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Planning IEEE 802.11 Wireless Networks for Coverage and Security

339 N. Bernardo Avenue, Suite 200
Mountain View, CA 94043
www.airtightnetworks.net

Wireless Local Area Network (WLAN) planning poses a new set of challenges for the network planners due to the invisibility of Radio Frequency (RF) and the need for protection against a new class of WLAN based security threats. Current state-of-the-art of doing site surveys by measuring actual signal at select points and placing WLAN transmitters at these points is neither accurate nor scalable; especially for large sites. This white paper describes the next generation RF Planning technology that is both accurate and scalable.

IEEE 802.11 based WLANs—also known as Wi-Fi—are gaining widespread acceptance for the convenience and flexibility they offer to the end users. Embedding of wireless technology into laptops, PDAs, and phones has significantly increased the user base of WLAN devices. WLANs are being aggressively deployed in enterprises of all sizes, public hot spots, airports, conference centers, university campuses, apartment complexes etc.
The WLANs use RF signals in 2.4 GHz and 5 GHz spectrum as a transmission medium. These signals are invisible for bare eyes and interact in complex fashion with the environmental factors such as spatial layout of the facility, location and material of obstacles to RF propagation, and movement of people and objects. Ideally, one would like to have a good WLAN radio coverage over the entire facility with lowest possible WLAN access point count and minimal security exposure from the spillage of radio signals outside the facility. This white paper describes the role of RF planning in achieving this objective.

What is WLAN RF Planning?

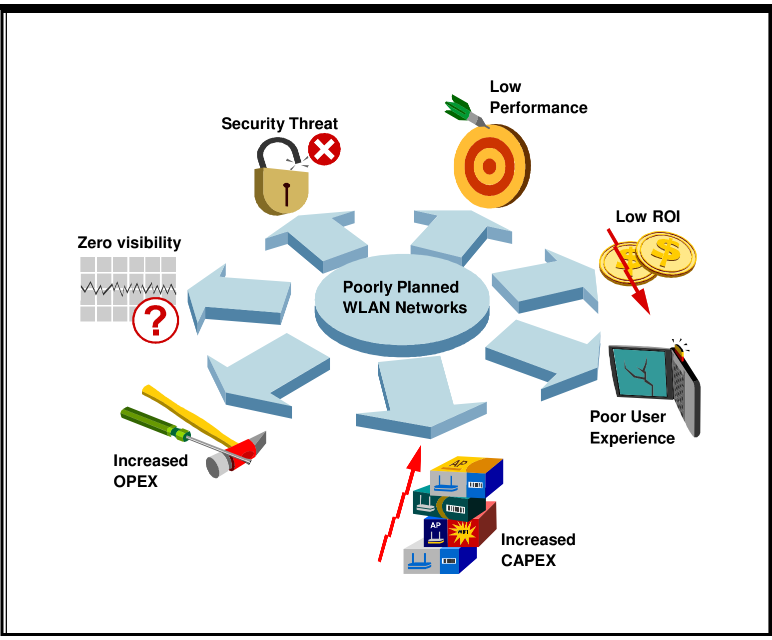
WLAN planning involves, preparing an RF landscape of the site where the network is to be deployed, compiling WLAN equipment inventory, (access points, antennas, and security sensors) and determining the location of WLAN access points throughout the site to maximize network coverage and minimize security exposure.
The RF planning provides insights into wireless coverage and its security exposure. It is essential for proper selection and placement of access points, antennas, and security sensors. However, there are a number of challenges in RF planning such as:

- **Invisible transmission medium**: WLANs operate using RF signals which are invisible to naked eye. As a result, the extent of network coverage is difficult to visualize.
- **Spatial signal variability**: RF signal characteristics at any point in space depend upon spatial factors such as path loss, obstacles to radio propagation (walls, doors, furniture etc.) in the path of the signal and signal reflections.
- **Temporal signal variability**: RF signal characteristics also change dynamically due to factors such as movement of people and objects in the vicinity, and changes in the site layout.
- **Diverse RF properties**: In-depth knowledge of RF characteristics of WLAN devices and building materials namely, pass through loss and reflection coefficient is essential for precision planning.
- **Two pronged desirable objective**: Planning for WLANs is not only about maximizing network coverage but also about minimizing security exposure from the spillage of RF signals outside the facility.
- **Application specific appliances** such as Wi-Fi phones and PDAs which do not run familiar operating systems such as Windows or Linux, do not follow security protocols and are outside the purview of IT administrators pose special challenge to WLAN planning and security.
- **Antennas play a key role** in directing WLAN radio signals to gain better coverage in some areas as well as stopping the signal from reaching other areas. Network administrators are often not familiar with this technology.

