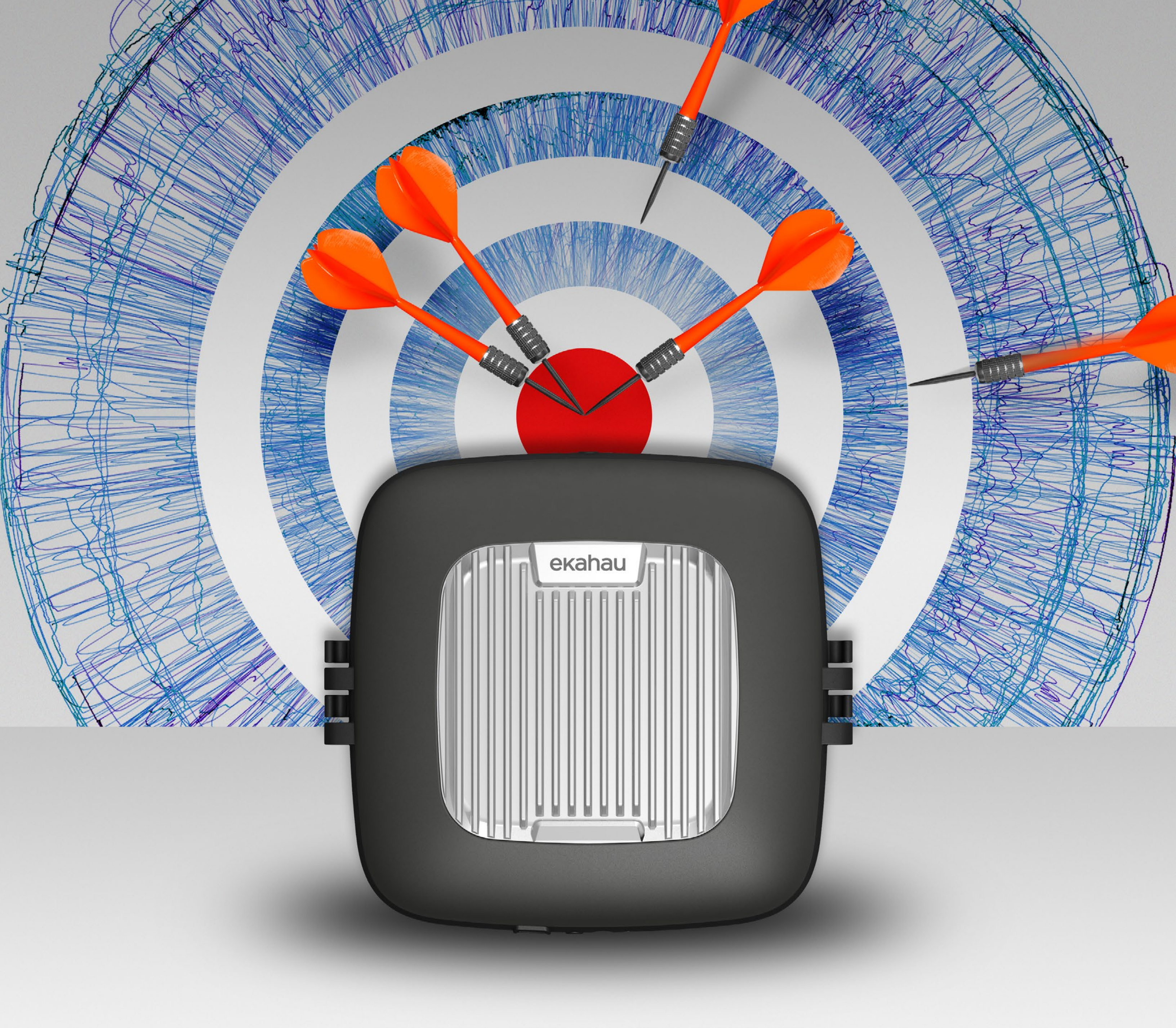

Bad Measurements Make a Bad Network:

How to Boost the Reliability of Your Wi-Fi

ekahau
WIRELESS DESIGN

Contents

Executive Summary

Wi-Fi is a mission-critical tool in virtually every industry sector. In business, retail, manufacturing, healthcare, education, and beyond, users need access to secure, reliable Wi-Fi to do their jobs.

Having a spotty or slow network is no longer acceptable. Wi-Fi professionals need to design and deploy reliable Wi-Fi that meets customer needs in a timely and cost-efficient manner. Accurate site survey measurements are critical to making this possible.

Unfortunately, the traditional, commonly used USB-based Wi-Fi adapters provide inconsistent and inaccurate measurements. This leaves Wi-Fi professionals with an incomplete, often false picture of the network performance. The problem is compounded when these adapters are employed to re-survey the site after the network problems are fixed.

Their imprecise readings can result in additional hours, or even days, of re-work that may result in a larger hardware investment that not only doesn't improve performance but may diminish it even further.

These risks can be avoided with the Ekahau Sidekick®.

This application note details the results of an external professional-grade lab comparing the performance of Ekahau Sidekick and USB-based Wi-Fi adapters Proxim 8494 and Comfast CF-912AC. Findings from these tests show that the Ekahau Sidekick is a substantially more accurate tool and will help boost the reliability of Wi-Fi networks with better measurement data.

Risks of Imprecise Signal Strength Readings

Wi-Fi professionals have a critical job to do and the last thing they need is their reputation to take a hit due to inaccurate measurement data. In fast moving technology businesses, professionals typically want to stay ahead of the curve when it comes to new and better tools and solutions.

Using outdated technology puts them in an unfortunate position with misleading data about the technical parameters of the network performance. By using traditional tools like USB dongles and Wi-Fi adapters (for example, Proxim 8494 or Comfast CF-912AC) for signal strength measurements, the surveyor may or may not be able to deliver sufficiently accurate measurements. Since accuracy depends on walking direction, posture, as well as the angle in which the measuring device is held in relation to access points, users can be lucky and achieve reasonable results. However, the problem is they can't be certain that the measurements are correct or repeatable which creates a false sense of security during the design process.

USB adapters have been used for Wi-Fi measurement for years, but this is simply because purpose-built measurement devices were not available. USB adapters were created as add-on components for laptops lacking the latest Wi-Fi technology. Their primary purpose has been to establish decent wireless data connection, and not to measure RF signal strength precisely. Thus, it's unsurprising that signal data is highly compromised when relying on these devices for accurate measurements.

Wi-Fi professionals care about doing good work and the last thing they want to have happen is to get a barrage of user complaints about the network performance causing re-work. It's expensive and time-consuming to go back and correct errors forced by poor signal readings during a site survey – if the source of the errors can even be found. Without accurate tools to re-survey the site, Wi-Fi professionals run the risk of making changes that only cost the customer more money – without actually solving the problem.

Accuracy in Wi-Fi Design Matters

If you're dubious about this statement, consider what can happen when you design your Wi-Fi network based on signal strength readings that are inaccurate.

Let's look at an example.

Below are two signal strength heatmaps. In Image 1 the building is surveyed with the Ekahau Sidekick. Against the set performance requirements, this network looks as if it will perform well. A few areas exhibit slightly smaller margin (yellow areas), but overall the minimum requirements are met.

