

Antenna Configurations for MIMO In-Building Distributed Antenna Systems



INTRODUCTION

The following white paper details over-the-air (OTA) data throughput testing performed on Verizon's LTE network at the Hilton Las Vegas Convention Center Hotel. The purpose of this study was to validate the performance benefits of MIMO vs. SISO radio architectures in a real world setting. While much has been claimed about the realization of MIMO benefits in live environments, little data has been published to credit or disprove its merits. This white paper endeavors to provide that missing data.

Finally, a variety of antenna configurations have been investigated to better understand their impact on end-to-end system data throughput.

TEST OVERVIEW

Selection of an appropriate test location within the Hilton Las Vegas Convention Center Hotel proved to be more challenging than initially expected. Since the over the air testing was performed on the deployed Verizon LTE network, existing macro cell sites external to the hotel provided significant penetration into the hotel in some locations.

Selection of the test site was done by turning off the in-building distributed antenna system (IDAS) and testing for network presence. After surveying several sites, a test location was chosen in a hallway (plan view shown in Figure 1).

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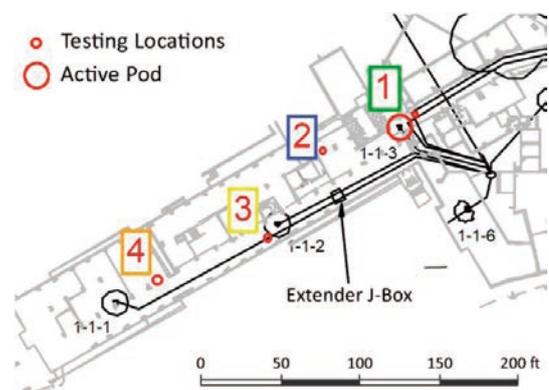


Figure 1 - Test location plan view in the Hilton Las Vegas Convention Center hotel [1].

The EnCOVER VE IDAS system consists of a control unit and several Access Pods mounted to the ceiling at each of the numbered locations shown in Figure 1. Further, each Access Pod has two external dipole antennas separated by ~8 inches that supporting the Verizon 750 MHz LTE spectrum. The ability to remove the Pod's external dipoles and connect other antennas enabled the investigation of different antenna configurations and their impact on performance as described further on.

The four test locations shown in Figure 1 are directly under the Pod location (test point #1) and at progressively further distances (#2, #3, #4). The furthest location was determined using the Pod's external antennas and walking to the furthest edge of coverage. Finally, OOKLA's speed test application for Android was used on a HTC Thunderbolt handset to measure data download and upload speeds. At each location tested, five tests were performed and the average recorded.

DISCUSSION OF RESULTS MIMO VS. SISO

Even though MIMO concepts have been widely discussed at conferences and trade shows, little measured data has been shared which demonstrate the achievable MIMO speed benefits. As a simple demonstration of the benefits provided by MIMO in the LTE 750 MHz band, the average download throughput was measured at each of the 4 locations outlined in Figure 1 and compared with the SISO throughput at the same locations.

The EnCOVER VE system was forced into a SISO mode of operation using two different methods; 1) by disconnecting one of the RF paths (see Figure 2) at the controller (Figure 3 case A) and 2) by simply disconnecting one of the Pod antennas and terminating the open port with a 50Ω load (Figure 3 case B). The MIMO mode used both external antennas provided with the system.



Figure 2 - EnCover VE IDAS system components [1].

