# TRANSMIT EIGEN BEAMFORMING

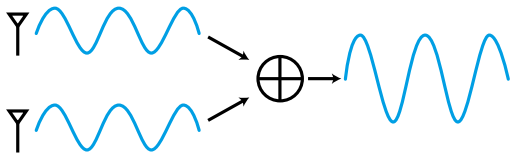
## TX BEAMFORMING

SILVUS TECHNOLOGIES

[Case Study]

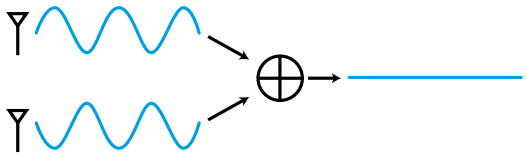
### Background

Silvus Technologies was the first networking communications system provider in the world to incorporate the power of Transmit Eigen Beamforming into its tactical MANET radios. This revolutionary MIMO technique can provide up to a 4X boost to signal levels at the receiving radio without the extra power consumption, heat or RF exposure associated with transmitting higher power. This results in enhanced throughput, range and reliability of the link.



*Signals Arriving in Phase*

To understand Beamforming, we first need to understand what happens when wireless signals converge in space. In MIMO systems, signals are transmitted from multiple antennas. When those signals arrive in phase, they add together, and the signal increases. When they arrive out of phase, they cancel, degrading the signal.



*Signals Arriving out of Phase*

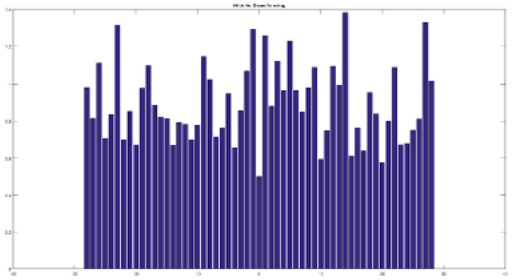
Other MIMO radios have no control over the phase that these signals arrive at the receiver with, often resulting in a suboptimal combination. StreamCaster MANET radios manipulate the phase and amplitude of the signal emitted from each transmit antenna in a way that excites the strongest Eigen mode of the channel. This effectively steers a beam towards the recipient, ensuring the signals arrive in phase at the receiving radio's antennae and maximizing the signal strength of the link.

Using 2x2 MIMO, the gain can be up to 3dB.  With 4x4 MIMO, the gain can be up to 6dB. In a free space environment, this equates to a doubling of distance.

### Orthogonal Frequency Division Multiplexing (OFDM)

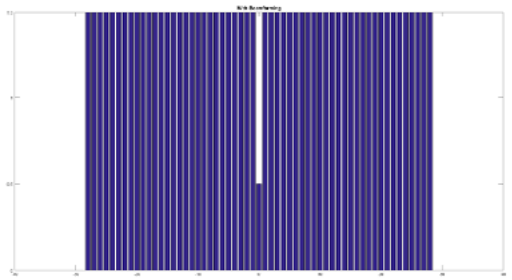
OFDM is a type of digital transmission used in digital modulation for encoding of binary digital data onto multiple carrier frequencies.

In a wideband OFDM system, fading effects of a channel will vary over frequency. Silvus' approach applies Transmit Eigen Beamforming to each individual subcarrier in the OFDM waveform, ensuring the strongest signal level possible across all of the subcarrier frequencies.



*OFDM Waveform without Transmit Eigen Beamforming*

In a multi-node Silvus mesh network, with multiple sources and destinations, each individual packet is beamformed towards its intended recipient. This is possible even in dynamic situations, including high mobility and extreme non-line-of-sight.



*OFDM Waveform with Transmit Eigen Beamforming*



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## The Challenge

To quantify the benefits of Silvus' TX Beamforming algorithm in a real-world environment, a simultaneous test evaluation was performed, comparing the link performance with TX Beamforming enabled, and with TX Beamforming disabled.

*Drive Path*

## Test Setup

The on-the-move quantitative test was conducted on a traffic heavy stretch of the Interstate 10 highway, utilizing a vehicle equipped with two SC4400 MANET radios – one with TX Beamforming enabled and a second with TX Beamforming disabled. The receive site was set up at 33°38'25.3"N, 115°16'31.9"W – at an AGL approximately 600 feet higher than Interstate due to terrain features.

A logging script queried the Silvus SC4400 MANET radio's API for the following statistics for both links:

| Time | GPS Coordinate | MCS | SNR | RSSI | Noise Power |
|---|---|---|---|---|---|

## Testing Methodology

The vehicle equipped with the SC4400 MANET radios began its journey at the receive site, then drove ~4km down a dirt path before transitioning onto the I-10 heading east. The test began as the vehicle left the receive site. There was approximately 6km of distance before the vehicle entered the beamwidth of the antennas. The test continued to run until the link range was broken at ~45km distance, when a terrain feature blocked line-of-sight.

To eliminate all possible variables besides TX Beamforming, the two radio links were set-up on the same RF channel, but with different Network IDs to prevent them from routing through one another. Since this was the only difference, both SC4400 MANET radios had equal access to the RF channel and would not interfere with each other.