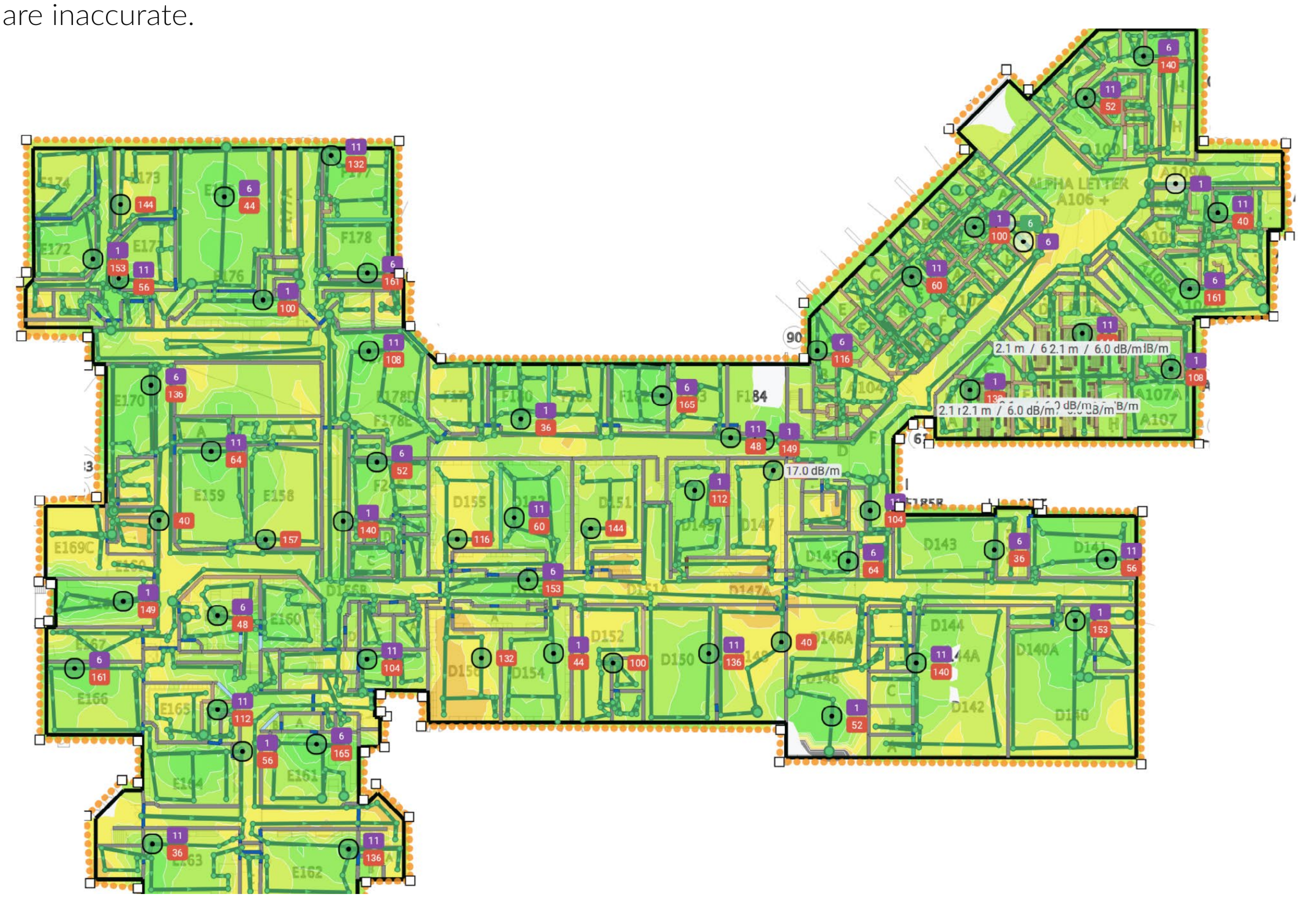

Image 1: An example of a heatmap with accurate signal strength measurements

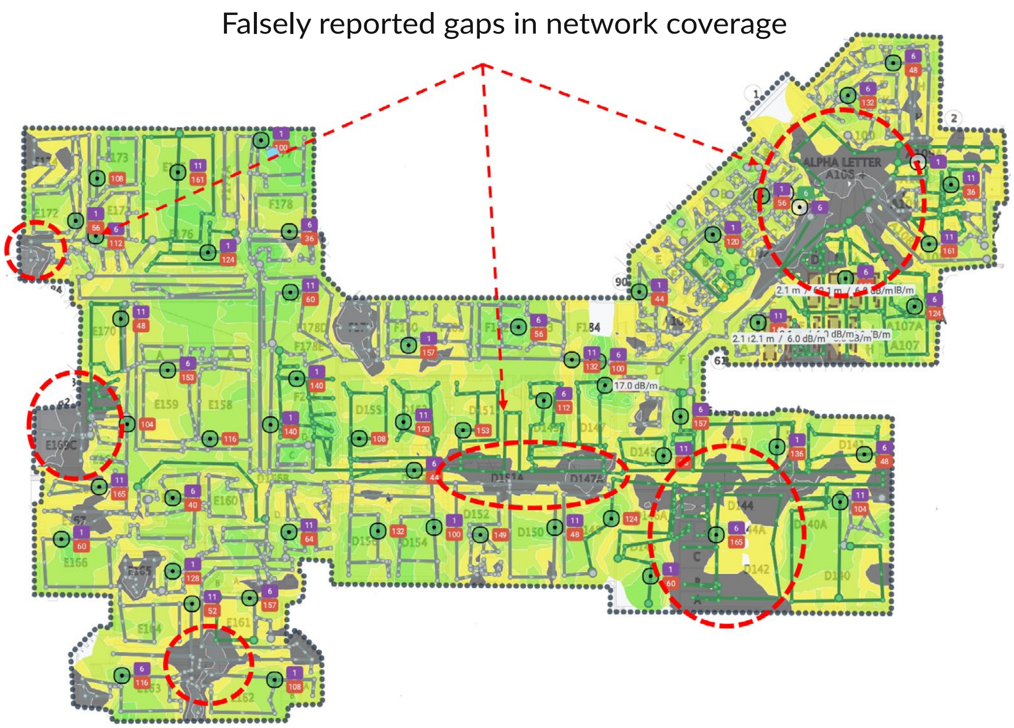

Image 2: A signal strength heatmap of the same network, generated by a less accurate device

Now let's look at another heatmap for the same network, floor and access points in Image 2. This time the data is visualized by readings from a less precise survey tool.

In this scenario, we see that network coverage appears to be good in most areas, but in other areas the performance requirements look as if they were not met.

However, in reality, this is not the case. The spotty signal coverage is not because the signal strength was low, but rather because the measurement data was negatively affected by the poor accuracy of the measurement device.

The direction in which the surveyor walked versus the access point location clearly impacted the measured signal strength. In some locations the signal was measured weaker than it actually was, simply due to the direction the surveyor was facing. Imprecise measuring devices can pick up signal strength differently depending on access point direction and resulting angle. If the surveyor had walked a different way, the heatmap might look different.

If the Wi-Fi designer only had the heatmap in Image 2 available, what would need to be fixed to solve the problem? Most likely the Wi-Fi professional would install a few additional access points (APs). In this specific case there were originally 58 APs.

To fix the falsely assumed coverage gaps they would probably plan to add 9 additional APs, and with those they would expect that the coverage gaps problems had been fixed.