Current Approaches to WLAN RF Planning

The current process for RF planning is largely manual and/or ad hoc. Many of the WLAN deployments have started with pilot implementations and have grown organically. Network QoS and security issues arise with size
Following methods are popular today for WLAN RF planning:

- **Ad-hoc Deployment**—The WLAN grows organically with placement of access Points as needed.
- **Best Practices**—Guidelines such as one access point for per 5000 sq. ft. or one access point for every 20 users are followed.
- **Site Survey**—Access Points are placed at "best guess" locations. Signals strength is measured at sample points to check for RF coverage. This process is repeated until satisfactory coverage obtained.



Disadvantages of Poor RF Planning

Method	Limitations
Ad hoc Deployment • AP Placement based on connectivity requirement • Organic network growth	• Unpredictable network coverage • Non-optimal network deployment • No visibility into security exposure • Not scalable • Not amenable to What-If analysis
Best Practices • AP for every 5000 sq ft • AP for every 20 users	• Potential for excessive deployment or poor coverage • No visibility into security exposure • Not amenable to What-If analysis
Site Survey • Physical placement of APs for signal measurement • Iteration until signal strength is satisfactory	• Dependency on RF experts • Expensive and time consuming • No visibility into security exposure • Limited What-If analysis

These limitations lead to poorly planned networks which suffer from poor coverage, incur high capital and operational costs, and are exposed to high security risks.

Desktop Based WLAN RF Planning—A Paradigm Shift

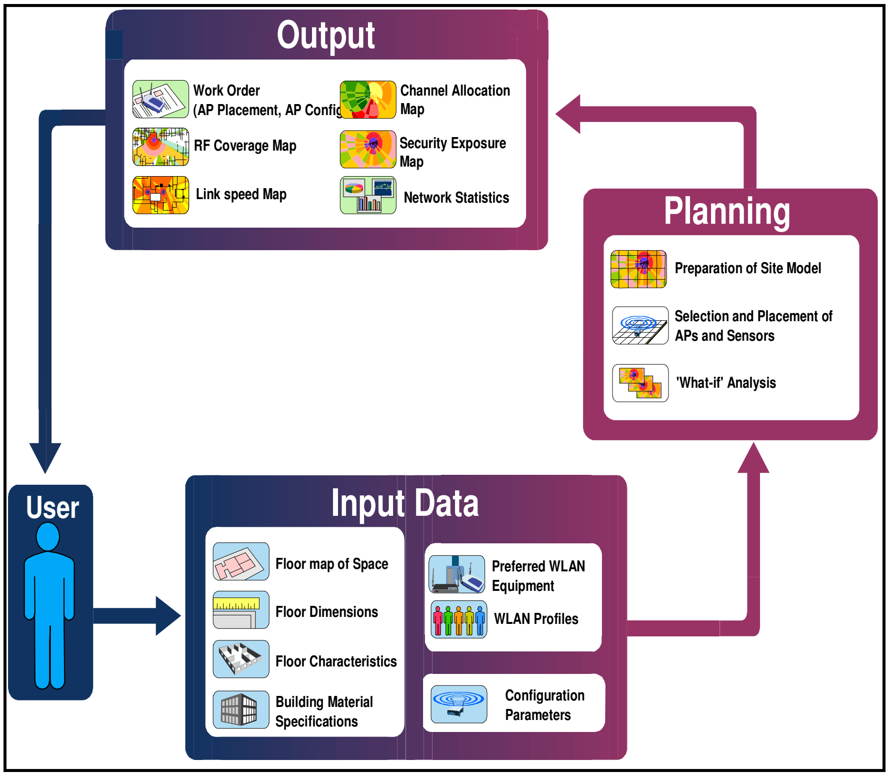
Commercial grade WLANs require an RF planning technology that simplifies the RF planning process, is highly scalable, and removes the disadvantages of poor RF planning described above. They require an RF planning technology that provides unprecedented visibility into the network coverage and security exposure, and enables the network planner to quickly perform "what-if" analysis.

