Overview

This document begins by identifying the specific radio environmental values that are needed for a successful voice deployment.

Note Cisco offers a Cisco Aironet Wireless Site Survey class for technical individuals who will be performing site surveys for wireless LAN solutions. This white paper does not replace the information in the site survey class. Cisco recommends that wireless LAN survey technicians take the Aironet Wireless Site Survey class as a requisite. Cisco also recommends that technicians study the *Cisco Wireless IP Phone 7920 Deployment Recommendations* before studying this white paper.

There are two types of wireless LAN VoIP surveys:

- A survey performed with Wireless IP Telephony (WIPT) handsets
- A survey that simulates WIPT operation

Cisco recommends that, if possible, you install the VoIP network following AVVID design guidelines before surveying for a WIPT network.

Tip Click this link to browse to a library of AVVID design guides:
http://www.cisco.com/warp/public/779/largeent/it/ese/srnd.html

Recommendations for Successful VoIP Surveys

The most effective surveys are performed using Cisco access points and Cisco WIPT handsets on active calls through Cisco's Call Manager. In the site survey, it is important that you test performance from the source to the end point and also from the end point to the source. For example, your WIPT site survey should use a wired VoIP phone (such as a Cisco 7960) in the core of the network to a WIPT (such as a Cisco 7920) handset with a live conversation going in both directions. The Cisco 7920 WIPT handset enables you to audibly monitor the quality of the call. Cisco also recommends that you use the customer's actual handset configuration when performing the survey.

Cisco considers it necessary to re-survey for voice at a site that has a trouble-free WLAN data network. Voice traffic is *isochronous*—to be usable, it must be transmitted without delay. Voice traffic has strict resource requirements for guaranteed bandwidth, low latency, low jitter, and low packet loss. The 7920 G.711 codec voice packets require a guaranteed bandwidth of 80 kbps. The G.711 packets have a 160-byte payload plus a 40-byte RTP/UDP/IP protocol overhead. Typically, voice packets are sent every 20 milliseconds (ms), and a corresponding service rate is expected from the network by the voice application. A delay or loss of two or more contiguous voice packets is generally noticeable as quality

degradation. This quality requirement also dictates the need for a fast roaming solution between access points where the network can reassociate a client to a new access point within 100 ms (that is, without suffering at most one packet delay or loss). People often walk around while talking on the phone, so users making voice calls tend to roam more than users of wireless computers. Users of wireless computers roam, but because very few users walk and use their computers at the same time, computer users are not using their computers when the roam occurs.

Because it might not be possible to have a VoIP network and WLAN network in place before the WIPT site survey, this document also describes a WIPT site survey process using standard wireless client cards and utilities.

Cisco recommends that all WIPT site surveys use diversity enabled access points and diversity antennas because a diversity configuration provides better throughput performance. A simple throughput test using an FTP data transfer of 50 MB in an office environment (with low multi-path signals) shows a 3-second improvement when using a diversity configuration. Diversity configurations are especially important in environments such as shop floors and hospitals, which often have heavy multi-path signals.