But, in fact, as shown in Image 1, the requirements *were* already met: **The network wasn't bad, only the measurement data was. All that would have been accomplished was making another 15% investment into network infrastructure to fix an imaginary problem.** Plus, by adding extra access points, they would also increase the overall interference level, degrading the data rates and capacity for network users- not to mention the hours spent installing more access points that weren't really needed.

After deploying those new access points, if an imprecise tool was once again used in the follow-up survey, the data could again be spoiled by inaccuracies, making troubleshooting difficult.

To summarize, less accurate survey device created several issues:

- Prompted additional hardware investment, and generated unnecessary expenses
- Resulted in a slower network with overall smaller capacity
- Cost the Wi-Fi designer wasted time installing and testing additional hardware
- Created a troubleshooting nightmare by using an inaccurate device
- Weakened the professional credibility of the Wi-Fi designer

This is a situation no one wants to be in. Fortunately, the risks of inaccuracy in Wi-Fi are balanced by the of benefits to doing the job right and conducting an accurate survey.

Good measurements enable a good design that equals good Wi-Fi. At a time when secure and reliable Wi-Fi is mission-critical, Wi-Fi professionals have the opportunity to help their clients reap important benefits such as:

- Enhanced communication and productivity in business, manufacturing and warehouse environments
- Boosted customer experience and loyalty in retail establishments
- Improved customer satisfaction in hotels
- Expedited access to data that can save lives in hospitals
- Increased access to knowledge and learning opportunities in schools and universities

Wi-Fi professionals can create these benefits for their customers by using tools that enable better Wi-Fi design through accurate signal strength readings.

Accurate Signal Strength Readings:
The Key to Good Wi-Fi Networks

Signal strength is the key parameter to signal-to-noise ratio (SNR) which dictates the available modulation methods and maximum bit rates.

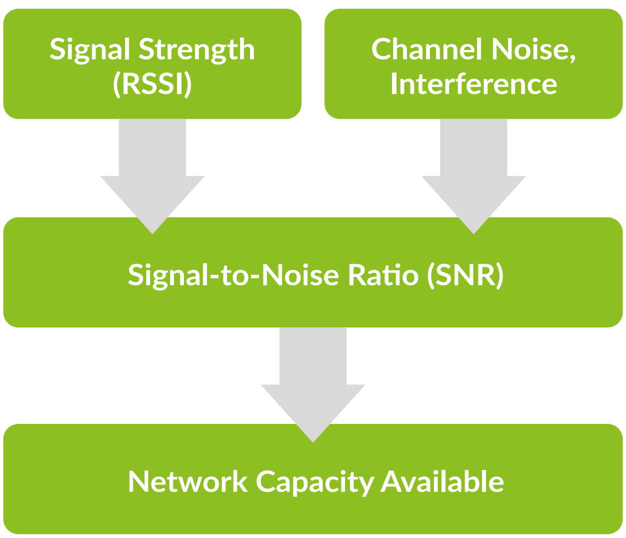

Image 3: Signal strength (RSSI) is the fundamental technical metrics to design for

If the signal strength is weak it means network capacity is limited. On the other hand, unnecessarily high signal strength leads to unwanted network capacity limitations in the form of additional interference with other access points.

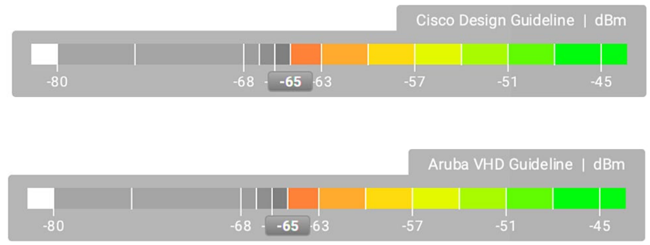

Image 4: Each network vendor has their signal strength requirement guideline for great Wi-Fi design

To reliably strike the right balance with signal strength, network vendors provide design guidelines for network planning purposes. However, in order to verify that a network really meets these requirements, there needs to be accurate data measurements. A variety of factors can hobble the measurements and making them unreliable:

- RF environment fluctuations
- Various survey device antenna design constraints
- Impact of surveyor behavior, including the route taken during the survey, how the device is carried, or at what speed
- Compromises in electrical or RF engineering of the measurement device
- Manufacturing variability due to component, material or assembly process inaccuracies

Bad data resulting from any of these can put Wi-Fi professionals in the undesirable position of making critical decisions based on guesses.

To illustrate what this looks like on a site survey, consider one physical location on the floor plan in Image 5. To make it simple, assume the signal strength is measured several times in the same location (circled in red). In a normal situation multiple measures of the same spot in a site survey would not typically happen but this experiment can be revealing.

Each star symbol in the heatmap legend below represents a single measurement in the specific red circle location. We can see the wide range of dBm values measured by Device A in green, compared with Device B in red.

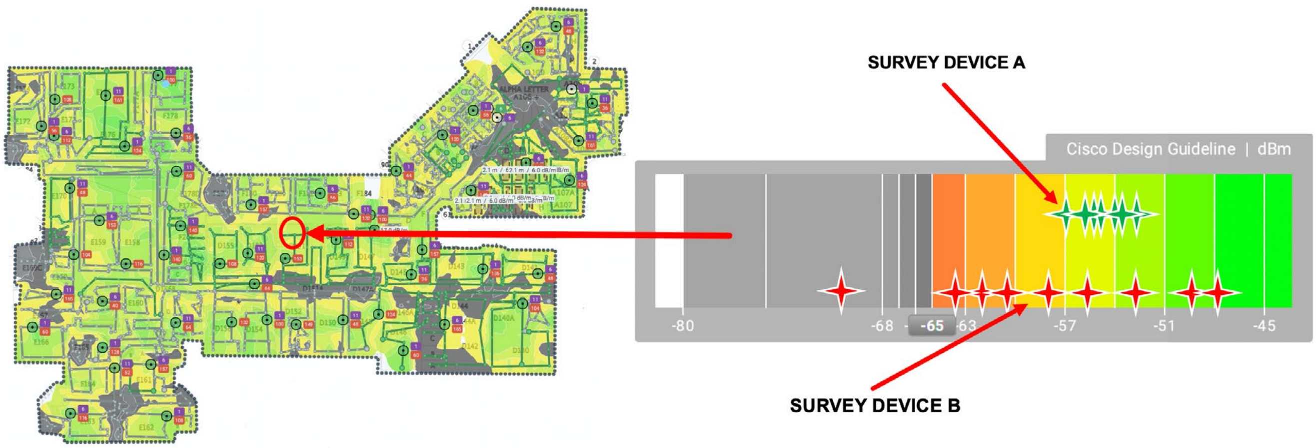

Image 5: Repeated survey device measurements of the same location generate different values. Each cross in the heat map on the right represents a single RF measurement of the space in the red circle in the floor plan on the left.

For Device A, the distribution and center point of the measurements on the dBm scale are nicely packed mostly over a single-color band (around yellow), while survey Device B's measurements are spread widely along the scale (from grey to green).

For any professional Wi-Fi designer, it's obvious that survey Device B is not a very reliable data collection tool. The measurement data for the very same location ranges widely from good to bad.

It's difficult from this data to conclude whether the network is performing well or poorly, and within what margin. Do we need more access points? Or is this location well-covered?

