

Effect of Height (Fresnel Clearance) on Signal Strength and Throughput for Medium and Long Distance Wireless Links

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<http://www.iitk.ac.in/mla>

Motivation

- Problem

- High Tower Cost
- Current state of art - AdHoc

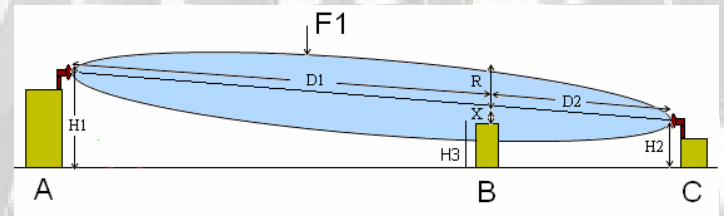
- Solution

- Accurate Estimation of Tower Height
Utilize **SRTM*** data for estimating obstruction height

- Ignoring Fresnel Clearance

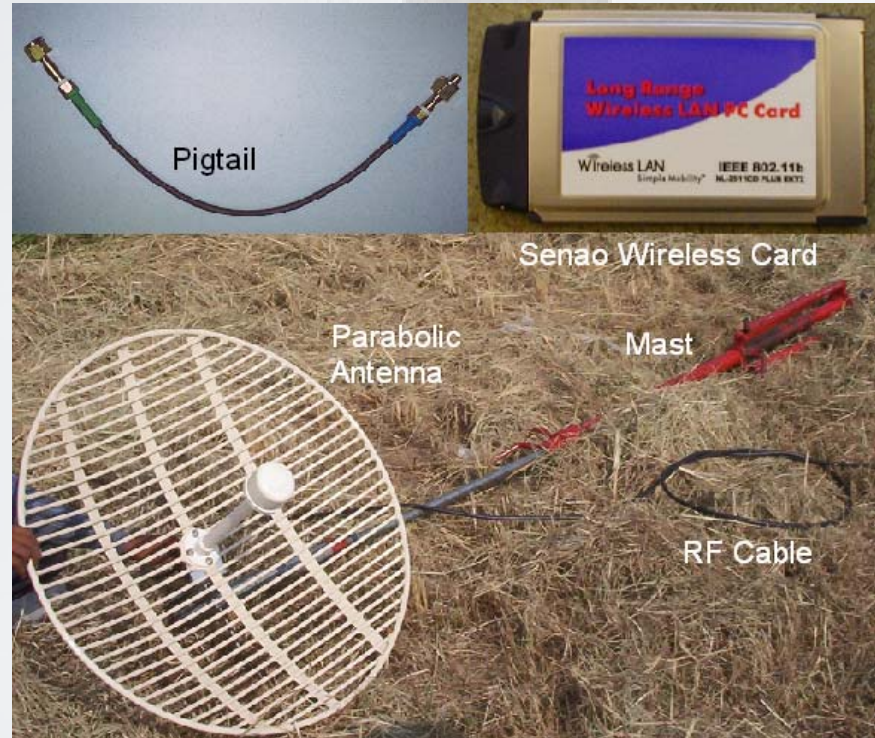
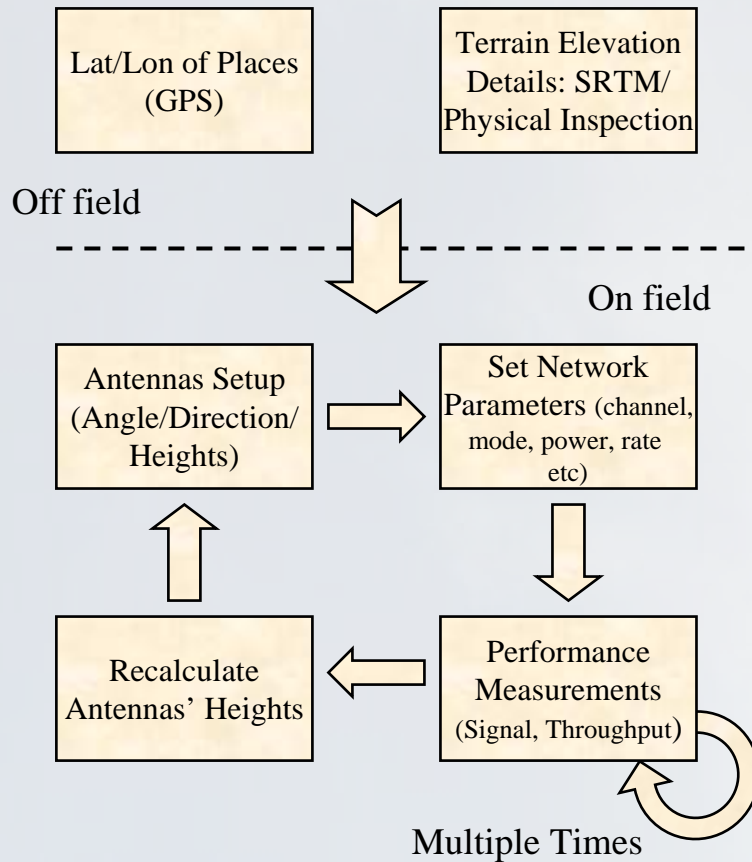
For 20Km long Wireless Link, Fresnel Clearance requires around 20m (**approx \$4000**) extra height of tower

Tower Ht (m)	Cost (\$)
10	100
15	150
21	800
24	950
27	1100
30	1850
45	5000



*<http://www2.jpl.nasa.gov/srtm/>

Methodology and Equipments



Results (Long Distance)

*FBTop(P)-MBSNL(Q)**

Height at Q (meters)	Signal (dBm)	Throughput (Mbps)
40	-58	6.29
30	-69	6.30
12	-69	6.29
9	-77	6.30

Link established 3-4 m above calculated height

**As per SRTM data, height ≥ 4 m at Q ensures 100% Fresnel Clearance
On Physical Inspection: No LOS even at 8 meters*



Distance PQ: 5.12 km,
Elevation Difference PQ: 30 m (tower) + 10.6 m.

