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Assessing Performance Between Spatially Separated SISO and Co-located MIMO Antennas Within a MIMO System

Laird White Paper

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When planning an in-building network, antenna selection is typically based on uniform and symmetrical radiation characteristics as measured in a free space environment. In a real world environment, however, these radiated characteristics are significantly altered by interferers such as obstructions and multipath. To mitigate the latter, MIMO systems replaced SISO systems to improve throughput and hence network capacity. In that regard, antenna development moved toward co-locating two antenna radiators under a single radome providing a 2-port MIMO antenna. As would be expected, moving two antennas close together influenced the uniformity of each antenna's radiation characteristics. A logical mitigation was to install MIMO networks using two uniform, symmetrically radiating, SISO antennas spatially separated. The additional installation costs were thought to be acceptable. This white paper will show that co-located MIMO will perform as well or better than the spatially separated SISO antennas installed as a MIMO solution and will secondarily show that antennas with symmetrical radiation characteristics did not appreciably improve network throughput over that of the network composed of antennas with non-symmetrical radiation characteristics.

Purpose and Scope

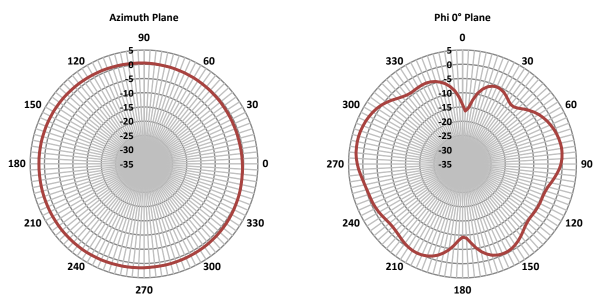
Three MIMO antenna solutions will be compared. Two composed of Co-located MIMO antennas and a third configured with two SISO antennas spatially separated by 6 feet. The two co-located MIMO antennas are differentiated by the improved uniform and symmetrical radiation characteristics of one 2-port MIMO antenna, the Laird CMX69273, over that of the other 2-port MIMO antenna, the Laird CMD69273.

The performance metric for evaluating all three antennas will be throughput measured at the physical layer (the layer that is closest to antennas). A local server was repeatedly downloading a file and throughput information was collected. In that regard, both a test site and test methodology needed to be defined.

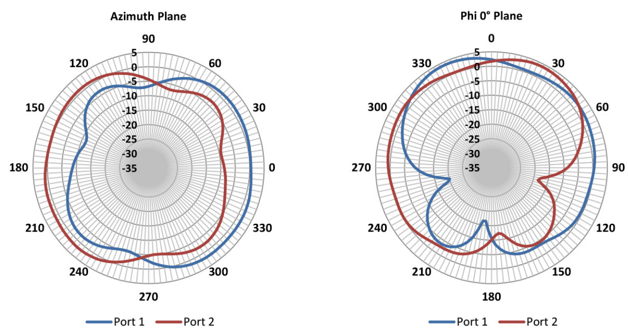
Prior to throughput testing, free space radiation patterns were collected in a Stargate 64 measurement range. Performance was evaluated and compared for uniformity and symmetry.

Radiation Characteristics of the Antennas Involved Do Test Significantly Different

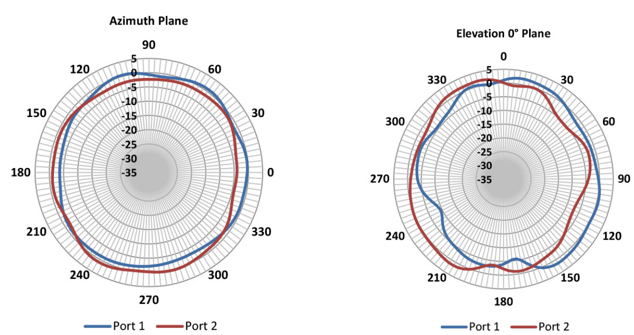
Two dual port MIMO antennas and one SISO antenna were selected for these tests. The MIMO antennas were Laird's CMD69273 antenna and Laird's CMX69273. The SISO antenna was Laird's CMS69273. All three antennas operate over the 698-960/1710-2700 bands and radiate over the tested band as follows:



SISO Antenna Laird CMS69273



2-port MIMO Antenna Laird CMD69273



2-port MIMO Antenna Laird CMX69273

The SISO antenna's radiation characteristics are the best of the three antennas being both uniform and symmetrical. When compared to the 2-port MIMO CMD antenna, significant radiation differences exist between both the SISO and 2-port MIMO CMX antennas. Because of these radiation characteristics, in a network solution either antenna would be selected before the CMD antenna. It should be noted, however, that the CMD antenna is configured to provide an overall omnidirectional coverage via both parts, rather than the individual port(s).