Fortunately, this uncertainty can be eliminated from your site surveys. Using a survey device that offers consistently accurate readings, Wi-Fi professionals can trust their measurements.

External Testing Proves Ekahau Sidekick is the Most Accurate Survey Device on the Market

To quantify Ekahau Sidekick's accuracy, Ekahau commissioned an external RF lab specialized in product verification and validation services. This lab conducted a series of tests comparing the Ekahau Sidekick, the Proxim 8494, and Comfast CF-912AC USB adapters. The testing confirms that Ekahau Sidekick consistently outperforms the adapters by a significant margin, proving that it's the most accurate survey device on the market.

How the Devices Were Measured

Test setup is illustrated below. These tests were executed in a professional room-sized RF isolated anechoic test chamber to eliminate external noise, unwanted signals and multipath components (i.e., reflections).

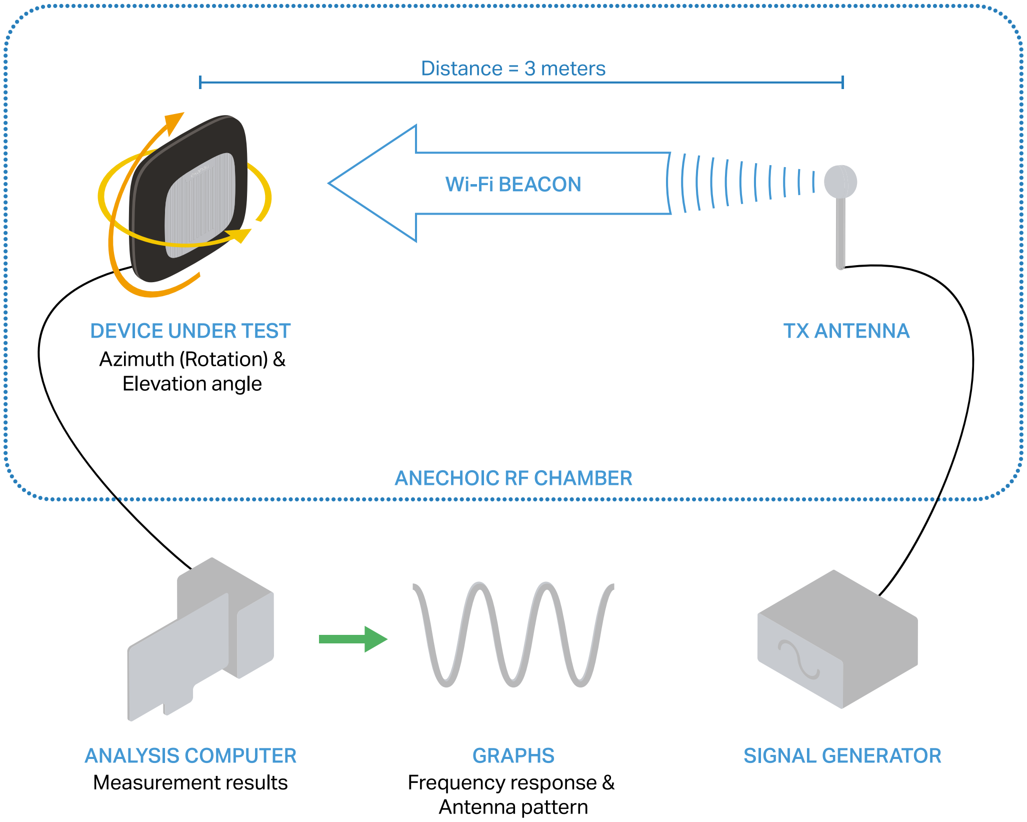

Image 6: Test arrangement for the measurements in the RF laboratory

A laboratory-grade vector signal generator (Anritsu MS2692A) was used as a transmitter to generate 802.11g 6 Mbps OFDM modulated Wi-Fi beacons. The signal generator was connected to a specially designed transmit (TX) antenna in which both vertical and horizontal polarization were able to be connected separately without physically turning the antenna. The transmit power level at the signal generator was set at 0 dBm. The attenuation/gain of the cabling and antenna were accounted for. During testing it was possible to automatically set the TX frequency to any Wi-Fi channel as well as any chosen polarization.

The Device Under Test (DUT) was placed 3 meters from the transmitting antenna, escaping the effects of the near-field area, and was attached in the automatically adjustable turning table with two axes. Axis one enabled horizontal rotation of the device (azimuth angle), simulated a variety of walking directions toward the transmitter. Azimuth angles were tested across 360 degrees. Axis two enabled elevation angle adjustment across 180 degrees, simulating the impact of the access point on different elevations. Angle adjustment was always fixed at 15 degrees.

The TX antenna remained in place in all DUT tilting, but the effect was the same as if the TX antenna had varied its angles. With all these angle variations, polarizations and Wi-Fi channels, there were several thousand different test points covered.

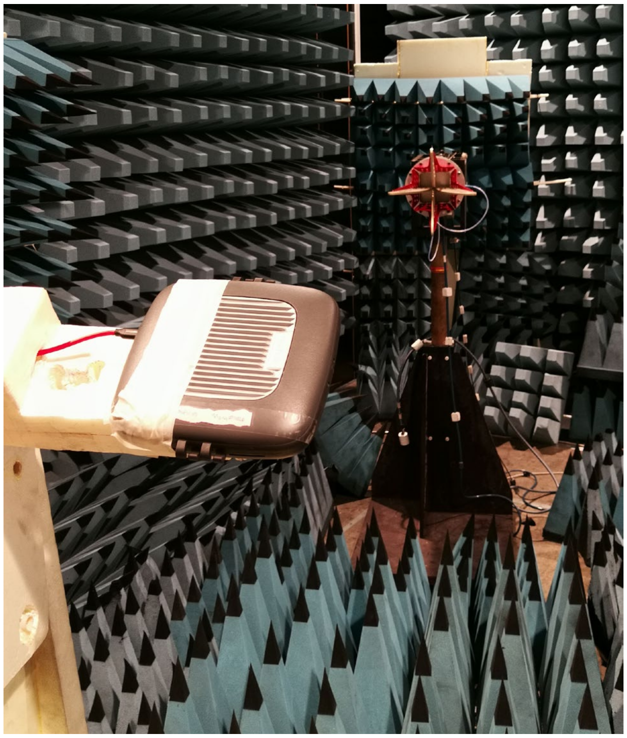

Image 7: Test setup in the RF laboratory

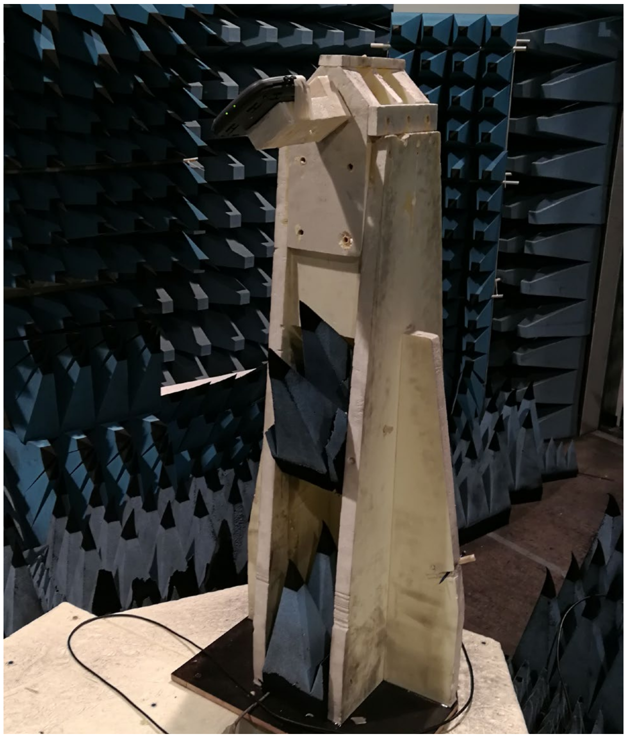

Image 8: Rotation table for device under test (DUT)

1st Key Finding: Sidekick Offers Unmatched Precision

Using the test setup described above, the lab gathered measurement data, using a vertically polarized transmitting antenna, to draw the complete frequency response and its variation.