SpectraGuard Planner from AirTight Networks, Inc. offers such solution via a software modeling based approach to WLAN RF planning. SpectraGuard Planner is based on the patent pending RF planning technology of AirTight. It enables "drag-and-drop" WLAN planning while beating the complexities of RF propagation from the end user. SpectraGuard Planner enables "what-if" analysis on selection and placement of network components such as access points, antennas, and security sensors. It has a comprehensive knowledge base on RF characteristics of popular access points (APs), client cards, antennas, and building materials. Also, this does not require any site visit or time-consuming manual measurements. SpectraGuard Planner covers the IEEE 802.11b/g/a protocols.

The key benefits of SpectraGuard Planner are:

- Minimized error prone, time consuming, and expensive site surveys
- Pre-deployment visibility into network coverage and security exposure
- Easy what-if analysis
- Built-in database of WLAN equipment and building material
- Correlation of predicted data with site measurements for site calibration

SpectraGuard Planner RF Planning Workflow

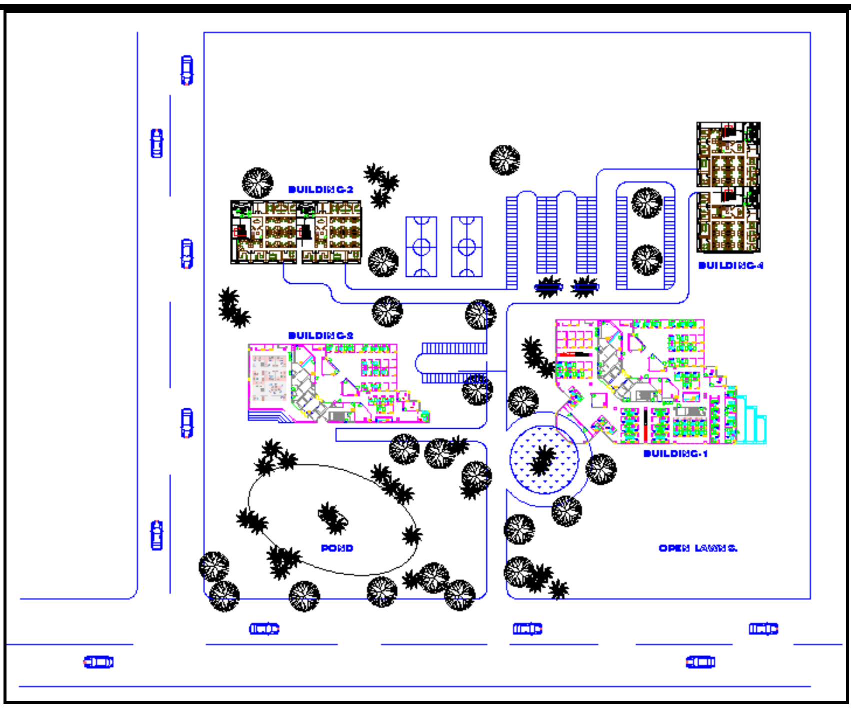


SpectraGuard Planner RF Planning Workflow

RF planning workflow in SpectraGuard Planner is illustrated here. Assume a business park spanning approximately 750,000 sq. ft (as shown in the figure "Architectural Layout of the Business Park) for which WLAN RF planning has to be carried out. The business park consists of four buildings, private roads, several trees, and parking lots. It is situated at the junction of two public roads. Building 1 has large open space in the front. Building 2 and 3 are close to one of the public roads.

The objectives of the RF Planning for this business park are:

