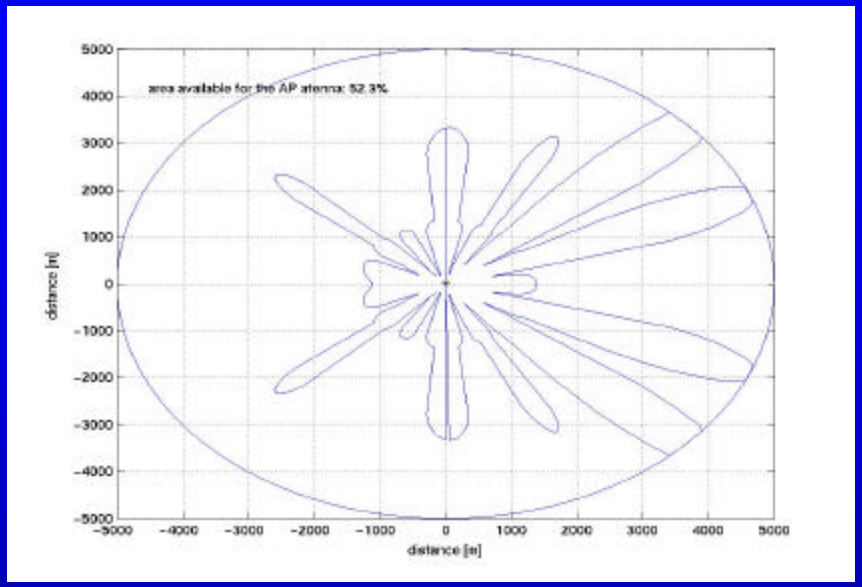

? AP = 180?
FAR [%]
35
30
25
20
15
10
5
0
500 1000 1500 2000 2500 3000 3500 4000 4500
Distance between IWS and AP antennas, da [m]
18 dBi
20 dBi
24 dBi

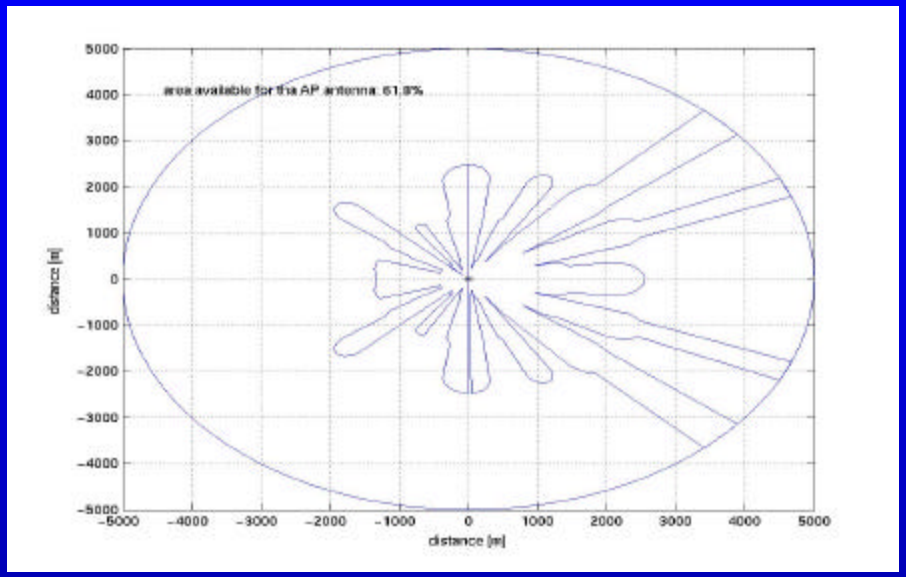

Improvement [no dim]
6
5
4
3
2
1
0
500 1000 1500 2000 2500 3000 3500 4000 4500
Distance between IWS and AP antennas, da [m]
? AP=0?
? AP=90?
? AP=180?