The following graph measures **frequency response** – or measured signal strength as a function of Wi-Fi channel, i.e. frequency – for the Ekahau Sidekick. Each measurement per Wi-Fi channel is plotted as a small dot to illustrate the distribution. Variation between the lowest and highest signal strength measured on each channel is highlighted in blue. The median curve is drawn in blue over the Wi-Fi bands, showing average signal strength on that channel.

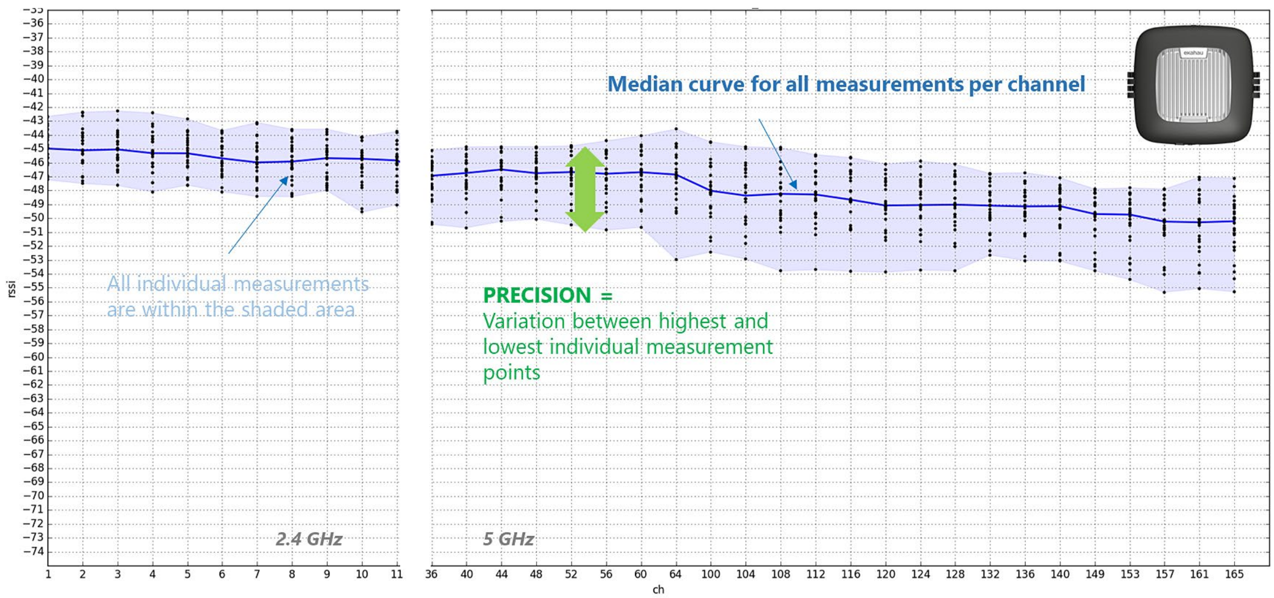

Image 9: Frequency response variation for the Ekahau Sidekick

The fundamental concept of accuracy, precision, is very visible in the graph. **Precision represents the random variation in the measurements, something that makes the measured values spread around some middle point when the measurement is repeated.**

Numerically speaking, the variation in Ekahau Sidekick is on average a bit over 5 dB, ranging from 4 dB (Ch1) to 8 dB (Ch64), which is a rather narrow range of uncertainty in signal strength measurement. This represents very good precision, especially considering that the test set up simulates many different angles from which access point signals would be received in a practical survey.

To put this in context, the lab conducted the same test on other typical survey devices: first with the Proxim 8494 USB adapter, traditionally considered the reference quality survey adapter, and lastly with the Comfast CF-912AC USB survey adapter, the lower cost option. Their frequency response graphs are below.