## SC4400 MANET Radio Settings:

| Test Parameter | Frequency | Bandwidth | Network ID | Link Distance |
|---|---|---|---|---|
| TX Beamforming Enabled | 2380 MHz | 20 MHz | BF_Enabled | 55000m |
| TX Beamforming Disabled | 2380 MHz | 20 MHz | BF_Disabled | 55000m |

## Test Vehicle Configuration

Two SC400 MANET radios were mounted on the roof of a SUV. Each featured 4dBi Omni-directional antennas attached to their RF ports. An IP camera was mounted to the roof of the SUV to provide a POV video feed.

## Fixed Site Configuration

The fixed site featured two SC4400 MANET radios on a "T" bar at the top of a mast, extended 12 feet off the ground. Each radio was connected to 12dBi sectorized antennas with right angle RF adapters attached to their RF antenna ports. Each sector antenna featured a horizontal beamwidth of 117° and vertical beamwidth of 18°.



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## Test Results

### Signal-to-Noise Ratio

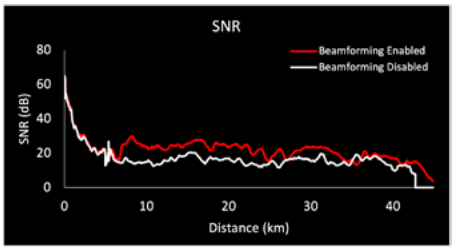
The goal of this comparative evaluation test was to validate the benefits of TX Beamforming in Silvus StreamCaster MANET radios. The quantitative comparison was accomplished using SNR and data rate throughput. During the test, all SNR measurements were performed concurrently. For these measurements, the data points at matching distances represent simultaneous measurements.

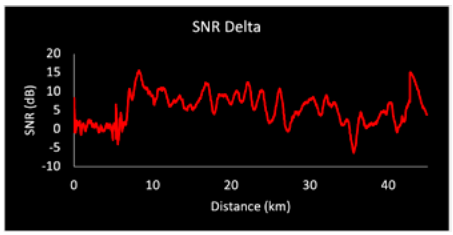
The SNR of the TX Beamforming enabled link showed mean of 5.57dB, nearly achieving the theoretical value of 6dB. This illustrates that the TX Beamforming algorithm is performing as designed throughout the testing evaluation.

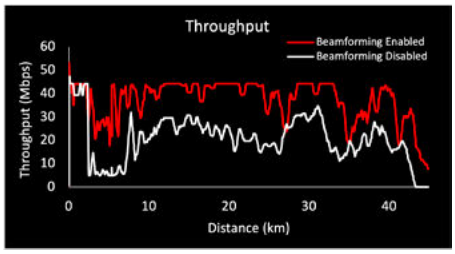
### Data Rate Throughput

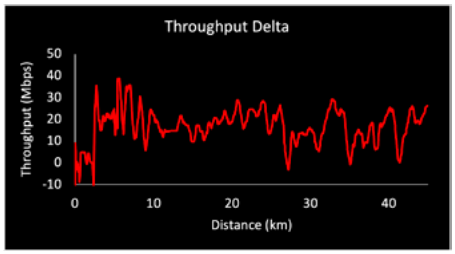
Although the SNR shows significant gain, the primary benefit of TX Beamforming on a Silvus MANET radio is exemplified in the Throughput gains. These gains were observed to be quite substantial, with the TX Beamforming Enabled SC400 MANET radios showing an improvement throughout the entire test. Throughput reached an astounding 38.74 Mbps in the most extreme case, with an average value of 15 Mbps throughout the test. In addition, the TX Beamforming Enabled link went a few kilometers farther than the TX Beamforming Disabled counterpart. It was estimated that both links could have achieved greater link range, if it were not for the mountain blocking the vehicle at the 45km mark.

**Watch the Video to Learn More about the power of TX Eigen Beamforming**




## Conclusion

Silvus Technologies is dedicated to one mission: Solving the toughest tactical communication problems on the planet. Serving Defense, Government, Public Safety and Commercial customers around the world, Silvus advanced StreamCaster MANET radios, powered by revolutionary MN-MIMO waveform technology provide the vital communications link in any operational environment. At Silvus, we never stop innovating communications technology at the tactical edge - through cutting edge research and development, validated in real-world testing environments. In this TX Beamforming test case, it was shown that Silvus' unique TX Beamforming algorithm achieved substantial improvement to both signal strength of the radio link and data rate throughput. By directly comparing the radio link with TX Beamforming Enabled, and TX Beamforming Disabled, the test results measurements illustrate what operators could experience in deploying a real-world tactical mesh network. Solidifying the performance of the TX Beamforming algorithm, the test performance results consistently showed higher Throughput gain and SNR across the test parameters, even reaching 5.57dB or 92% of the theoretically possible gain. The TX Beamforming enabled link also showed a more consistent link strength throughout a dynamically changing test environment, maintaining high throughput even as Interstate traffic and overpasses caused shadowing.

## For More Information:

For more information on TX Beamforming, or to request a demonstration to test it for yourself, contact your Silvus Sales Representative, or email: info@silvustechnologies.com



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