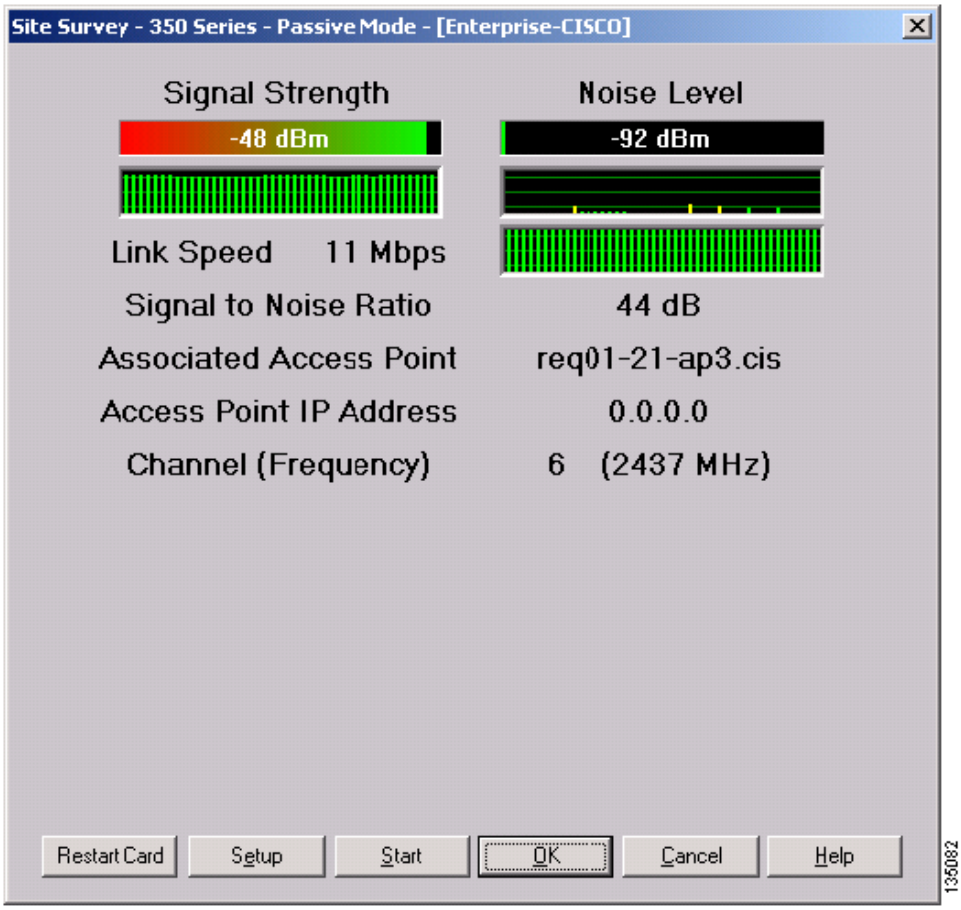
Cisco also recommends that you use 256-byte packets when you perform receive and transmit tests during the survey. Voice traffic consists of two-way transmissions, usually a burst of packets in one direction followed by a burst of packets in the other direction. You should check performance, error rates, and signal levels in both directions.

This document also describes how to use signal levels and signal-to-noise ratios (SNRs) in WIPT site surveys. WLAN site surveys that use only signal level tests are designed to identify the wireless network coverage area. Previous site surveys have shown that signal level tests alone are not sufficient for voice traffic and many times are not sufficient for data traffic. WIPT site surveys must also consider voice call capacity within a wireless cell. Currently, call loading is 7 active voice calls per channel using the G711 codec. This number is based on simultaneous requirements for data clients and quality voice calls with current data rates and packet sizes. Cisco recommends that all WIPT site surveys and installations use non-overlapping channels. For 802.11b/g operation the non-overlapping channels are a minimum of 5 radio channels apart. Cisco also recommends that you use a data rate of 11 Mbps to determine the cell size for the Cisco 7920 WIPT handset. If other data rates are allowed, call capacity might be substantially lower.

Getting started

Part of any site survey is measuring the noise level within a wireless cell. Noise levels vary from site to site and also within different locations of a site. The noise level affects a radio's ability to receive data or voice packets. Figure 1-1 uses the Cisco Aironet Client Utility (ACU) and a Cisco PCM350 client adapter to identify the noise level, signal strength, and SNR at a specific location with a wireless cell. The ACU window shows that the signal strength is –48 dBm, the noise level is –92 dBm, and the SNR is 44 dB.