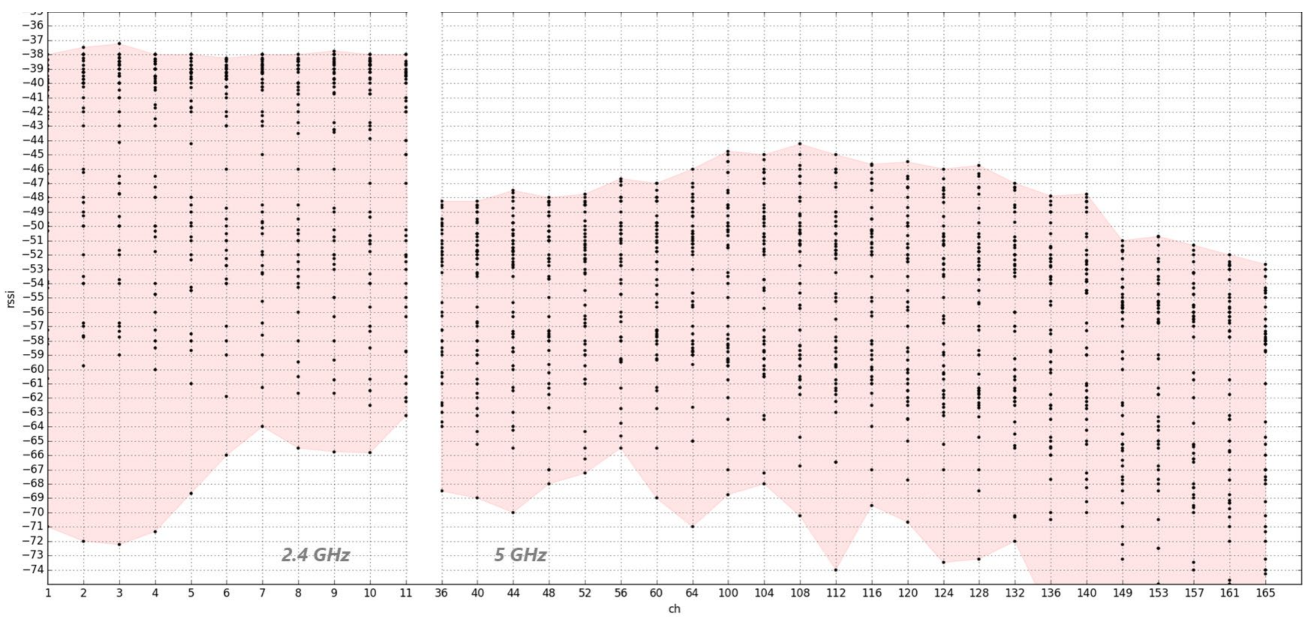

Image 10: Frequency response variation for the Proxim 8494

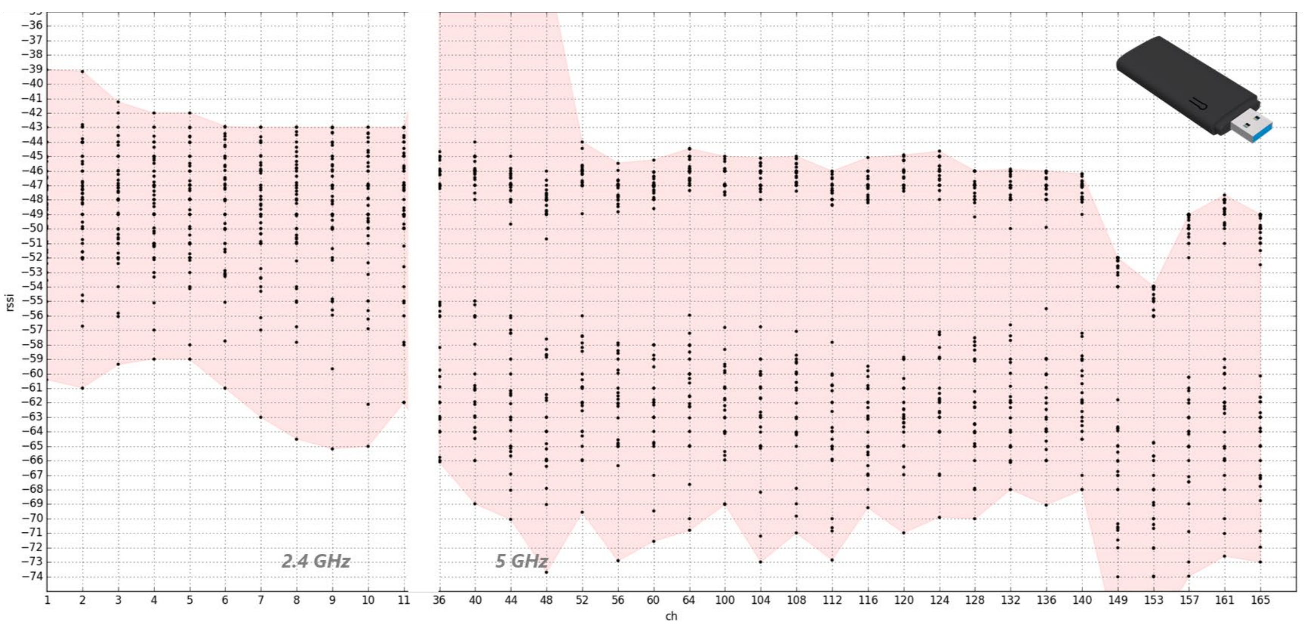

Image 11: Frequency response variation for the Comfast CF-912AC

With both USB adapters the variation is much wider. In the case of Proxim 8494 in Image 10, it is on average 26 dB (19 dB to 35 dB). And in the case of Comfast CF-912AC in Image 11 it also is approximately 25 dB (17 dB to 42 dB).

Precision of both adapters is mostly compromised by poor antenna patterns that cause the received signal to vary highly, depending on direction and angle of the adapter. In other words, how accurately the adapters measure signal strength largely depends how they are held by the user during the survey. Walking direction in relation to \AP location further impacts the precision of signal strength measurement.

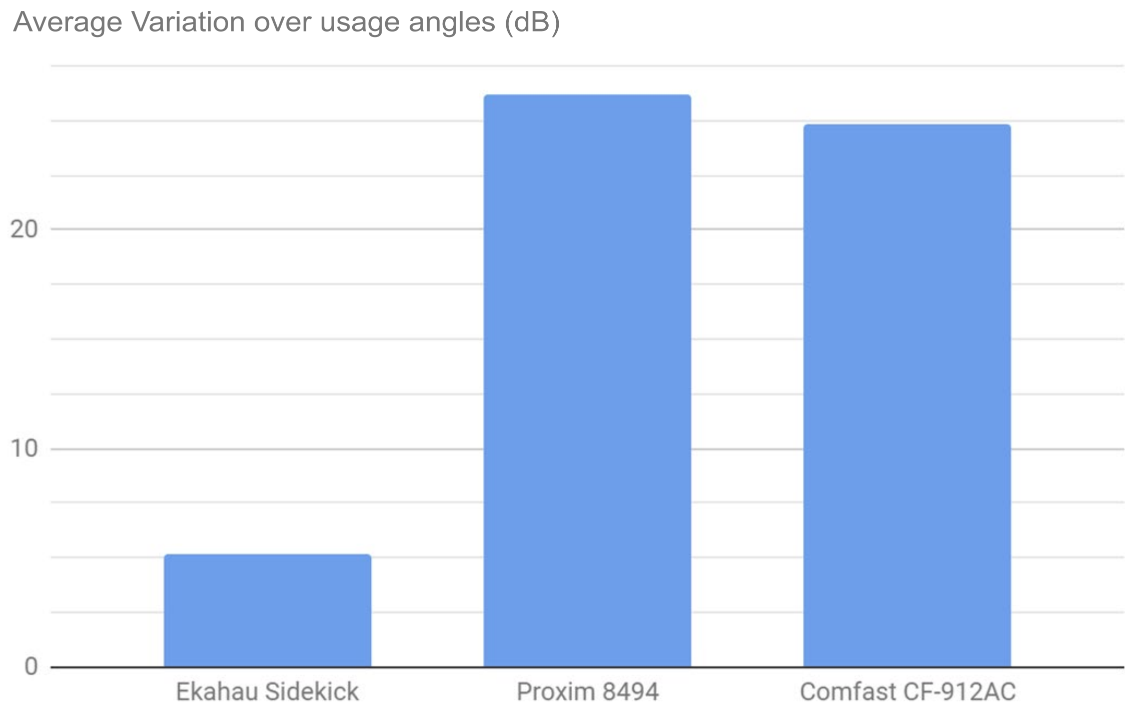

Image 12: Average variation over Wi-Fi channels in dBm

2nd Key Finding: Sidekick's Omni-directional Antennas Enable Precise Readings, Regardless of AP Direction

In light of previous test results, a second test was conducted to determine what happens when access points are installed below and above the area where the survey device is typically carried. How would the three devices perform when the signal was received from above, below or behind, for example, a bench?

The setup repeated previous measurements but replaced the laboratory signal generator and special antenna with a commercial Cisco AP3802 802.11ac access point. According to the AP's specs, it contains 12 antennas placed in cross-polarization.

Transmit power (emitted) was measured, indicating what absolute signal levels to expect. The device was also rotated over both axes: azimuth and elevation.

Image 13 and Image 14 show two channels: Channel 6 in the 2.4 GHz band and Channel 52 in the 5 GHz band. The antenna pattern is plotted in both horizontal and vertical planes. The azimuth (rotation) angle is graphed on the top and measures the view downwards from above the device during the survey. This view is a 360-degree polar graph, where each presented angle shows a different relational direction towards the access point.

