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TMA impact on uplink throughput

Do TMAs fully compensate for UL degradation when the RRU is moved to the ground?

As mobile traffic continues to grow, network operators attempt to meet capacity demands with strategies such as spectrum overlays, sector splitting and beamforming active antennas. While locating additional equipment at the top of the tower is preferred, space and weight constraints frequently require some radios to be placed on the ground. The radios are connected with feeder cables, resulting in signal loss and uplink (UL) degradation.

For over 20 years, tower-mounted amplifiers (TMAs) have been used to compensate for that feeder loss. This enables network operators to reduce downlink/uplink (DL/UL) imbalance and improve UL coverage. The result is improved overall cell coverage.

At the same time, the introduction of LTE has emphasized the importance of capacity improvements. The TMAs improve the overall signal-interference-to-noise ratio (SINR) of the system, but the lingering question has been: Can TMAs provide the necessary improvement to protect the key performance indicator—UL throughput?

A link budget analysis can indicate the extent to which the TMA can improve the system's noise figure (NF), which we can then translate into sensitivity improvement. But how does that relate to user throughput? Using Forsk's Atoll software suite, CommScope performed a series of predictions using real network data to quantify the impact of TMAs in urban/suburban areas.

Baseline scenario

To create a baseline for comparison, the team designed a cluster of 68 cells in and around a focus zone with an area of 8.5 square miles (22 square kilometers). All remote radio units (RRUs) were installed at the tower tops near the antennas. Using automatic cell planning (ACP), antenna electrical downtilts (EDT) were adjusted to optimize performance in the focus zone.

A prediction was made of the allocated bandwidth throughput (UL). The results, in the form of a heat map, are indicated in Figure 1. With radios installed near the antennas, the UL signal experiences minimal loss before reaching the receiver. This condition is critical to UL performance since transmission line losses add directly to the receiver NF.

Macro network model:

- **27 sites, 68 sectors**
- **Inter-site distance: 1 mile typical**
- **Average tower height: 60 feet**
- **Focus zone area: 8.5 square miles**
- **LTE Band 2 (1900 MHz)**
- **Carrier bandwidth: 15 MHz**
- **Antennas: SBNHH-1D65B**
- **eNodeB: 4T4R, 40 W, 2.5 dB NF**
- **UE cat 16DL/13UL, 2T4R**
- **256-QAM DL, 64-QAM UL max**
- **Geodata resolution: 2 meters**
- **3D building vectors**
- **Crosswave propagation model**
- **DL traffic load: 50 percent**
- **UL noise rise: 3 dB**

Figure 1: UL throughput; baseline scenario, RRU at top of tower. Focus zone with green outline.

Comparing performance with and without TMAs

In the second scenario, the RRUs are moved to the ground but no TMAs are installed. Then, 7/8-inch feeder cables are added—their lengths being equal to the tower height plus 20 feet. For the 68 sectors, feeder lengths vary between 40 and 145 feet, with an average of 80 feet. In this scenario, UL throughput is predicted to degrade in 70 percent of the focus zone area. On average, the throughput is 4.8 Mbps lower. The difference between the second scenario and the baseline is plotted in Figure 2.