Test Site and Methodology

The test site is a building complex with active offices and laboratories. This environment presents multipath fading phenomena which are very common in wireless communication channels. Throughput measurements were carried out during working hours (10am - 3pm) along routes that consist mostly of hallways with some cubicle areas included. The test area has concrete floors and drop-ceilings 2.5-meter (9-foot) high. The floor plan is shown in Figure 1:

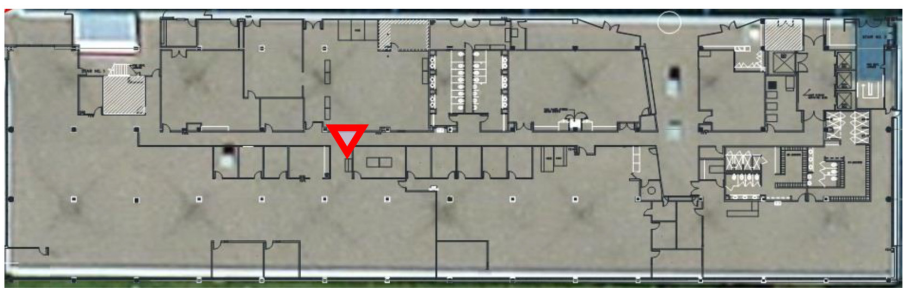


Figure 1: Test facility floor plan. (Area size - 80 meters by 23 meters)

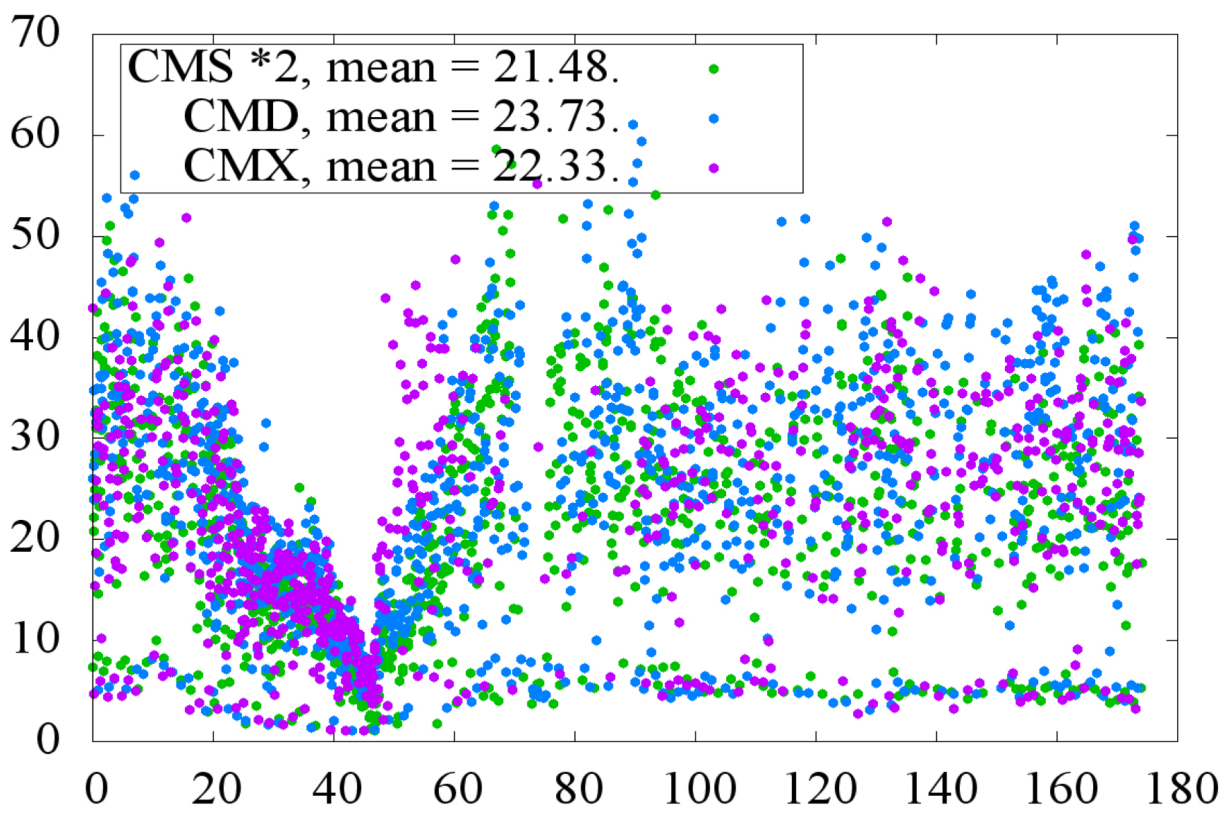
The Server side equipment consisted of a Fujitsu S110 BroadOne, dual-band 2x2 MIMO LTE 4G femtocell (modified with external SMA connectors). The femtocell connects to an EPC (Evolved Packet Core) and then to an internal server for streaming files. The antennas under test are mounted under the drop-ceiling at the location marked by the red triangle-sign in the floor plan (Figure 1).