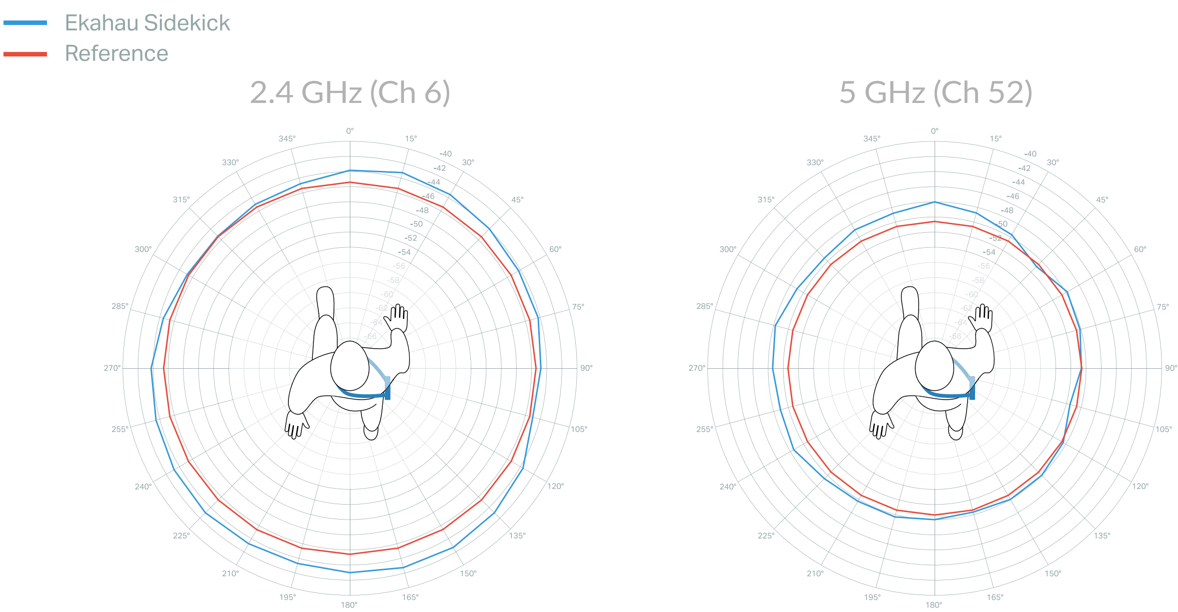

Image 13: Antenna pattern of Ekahau Sidekick over azimuth rotation angle

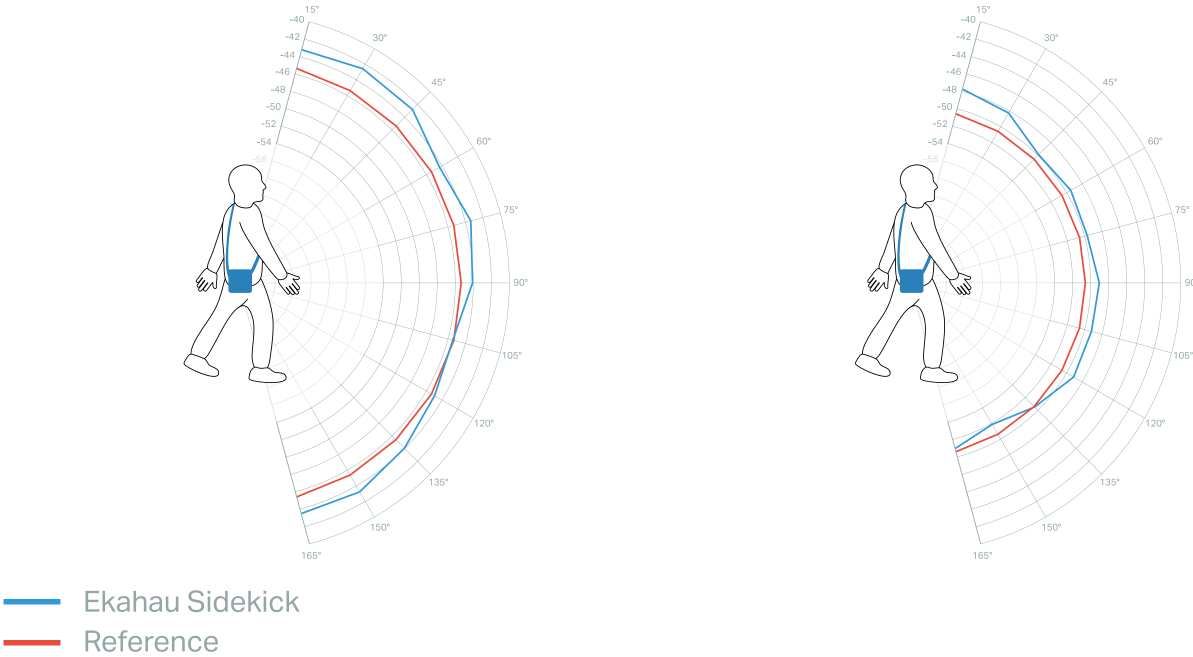

Image 14: Antenna pattern of Ekahau Sidekick over elevation angles

The distance from the center is the signal strength measured in the corresponding angle. The ideal antenna pattern curve is a perfect circle.

Image 14 graphs, elevation angle, is the view from the side during the survey. This is similar to the polar graph, but now only shows angles from +90 to -90 degrees. The extreme ends represent cases where the access point is straight above or below the survey device. And zero degrees point shows where the access point is on the same level (same elevation) as the survey device. Again, the ideal antenna pattern curve would be a perfect half circle.

From the curves, one can conclude that Ekahau Sidekick has very circular antenna patterns, with variation over angles within the 4 dB range (-1 dB to 3 dB). **This range is small enough for Ekahau Sidekick to function practically as omni-directional.** The graphs also show how accurately Ekahau Sidekick measures compared to the reference signal level (absolute truth).

In other words, it doesn't matter where the access point sits relative to the surveyor or the direction the user is walking while surveying. The signal strength is always reliably obtained precisely and accurately when using the Ekahau Sidekick.

3rd Key Finding: Sidekick Units Function Consistently

Production of the Ekahau Sidekick is designed to ensure that each device provides measurements that closely mirror those of every other Sidekick. This is achieved by testing every unit on the production line to a stringent set of performance requirements.

Ekahau verifies the RF for each antenna separately and compares it to a reference device unit.

Only a limited variation in the signal strength is allowed for each device. If the device passes all these RF tests, it is accepted for customer shipment.

To illustrate production consistency, units were randomly chosen from the production line and tested for frequency response as previously described.

Image 15 shows the median frequency curve of all of the tested units. The ideal result would be identical curves. The test shows a small variation, all within a magnitude of 2 dB, which in practical terms is negligible and proves the consistency of Ekahau Sidekick units.