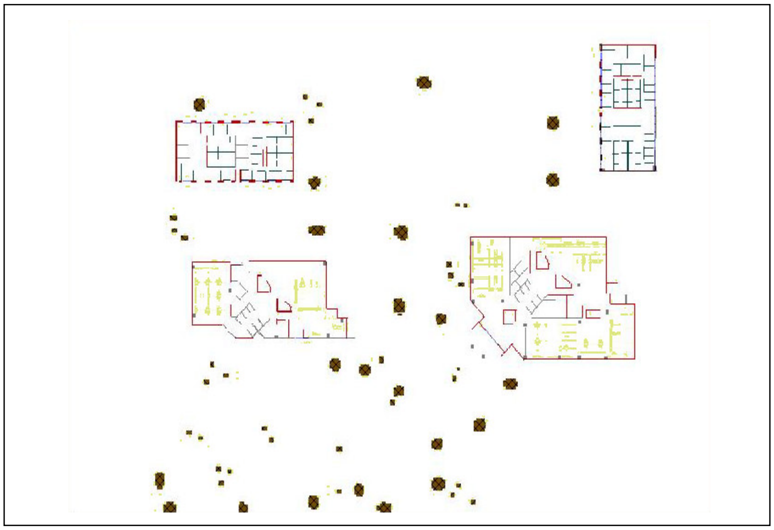
- To provide WLAN coverage in each building including open space of Building 1
- To minimize signal spillage onto the public roads
- To plan for securing the WLAN by deploying an RF sensor network



Architectural Layout of the Business Park

Preparation of Site Model

The first step in preparing the site model, would be to convert the architect's site drawings in .dxf (CAD format), gif or jpeg format into a model that can be used for RF planning. This model would consist of a site layout along with annotation of objects such as walls, windows, doors, furniture, metallic objects, isles, elevator shafts, columns, machinery, metal objects, open spaces, trees and bushes. For walls, windows, columns and furniture, it is necessary to indicate the construction material such as bricks, sheet rock, concrete, wood and metals. Accurate preparation of the site model is critical for creating an accurate RF plan. The figure below of the business park shows the site model prepared by using the SpectraGuard Planner layout modeler.



Business Park Site Model for RF Planning

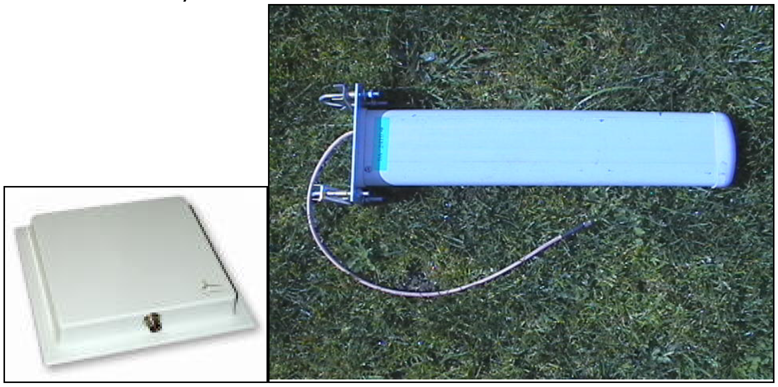
Selection of WLAN Devices

The selection of WLAN devices requires the selection of WLAN protocol, access point vendor(s), and transmission parameters such as output power and the channel.

The transmit power of an access point can be used to achieve desirable network coverage as well as to minimize the security exposure. An access point covers a larger area if its transmit power is increased and vice versa. The transmit power must always be within the admissible power level as set by the IEEE standard and enforced by local telecommunication/wireless communication regulator.

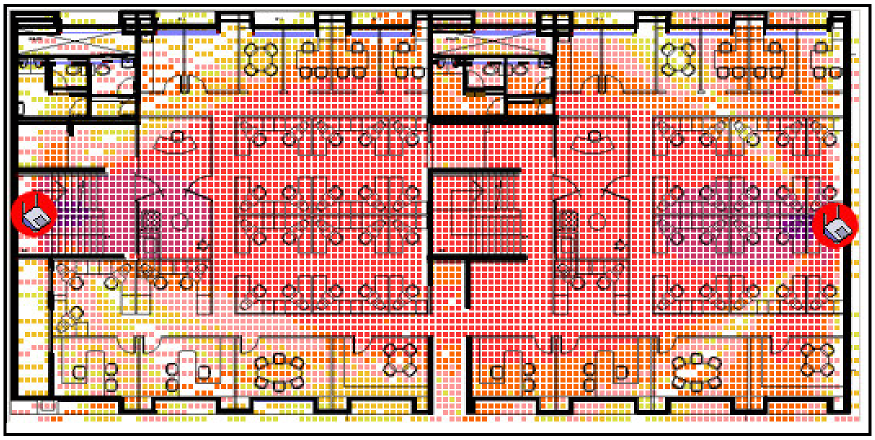
Selection of Antennas

An antenna increases WLAN RF signals in one direction while reducing the signal strength in the other direction(s). An omni-directional antenna transmits and receives equally from all directions. On the other hand, a directional antenna transmits and receives more from one direction and less from the other direction thus creating non-circular signal coverage. WLAN systems typically use an omni-directional dipole antenna for 3600 coverage and a Yagi antenna or a Patch antenna for directivity.