The Remote side UE (User Equipment) for data collection consisted of a Sony handset Xperia Z2 running TEMS Pocket professional. The handset is mounted about 1.2 meters (4 feet) above floor level on a push-cart. The physical layer throughput values were recorded about every two seconds. The time and location associated with any particular throughput value were also recorded in the same logfile. The UE was configured so it would only register on the femtocell, not any other cell that might be present at the test site. It was intended to have a portion of the test route at the edge of the coverage area for gauging the response under low signal levels.

**Tests were conducted in Band IV of the LTE frequency (downlink 2110 MHz - 2155 MHz).*

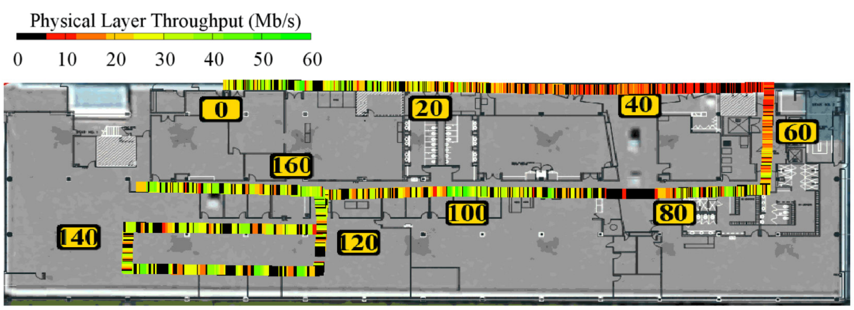
Throughput Is Minimally Impacted by the MIMO Test Configurations and Antenna Radiation Characteristics

Physical Layer Throughput data was collected along the route for the three MIMO solutions. Using Heat-maps, histograms and a Scatter Plot some interesting observations can be made. Noting that the horizontal axis represents the UE traversed distance, one can observe that the over-all average throughputs differ by less than ten percent from 21.48 to 23.73 Mb/s. Although the Laird CMS antenna exhibited significantly better radiation and isolation characteristics, there are relatively small differences in throughput performance. A similar case can be made for the Laird CMX antenna when compared to the Laird CMD antenna.



Throughput Is Minimally Impacted by the MIMO Test Configurations and Antenna Radiation Characteristics

It should be pointed out that the performances of all three MIMO configurations suffer around the 40-meter mark. Especially at 45 meter, where the UE sometimes dropped the connection. To get a better view of the throughput in this region, data is presented in a histogram format. Clearly, data shows that both co-located MIMO antenna solutions, when compared to the spatially separated SISO antenna configuration, exhibit better throughput within this difficult area.