Figure 1-1 ACU Site Survey Window



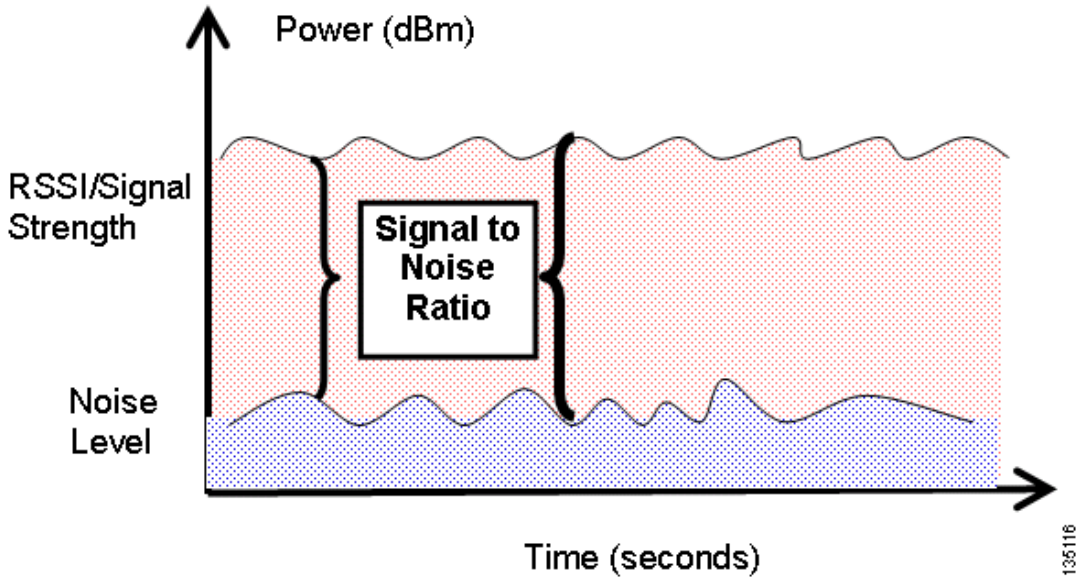
Noise is defined as a 2.4-GHz signal that is not in an 802.11 DSSS format but is in the frequency range of the access point's configured channel. The noise can originate from an 802.11 2.4-GHz frequency-hopping radio, a 2.4-GHz wireless phone, a 2.4-GHz HAM radio, a Microwave oven, or a Bluetooth radio. Signals from a distant out-of-network 802.11b or 802.11g radio may also be seen as noise. Any 2.4-GHz signal that the access point cannot decode is considered noise. However, valid data packets from 802.11b or 802.11g radios that are not associated to the access point are considered data traffic. Those packets are decoded by the access point and client devices but are discarded. However, they increase the channel utilization on the access point, thus limiting the number of voice clients that can associate. Same-channel interference must be minimized.

If the signal strength on a valid packet is higher than the receiver threshold of the access point radio or the client device radio, the data packet is decoded. Most 802.11 radios have a receiver sensitivity value of –94 dBm to –85 dBm at a data rate of 1 Mbps (the lower the dBm value, the better the radio's receiver sensitivity). Radio receiver sensitivity changes with data rates; for example, an access point radio might have a receiver sensitivity of –94 dBm at 1 Mbps, but the radio sensitivity might be –84 dBm at 11 Mbps.

The access point discards random data traffic--valid packets that can be decoded but which are not from clients associated to the access point. Random data traffic can originate from a shared media or from a client device that is transmitting at a data rate that the access point does not support.

In Figure 1-1, the noise level reported by the ACU is –92 dBm and the PCM350 receiver sensitivity at 11 Mbps is –84 dBm, which provides a margin of 8 dB at the receiver. A signal strength value of –48 dBm less the noise value of –92 dBm equals an SNR of 44 dB as reported by the ACU (see Figure 1-2).

Figure 1-2 Signal to Noise Ratio



Minimum Requirements for WIPT Cells

Table 1-1 lists the minimum values for voice and data cells. For WIPT cells, Cisco recommends that the cell edge be –67 dBm and the SNR be 25 dB using a data rate of 11 Mbps. These values are much more restrictive than those needed for data because of the sensitivity to delays and retries for voice clients.