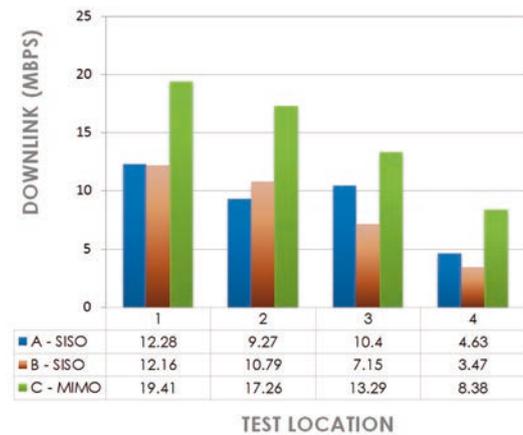
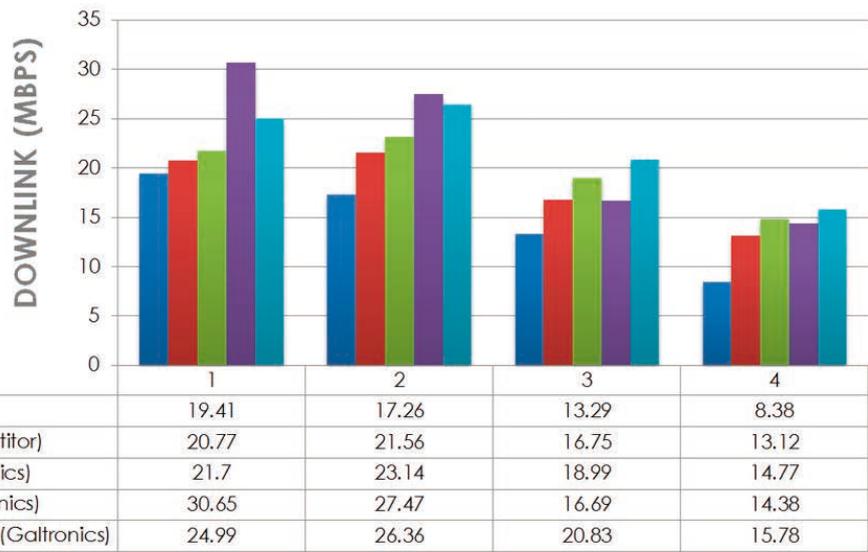


Figure 3 - SISO vs. MIMO Test Results [1].

It is clear from the measured results that MIMO provides 1.4X to 2.4X the download throughput as configured on the Verizon network. Although the theoretical maximum performance benefit of a 2x2 MIMO system is 2X that of a SISO system, the test results show that in cases where the SISO data rate starts to fall due to weak signal and increased multipath, the apparent throughput increase can be slightly higher. This is in part due to the SISO architectures' lack of ability to deal with multipath which limits its usable data rates (interface limited). In contrast, the MIMO architectures' reliance on multipath enables its' data rates to remain high further from the Pod.



TEST LOCATION

Figure 4 - MIMO antenna configurations: (D) OEM external dipoles, (E) spatially separated V-Pol (competitor), (F) spatially separated V-Pol (Galtronics), (G) co-located V-Pol & H-Pol (Galtronics), (H) spatially separated V-Pol & H-Pol (Galtronics) [1].

OPTIMIZATION OF ANTENNA CONFIGURATIONS

The OEM external dipoles of the Pod enable MIMO operation (Figure 4 case D), but do they also provide the best possible coverage and throughput?

To investigate if the dipoles provided with the Pod yielded the optimal data throughput, three configurations of external antennas were connected to the Pod. The first configuration used two vertically polarized antennas separated by 6 feet (1.8m) (case E & F). The second used a single Galtronics co-located, dual polarized antenna (case G). Finally, the third configuration used two Galtronics co-located, dual polarized antennas separated

by 6 feet (case H) wherein one antenna used only the vertically polarized port and the second used only the horizontally polarized port. The resulting average downlink throughput for each test location is summarized in Figure 4. For clarity, the performance enhancement of each configuration is defined by normalizing to the OEM external dipole case. The normalized values appear in Table 1.

TEST CASE	TEST LOCATION			
	1	2	3	4
E	1.07	1.25	1.26	1.57
F	1.12	1.34	1.43	1.76
G	1.58	1.59	1.26	1.72
H	1.29	1.53	1.57	1.88

Table 1 –Normalized throughput improvement relative to Pod external dipoles.