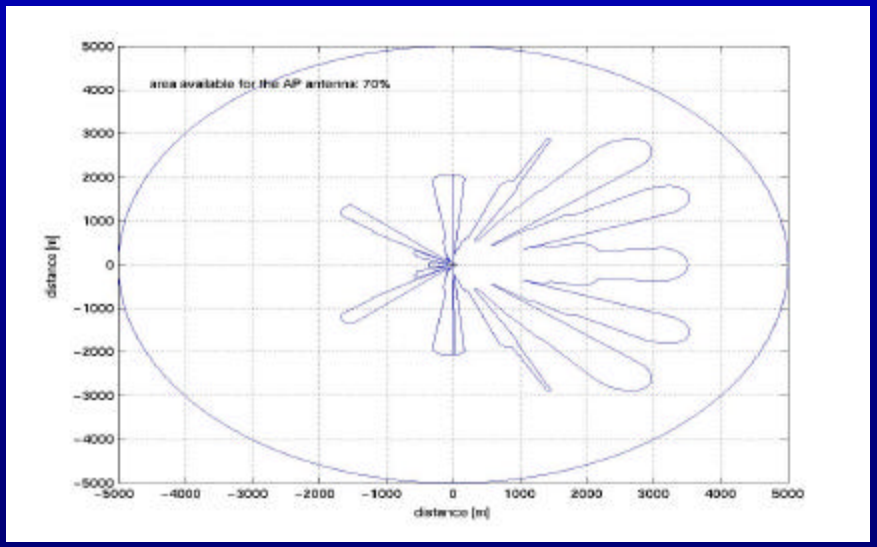
Effects of the Antenna Gain Increase and Power Control

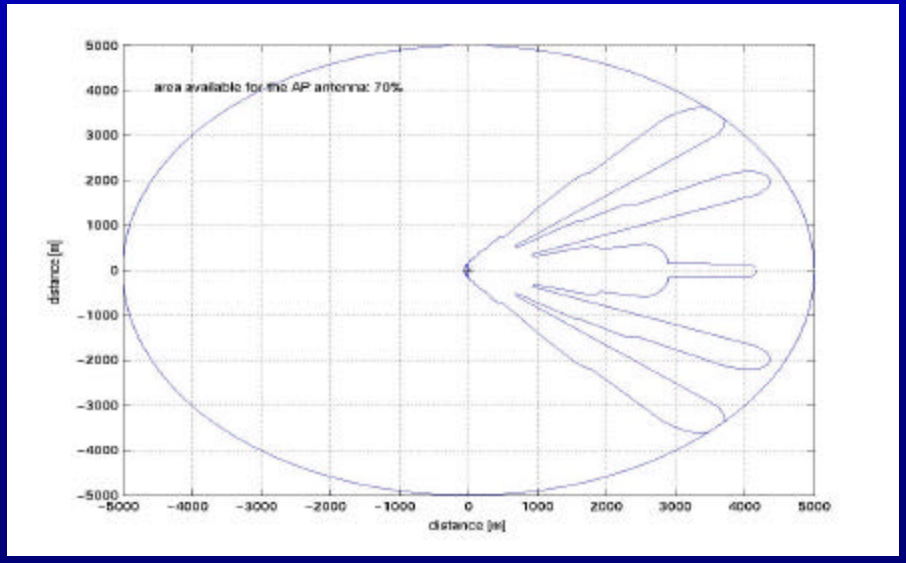


AP Antenna Interference









Summary

- Maximizing the area coverage
  - Select a direction for the AP antenna
  - Maximize the distance between the AP and the IWS antenna
  - Adjust the AP antenna height
  - Determine whether power control is necessary
- Repeat the steps if necessary
- Determine which step applies for specific implementation

Future Work

- A case with two or more antenna in the sector
- Using different antenna patterns
- Use different frequency
- Confirm the finding with measurements from real-life case scenario

Questions