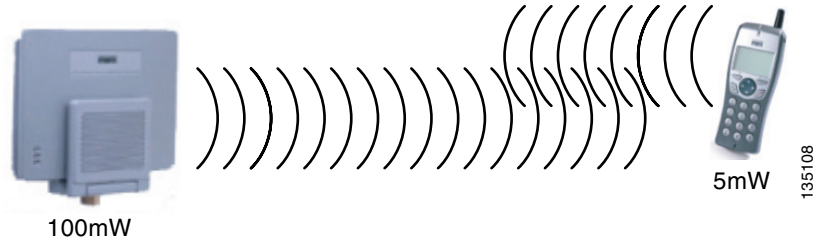
Table 1-1 Minimum Signal Strength and Signal to Noise Ratios for Voice and Data Cells

	Data Cell		WIPT Cell	
Data Rate (Mbps)	Minimum Cell Edge Signal Strength	Minimum SNR	Minimum Cell Edge Signal Strength	Minimum SNR
54	–71	25	—	—
36	–73	18	—	—
24	–77	12	—	—
12 or 11	–82	10	–67	25
6 or 5.5	–89	8	–74	23
2	–91	6	–76	21
1	–94	4	–79	19

Figure 1-3 shows how the difference in transmit powers between the access point and the WIPT client creates different effective ranges. The 5 mW signal probably would continue all the way to the access point, but if the access point antennas do not have enough gain to make up the difference in received signal of the WIPT client, then the WIPT packets will not be decoded. A high-gain antenna on an access point will receive a signal from a 5-mW client from a greater distance than a low-gain antenna. It is the

difference in transmitter power and receiver sensitivity that matters because the gain of an antenna is reciprocal. To verify the cell coverage edge of –67 dBm while the client is actively sending and receiving voice size packets, check the access point's Station Information and Status page for a dBm value of –67 dBm or higher.

Figure 1-3 Transmit Power Imbalance



The Ideal WIPT Environment

Figure 1-4 shows the ideal WIPT cell with the recommended cell edge signal strength value of -67 dBm at an 11-Mbps data rate and the recommended same-channel separation of 19 dBm at an 11-Mbps data rate. The two yellow cells have a cell edge of –67 dBm. The measured overlap of a channel should not exceed –86 dBm (from the center of the measured cell to the edge of the neighboring cell of the same channel). This is the value of –67 dBm plus the 19 dBm for separation. Keeping the separation at 19 dBm between same-channel cells produces a cell with minimal throughput degradation because of media contention. This helps maintain up to 7 good-quality WIPT calls in a cell.