Results (Long Distance) cont..

FabLab(M)-MS3(N)

Height at N (m)	Signal (dBm)	Throughput (Mbps)
30	-62	6.22
17	-69	6.10
15	-73	6.00
11	-74	5.93
8	-75	5.60
7	-76	5.57

Link established 3-4 m above calculated height



Distance MN: 5.57 km,
Elevation Difference MN: 30 m (tower) - 10.2 m.

Results (Medium Distance)

FBTop (A) – Hall3 (B) – Hall8 (C) :

Height at C (m)	Fresnel Clearance	Signal (dBm)	Thr (Mbps)
14.84	F1*	-57	8.12
13.3	0.96F1	-58	8.12
12.1	0.81F1	-60	8.02
7.34	0.20F1	-64	7.90
5.8	0.0049F1	-64	8.35
4.5	No LOS	-76#	8.20
3.0	No LOS	-78	7.27



Visual LOS ensures link establishment

*F1: First Fresnel Zone

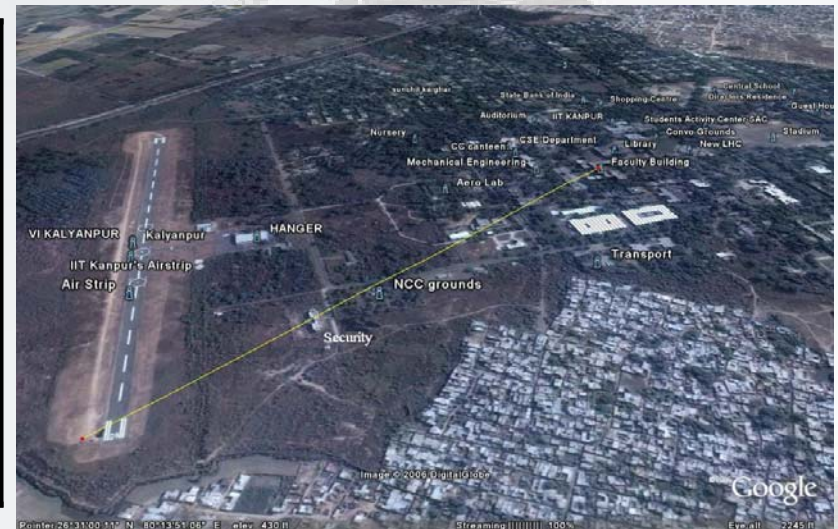
Multipath may be a possible cause

Distances AC: 954.40 m, AB: 630 m;
 Fresnel Radius F1 (at B): 5.17 m.
 Fix Heights: A: 30 m, B: 14 m.

Results (Medium Distance) cont..

FBTop (A) – Security (D) – Airstrip (E) :

Height at C (m)	Fresnel Clearance	Signal (dBm)*	Thr (Mbps)
5.2	0.28F1	-60.02	7.20
4.5	0.19F1	-59.58	7.12
3.7	0.09F1	-60.57	6.75
2.8	No LOS	-59.56	6.70



Visual LOS
ensures link establishment

Distances AE: 980.82 m, AD: 662.02 m;
Fresnel Radius F1 (at D): 5.18 m.
Fix Heights: A: 30 m, E: 11.8 m.

*used */proc* to obtain per packet signal strength

Sources of Error

- GPS Positioning Error
- Assumption of perfectly spherical Earth Surface for distance calculation
- Low resolution SRTM Data
 - 3 arc second (~ 90m separation)
 - Height of missing data interpolated from 4 closest 3D Records.

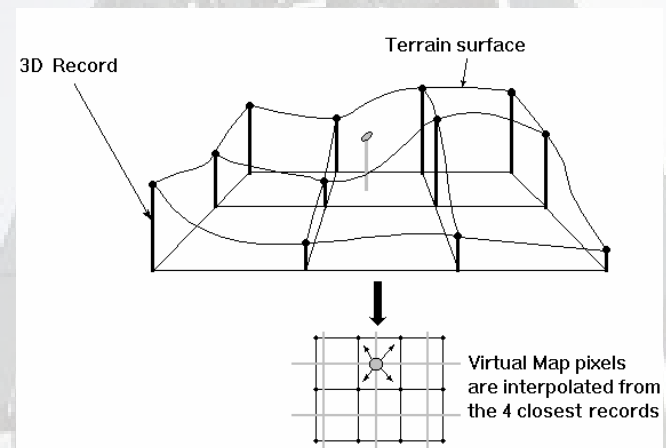


Figure from Radio Mobile@Yahoo Group

Conclusion and Future Work

- **Ensuring LOS** ensures Link Formation (needs further experimentation)
- Higher resolution terrain details needed to carry out more accurate measurements.
- In-depth experimentation by varying several key parameters.