Patch and Yagi Antenna

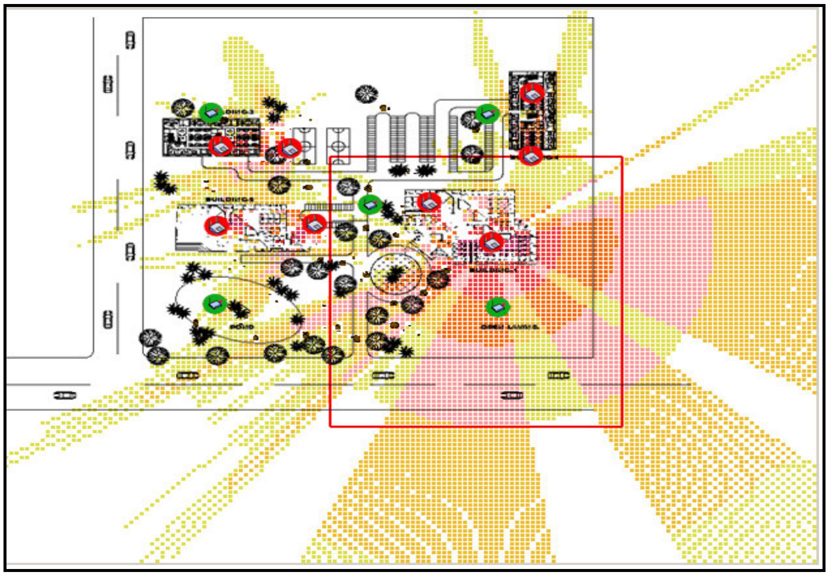
The figure below shows the use of a directional antenna to avoid signal spilling from Building 3 onto the public road.



Use of Directional Antenna to Minimize Signal Spillage

It is difficult to master a specialized field like physics of radio propagation. However, understanding how antennas direct signals and using a planning tool that embodies this knowledge is crucial to better RF planning.

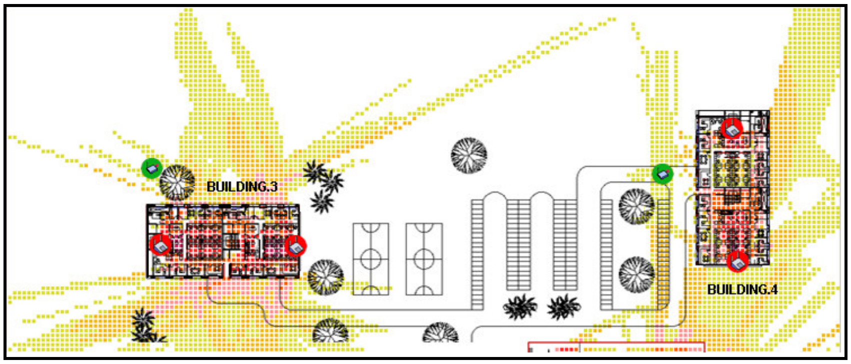
The figure below shows the use of an Omni Directional Antenna.



Omni-directional Antenna Coverage for Building 1

WLAN Device Placement

SpectraGuard Planner takes only a few seconds for the generation of signal coverage and security exposure views after the placement of devices. However, with site survey, it can consume any amount of time; from a few hours to a few weeks. Further, APs can be moved with a simple "drag and drop" operation for "what-if" analysis until the desired results are obtained. The figure below shows the APs planned for Buildings 3 and 4 and the signal coverage.