Figure 1-4 Ideal WIPT Environment

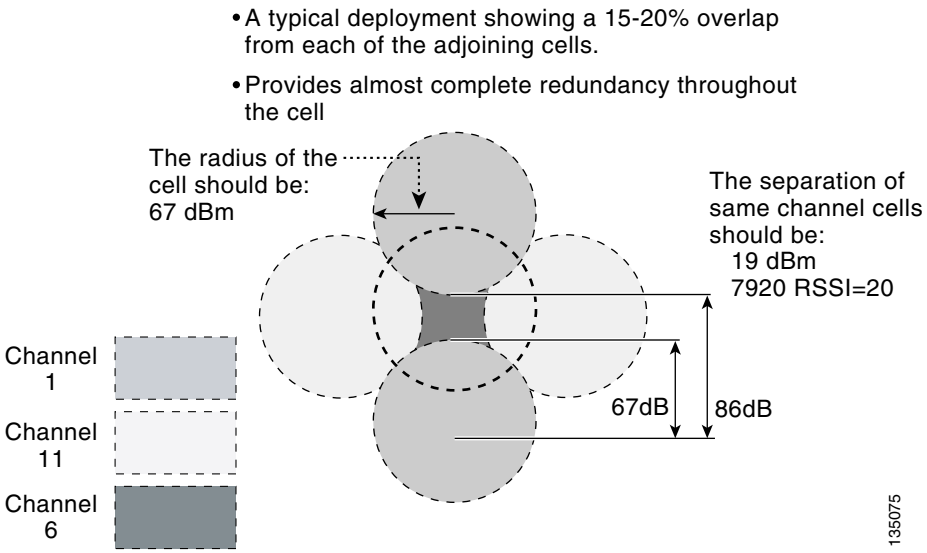


Figure 1-4 also illustrates the recommended overlap of 15 to 20 percent for WIPT cells (larger than the 10 to 15 percent for data cells). The reason for the increase in overlap is to provide enough capacity for quality calls, efficient roams, and better load balancing. With a 15% to 20% overlap the call capacity would be double that of a cell without overlap. However, it is important to avoid excess overlap because it can cause frequent roams by the WIPT clients which may result in lower quality calls.

Data Rate and Signal Strength Considerations

You should consider data rate and signal strength before beginning any WIPT site survey. Signal strength or transmitting power of the access point radio combines the configured transmit power of the access point and the antenna attached to it. If an additional antenna cable is placed between the access point and the existing antenna cable, there is a loss in transmitted power. Generally, the longer the cable between the access point and the antenna, the lower the transmitted signal strength will be. The combination of radio transmit power, antenna cable loss, and antenna gain is known as Effective Isotropic Radiated Power (EIRP). For example, if the 100mW transmit power of the radio equals 20 dBm, the loss of a 100-foot cable is 6 dB, and the gain of an antenna is 3 dBi, the result is an EIRP of 17 dBm. Using the EIRP value of 17 dBm from this example and considering the receiver sensitivity of the Cisco 7920 radio, the coverage area in an open office without noise would be about 140 feet from the access point at a data rate of 11 Mbps.

This example highlights the guidelines for surveying for the Cisco 7920 WIPT handset. Cisco recommends an access point data rate configuration of 11 Mbps for WIPT cells. The faster data rate means that packets take less time to be received and results in higher call quality. The 1-Mbps data rate has a theoretical throughput of 650,000 bits per second for 256-byte packets. The codec used by the Cisco 7920 has a packet size of 236 bytes. The data rate of 11 Mbps has a theoretical throughput of 2,000,000 bits per second for 256-byte packets. This means the Cisco 7920 packets require almost 4 times more time at the 1 Mbps than at the11-Mbps data rate. Another important reason for using the 11-Mbps data rate is the reduced cell size. At 11 Mbps, the 802.11b/g radio of the access point has an open office cell size with a radius of 160 feet. The 1-Mbps cell size for the same radio has a radius of over 400 feet. The larger the cell size, the more clients that can be active in the cell. For the Cisco 7920, we recommend only 7 handsets in a cell, which results in better quality calls.

The data rates configured on the access point depend on the other types of client devices used at the customer site. The customer might have an installed base of legacy 802.11 clients that require support of a 2-Mbps data rate. It is highly unlikely that any 802.11b network would need support for a data rate of 1 Mbps. This rate should be disabled because it uses long headers, and the slowest required data rate is the data rate used by the access point to send 802.11 control and management packets. Other configuration parameters that could have negative impact on legacy 802.11 performance are short headers and beacon rates. The 350 series access point, the 1100 series access point, and 1200 series access point running Cisco IOS software default to short headers, as do the Cisco 7920 handsets.

Note Older clients might require long headers. The Cisco 7920 works correctly with long headers, as should all client devices.

802.11b might use a long 144-bit preamble or a shorter 72-bit preamble. The short preamble cuts 96 ms off the transmission time of every packet. It can significantly improve performance, especially for smaller-sized voice packets. There is a throughput hit with long headers of about 500,000 kbps with a 256-byte packet at the 11-Mbps data rate.