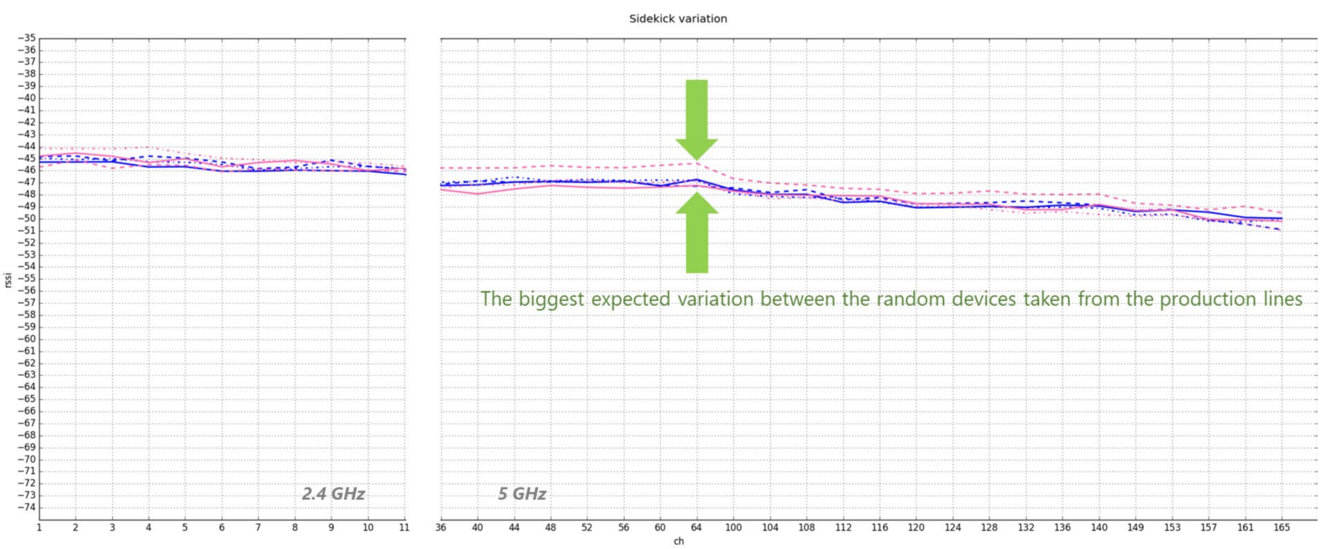

Image 15: Frequency response curves of six randomly chosen Ekahau Sidekicks

The Sidekick also consistently delivers dBm readings within a narrow band. Image 16 below compares the accuracy of the three survey devices in terms of dBm readings. Using one given location, the graph shows how the different survey devices would behave in a typical survey scenario. The red line shows actual signal strength in that single location.

In the top graph, the blue bar shows how accurately the Ekahau Sidekick reported signal strength. Proxim 8494 and Comfast CF-912AC would have reported the same but with clearly higher variance. In some readings they would have measured the signal correctly, but it's more likely they would have reported bad data.

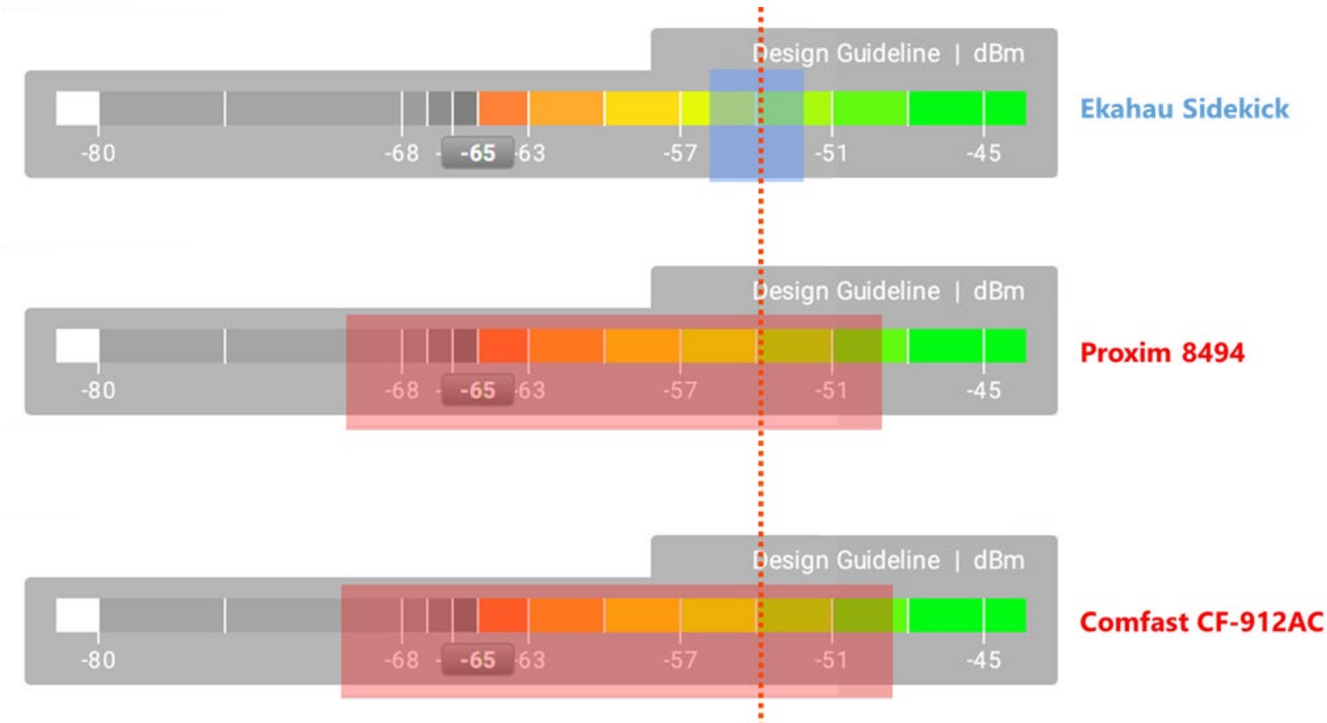

Image 16: Comparison of survey tools in terms of their measurement variation around the actual signal

Conclusion: Sidekick is the Best Tool for Wi-Fi Professionals Who Want Consistently Accurate Survey Data

Unmatched precision is one of the greatest benefits of Ekahau Sidekick. A user can trust the signal strength reading in all conditions, regardless of the direction the surveyor walks, or where the APs are physically located. This dramatically reduces the time Wi-Fi professionals spends and enables them to conduct extremely accurate surveys in much less time. It also allows surveys to be to be delegated to those with less expertise freeing up Wi-Fi professionals for other projects.

Achieving these same results reliably with USB adapters can be challenging since it requires the surveyor to ensure that the adapter antenna is always in acceptable orientation toward the access points. When a team surveys a larger network, using tools that are equally accurate and comparable, it enables individuals to share their work to help expedite Wi-Fi design projects and meet the network vendors design guidelines.

However, in order to verify that a network really meets these requirements, there needs to be accurate, consistent and comparable, measurements.

The Ekahau Sidekick offers:

- Unmatched precision
- Omni-directional antennas which enable precise readings, regardless of AP direction
- Consistency between Sidekick units
- Narrow band dBm readings

Wi-Fi is a mission-critical tool in every industry. Wi-Fi professionals need to design and deploy reliable Wi-Fi that meets customer needs in a timely and cost-efficient manner. The Ekahau Sidekick accurate site survey measurements are critical component to making this possible.

About Ekahau

Wi-Fi is like electricity in today's business world. Work stops when the Wi-Fi is down. That's why **Ekahau** is used by the world's biggest brands (New York Yankees, Amazon, Google, Microsoft, Stanford University, and more) and for the most important events, including Super Bowls and product launches. **Ekahau Connect** revolutionizes Wi-Fi planning, analysis and troubleshooting; **Ekahau Sidekick** sets the industry standard for enterprise Wi-Fi measurement; **Ekahau Survey** for iPad and iPhone changes the game for Wi-Fi site surveys; and **Ekahau Analyzer** redefines the future of troubleshooting through faster, easier, and more accurate network health validation.

Ekahau is headquartered in Reston, Virginia and has much of its R&D and product related functions in Helsinki, Finland.

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