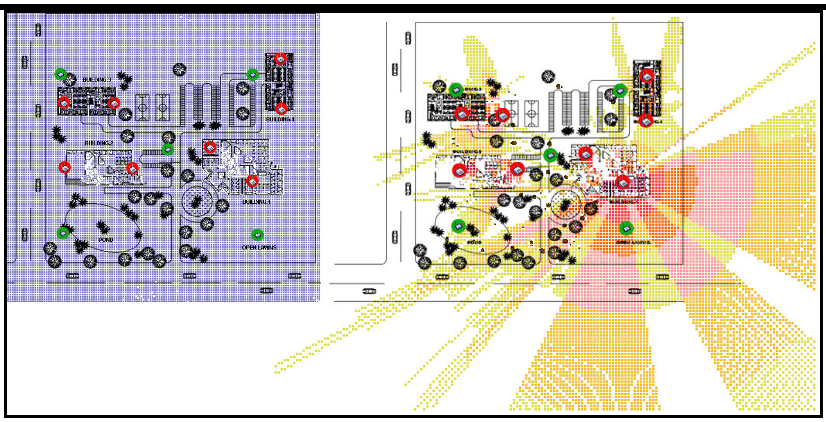


Directional Coverage for Building 3 and Building 4

RF Sensor Placement

RF Sensors are similar to access points but perform a different function. They gather information related to wireless devices in their RF visibility area and should be placed such that they can detect all transmission in the coverage space.

Sensor coverage and signal spillage (shown in the figure below) give WLAN network planners a view of the security exposure and the 'proposed' air cover to alleviate security threats arising from the deployment of WLAN network.



Sensor Coverage and Signal Spillage View

Preparation of Network Inventory

A report containing a WLAN equipment list and network views namely, Signal Coverage, Spillage, Channel Allocation, Link Speed, and Sensor Coverage is generated for each layout and the outdoor terrain. This can help in purchasing WLAN equipment as well as in installing and commissioning of the WLAN equipment.

In Summary

- WLANs are gaining widespread acceptance due to convenience and the flexibility they offer to the end users. However, there are significant challenges in RF planning for WLANs. Some of these challenges come from invisibility of RF signals and complex manner in which they interact with environmental factors.

- Current WLAN planning methods such as ad hoc deployments and manual site surveys are inadequate, expensive and time consuming when applied to planning commercial grade WLANs that demand high network performance and low security exposure.
- A desk top based planning method using RF predictive techniques is described. Key advantages of the method are pre-deployment visibility into network security and coverage analysis and easy to understand visuals.
- SpectraGuard Planner represents paradigm shift in WLAN planning. It provides solution for RF planning in commercial grade WLANs via software modeling based approach. It greatly simplifies the RF planning process, is highly scalable and removes the disadvantages of poor RF planning.

AP ID	Vendor / Model	Location From NW corner	Protocol	Channel (a, b, g)	Transmit Power (mW) (a, b, g)	Antenna (a, b, g)
AP01	D-LinkAirTM DWL-700AP	32 ft E, 86 ft S	b	-,1,-	-,50,-	Generic_5dBi Patch
AP02	Cisco_Aironet 1200_Series	137 ft E, 94 ft S	b	-,1,-	-,100,-	Generic_2.2dBi Dipole
AP03	Linksys WAP54G	113 ft E, 74 ft S	b	-,1,-	-,32,-	Generic_5dBi Patch
AP04	BreezeCom AP-100	69 ft E, 86 ft S	b	-,1,-	-,50,-	Generic_5dBi Patch,
AP05	Proxim_ORiNOCO AP-4000_US_FCC-MU	32 ft E, 50 ft S	g	-,-,1	-,-,30	Generic_5dBi Patch
AP06	Cisco_Aironet 1200_Series	154 ft E, 53 ft S	a	36,-,-	40,-,-	Generic_5dBi Patch,
AP07	Proxim_ORiNOCO AP-4000_US_FCC-MU	60 ft E, 50 ft S	g	-,-,1	-,-,30	Generic_5dBi Patch
AP08	Cisco_Aironet 1200_Series	152 ft E, 25 ft S	a	36,-,-	40,-,-	Generic_5dBi Patch
Sensor01	AirTight Networks	30 ft E, 34 ft S	a, b, g	All	100,100,100	Generic_2.2dBi Dipole
Sensor02	AirTight Networks	31 ft E, 123 ft S	a, b, g	All	100,100,100	Generic_2.2dBi Dipole
Sensor03	AirTight Networks	137 ft E, 35 ft S	a, b, g	All	100,100,100	Generic_2.2dBi Dipole
Sensor04	AirTight Networks	140 ft E, 124 ft S	a, b, g	All	100,100,100	Generic_2.2dBi Dipole
Sensor05	AirTight Networks	90 ft E, 76 ft S	a, b, g	All	100,100,100	Generic_2.2dBi Dipole