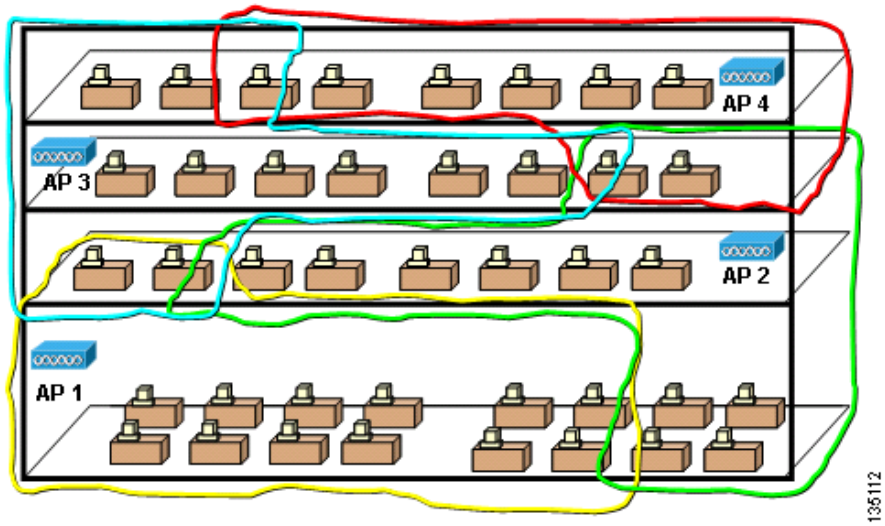
Note An 802.11 transmission channel is simplex only. Only one device can transmit at a time, exactly like shared Ethernet.

The characteristics of VoIP require a meticulous WIPT site survey. To avoid a call with jitter, the delay variation between packets should not exceed 30 ms. The one-way delay should not exceed 150 ms and packet loss should not exceed one percent. Surveying for a one percent packet loss is important because VoIP uses the Real-Time Transport Protocol (RTP), which does not retransmit for lost packets. Voice packets are small but are sent at consistent intervals. The 7920 client assumes that it has lost its connection to an access point if it misses 3 consecutive beacons. The access point sends a beacon every 100 ms, which means that the Cisco 7920 looks for another access point if it does not see beacons every 300 ms from the access point to which it is associated.

Multi-floor survey

At many sites it is important to consider the effect of above-floor and below-floor coverage. An antenna placed near a ceiling in a multi-floor facility can easily provide coverage to the floor above. There will be considerable loss in dBm signal strength, but the signal can still have enough quality to be usable. Depending on the capacity, throughput, and coverage requirement for the site, the power of the access point may be turned down to minimize the signal coverage between floors. An Omni antenna propagates directly above it into the floor above. A patch antenna will also propagate signal into the floor above, but not directly above as the Omni antenna will. Although directional antennas help focus the signal energy in a particular direction, which can help to overcome fading and multipath signals, multipath signals reduce the focused power of a directional antenna and the amount of multipath seen by a user at a long distance from the access point can be much greater. Directional antennas used indoors typically are low gain (5 dBi to 10 dBi), and therefore have lower front-to-back and front-to-side lobe ratios. This reduces the radio's ability to reject or reduce the interference signals received from directions outside the primary lobe area. A low-gain directional antenna, such as a 6.5-dBi patch, will receive signal from the sides and the back, but the primary coverage area will be forward. The coverage in Figure 1-5 represents an Omni antenna coverage. The cell coverage overlap and same-channel separation should be maintained at a multi-floor site.

Figure 1-5 Survey in a Building with Multiple Floors



Different types of facilities, such as hospitals and schools, have different signal propagation patterns, multipath levels, and attenuation levels.