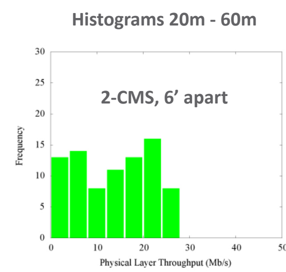
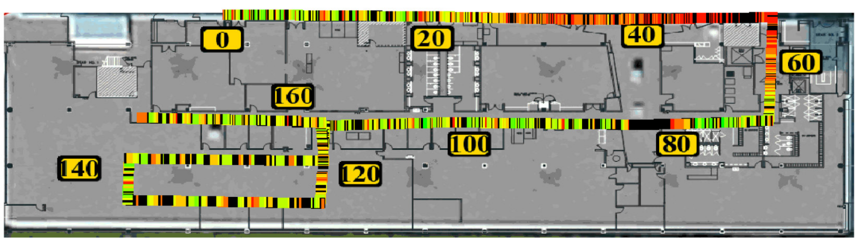


Figure 2: Throughput Heat-map, MIMO via two spatially separated (by 1.8m) SISO antennas.



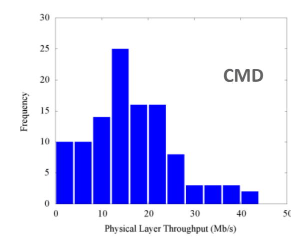
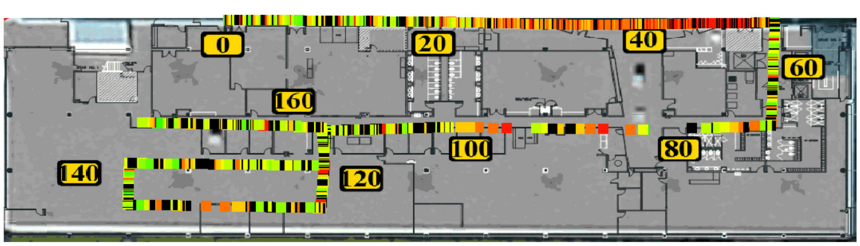


Figure 3: Throughput Heat-map, MIMO via 2-port MIMO CMD antenna.



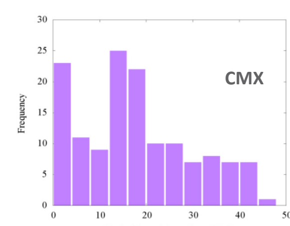


Figure 4: Throughput Heat-map, MIMO via 2-port CMX antenna.

Conclusions

The conventional way of planning for indoor antenna installations is to rely on data such as radiation patterns, isolation and polarization. This approach naturally favors antennas that have good omni-directionality and polarization purity. In reality, the indoor antennas are always used in environments that have steel beams, metal pipes/conduits and other building materials that would reflect/attenuate RF signal. These facts render the data obtained in free-space (anechoic chamber) less relevant. Since each environment is unique, there is no good way to characterize the radiation properties of antennas in a general sense. Although free-space data should still be used for selecting antennas, in a multipath/cluttered environment the throughput results herein contained leave room for other considerations in antenna selection. Alternate considerations could be the ease of installation (one antenna versus two) and the aesthetic value that low-profile collocate MIMO antennas could bring.

Glossary

CMD: Ceiling Mount Dual Port

CMS: Ceiling Mount Single Port

CMX: Ceiling Mount Next Generation

EPC: Evolved Packet Core

LTE: Long Term Evolution

MIMO: Multiple Input / Multiple Output

SISO: Single Input / Single Output

SMA: SubMiniature version A

TEMS: Test and Evaluation Modeling and Simulation

UE: User Equipment

About Laird

Laird provides systems, components and solutions that protect electronics from electromagnetic interference and heat, and that enable connectivity in mission critical systems through wireless applications and antenna systems.

We are a leader in the design, development and delivery of innovative technologies that enable people, organizations and applications to connect efficiently and effectively. Our reputation has been built on three guiding principles:

- Innovation - putting our in-depth knowledge of the latest materials and processes to work in creating outstanding products for our customers.
- Reliable fulfillment – delivering what our customers need to their exact specifications, on time and on budget, and in the quantities required.
- Speed - rationalizing the design and delivery cycle to minimize the time from initial concept to final implementation.

With a proud history stretching back to 1824, Laird has been at the forefront of technological innovation for almost two centuries. And we continue to deliver.