CASE E & F: SPATIALLY SEPARATED VERTI- CALLY POLARIZED ANTENNAS

Examination of test cases E & F in Table 1 revealed that performance benefits are obtained when the antennas are spatially separated. In both of these cases the antennas were separated by a distance of 6 feet as compared to the ~8 inch (~20 cm) separation of the original Pod external dipoles. The benefits of spatial separation are most apparent far from the Pod where up to 76% improvement is observed. However, benefits of only ~10% are achieved close to the Pod. Finally, we note that the only difference between case E & F is the antenna design (manufacturer) yielding differences of 5% to 19%. Case E represents the antenna design from a competitor and Case F a design from Galtronics.

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CASE G: CO-LOCATED, DUAL POLARIZED ANTENNA

Deploying two vertically polarized antennas, having a separation of 6 feet, has some notable disadvantages. Aesthetically, the resulting deployment now encompasses not only the presence of two antennas, but also the requirement to install them at a 6 foot interval. From an installation point of view, two antennas must be mounted and cabled. The use of a single dual polarized antenna offers an alternative with better performance.

In Case G, a single dual polarized Galtronics antenna was connected to the Pod; one port connected to the vertical polarization and the second to the horizontal polarization. It is evident from Table 1 that this configuration provides improvements of 58% to 72% relative to spatially separated, external dipoles. Of particular importance, the performance near the Pod is significantly increased when compared with the spatially separated, vertically polarized antennas of Cases E & F.

CASE H: SPATIALLY SEPARATED AND DUAL POLARIZED ANTENNAS

In a final attempt to achieve the best performance, a combination of spatial separation and dual polarization was investigated. Case H used two dual polarized antennas separated by a distance of 6 feet. The first antenna used only the vertical port and the second antenna used only the horizontal port. The resulting increase in performance at the edge of the Pod coverage area is 88% (see Table 1). Near the Pod, the performance improvement is nearly as good as the single dual polarized antenna (Case G) at 29%. The use of both spatial separation and dual polarization appears to provide the most uniform throughput improvement over the entire coverage area.

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Finally, the deployment described here leaves two unused ports. These ports are of practical importance to operators desiring neutral host sites, namely that the unused ports can be used for a second carriers' 2x2 MIMO deployment.

CONCLUSIONS

MIMO architectures have been measured to have 1.4x to 2.4x the data throughput of SISO architectures in the 750 MHz LTE band in-building. Multiple antenna configurations were investigated to determine the improvements provided by spatial separation and dual polarization. Spatial separation provides 12% - 76% improvement with the greatest benefit achieved at the edge of coverage. Dual polarization provides 26% to 72% improvement with significant improvements near the Pod.

Finally, a combination of spatial separation and dual polarization yields a uniform increase in performance over the entire coverage area with 29% to 88% while leaving room for expansion at neutral host sites.



ACKNOWLEDGEMENTS

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REFERENCES

- [1] 2011, American Tower Corporation, "700 MHz LTE Design & Deployment at the Las Vegas Hilton", presented to the DAS Congress May 23rd, 2011

ABOUT THE AUTHOR

David C. Wittwer, PhD. – David is a Principal RF Engineer with Galtronics Ltd in Tempe, AZ. He has published and/or presented more than 30 technical papers on the topics of antennas, antenna propagation, RF channel modeling and antenna methods for optimizing MIMO systems. Dr. Wittwer is currently focused on developing LTE distributed antenna systems.

ABOUT GALTRONICS

Galtronics is a global company providing innovative antenna and communications solutions of the highest quality and design. Headquartered in Tiberias, Israel, with locations in North America, Europe and the Far East, Galtronics has state-of-the-art design centers around the globe as well as world class manufacturing facilities in Israel and China. The company offers custom and off-the-shelf antenna solutions from concept and design to production and delivery of products for the world's leading network carriers, building and facilities owners and users of mobile communications technology.

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