Comparison of a Manual Survey and an Automated Survey

Figure 1-6 shows an actual hospital survey done using AirMagnet Surveyor with an 802.11b Cisco PCM350 client card. Four panels on the AirMagnet window show the survey results. The top-left panel shows that the survey data was collected in passive mode. The middle left panel shows the access points seen by the survey client while doing the passive mode walkabout to collect survey data. The right panel shows the floor plan that was imported and the strength of signal as reported by the client walkabout for the survey area. The dark green to light blue colors indicate that the signal strength on the floor of the hospital wing varied from -30 dBm to -55 dBm. The five access points that are located on the floor are tagged with their MAC addresses. The room walls on this floor had 6 dB of attenuation and the doors had 7 dB of attenuation. The through-floor attenuation was 7 dB.

Figure 1-6 Hospital Floor Survey with AirMagnet Surveyor

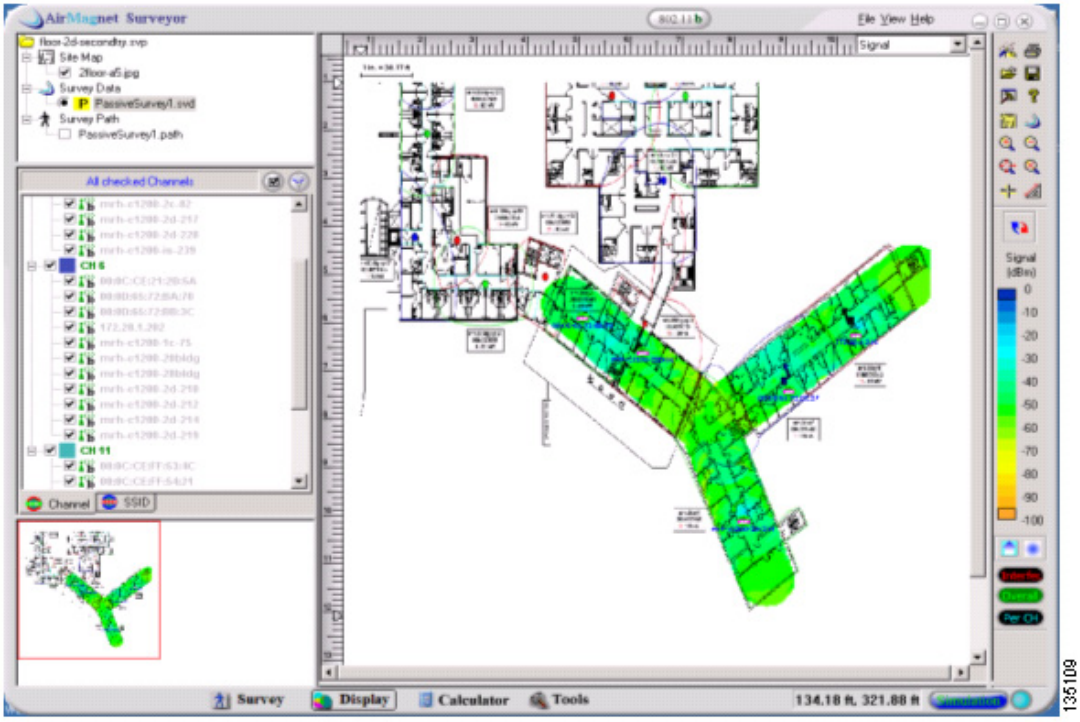


Figure 1-7 shows the manual survey results of a group of survey engineers. The AirMagnet Surveyor report shows a remarkable similarity to the manual survey. The survey in Figure 1-6 shows that throughout the floor the signal is above -65 dBm. The manual survey was done with a cell edge requirement of -65 dBm. The manual survey was completed several weeks before the AirMagnet Surveyor survey. The floor plans used for AirMagnet Surveyor were imported from the drawings provided by the contracted survey team. By necessity, the survey team spent a great deal of time determining the proper location, power settings, and antenna types to be used on the floor. However, the AirMagnet Surveyor provided an updated survey in a couple of minutes from a walkabout that took less than 20 minutes.

Figure 1-7 Hospital Floor Survey by a Survey Crew