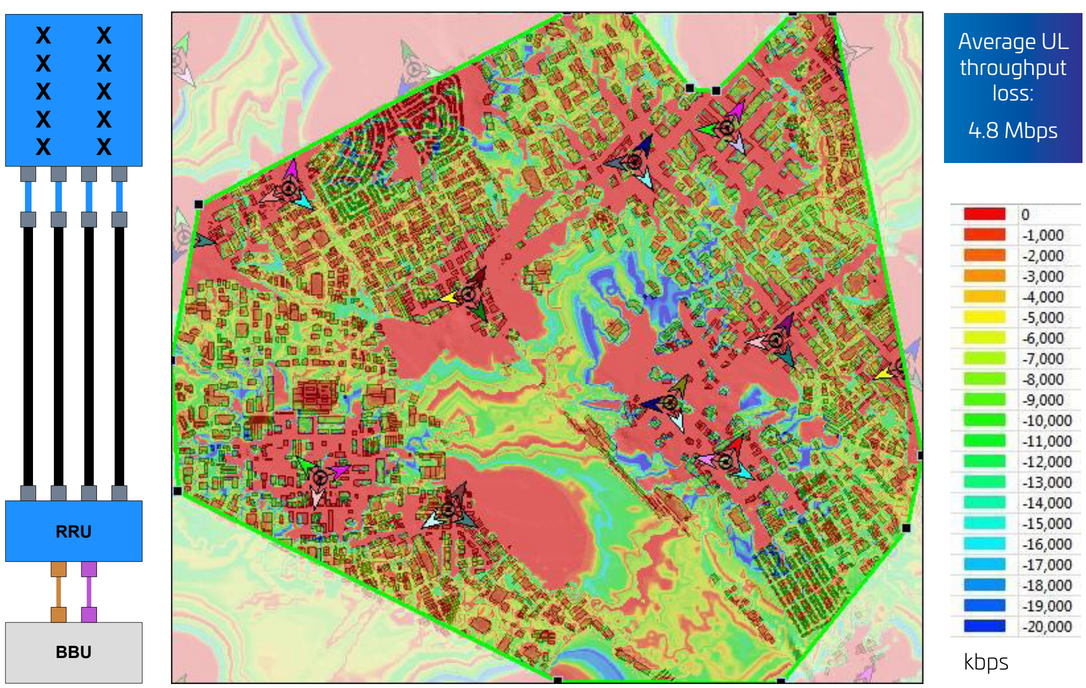

Figure 2: UL throughput degradation; second scenario vs. baseline, moving RRU to the ground.

With the RRUs on the ground, we then installed TMAs at the tower top, creating the third scenario. Figure 3 compares the UL throughput of scenario three (with TMAs) and scenario two (without TMAs). As seen, use of the TMAs improves UL throughput by an average of 6.8 Mbps in the focus zone.

Figure 4 compares the cumulative UL throughput distributions for the three scenarios. Scenario three, with radios on the ground and TMAs near the antennas, provides the best performance. It demonstrates that TMAs not only fully compensate for UL degradation when RRUs are moved to the ground, but that performance with ground-level RRUs and TMAs can be superior to RRUs at the top of the tower.

TMA specifications:

- **NF: 1.5 dB**
- **RX gain: 12 dB**
- **TX loss: 0.5 dB**

UL throughput in 65 percent of the focus zone improved an average of 2 Mbps with RRUs ground-mounted and TMAs on the tower vs. RRUs mounted at the top of the tower.

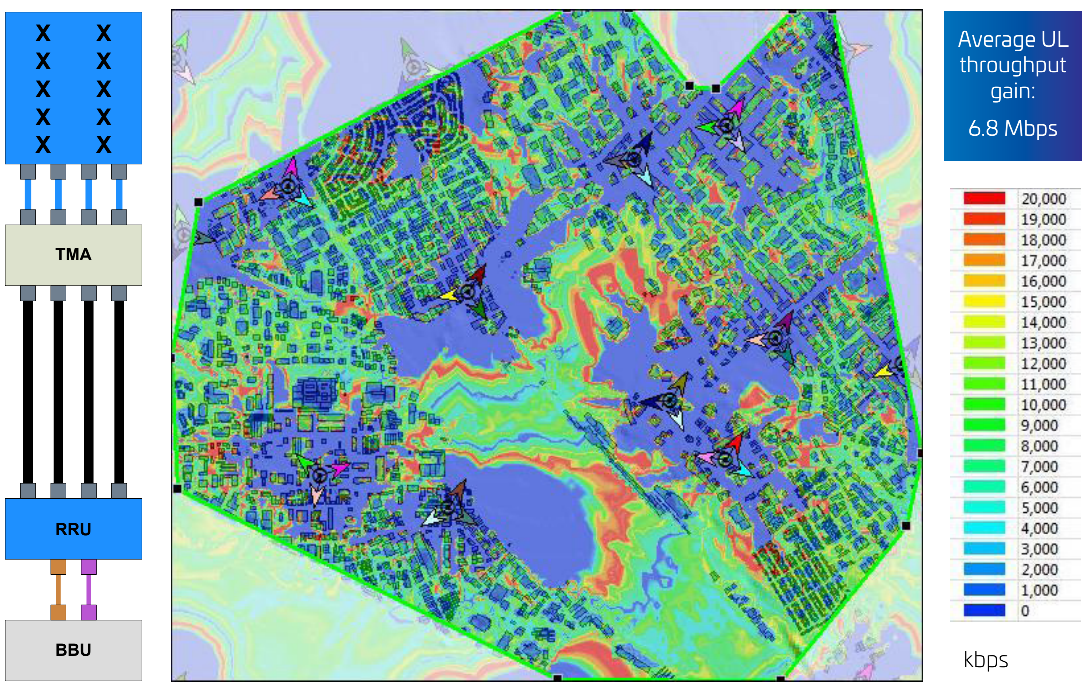

Figure 3: UL throughput improvement with TMA; third scenario vs. second scenario, adding TMA.

It is also worth noting that the focus zone in this study includes a high percentage of in-building locations with degraded performance. The analysis not only quantifies the UL improvement when using TMAs; it shows that adding TMAs improves signal quality in the interior of the buildings. As a result, network operators can use TMAs to improve UL performance in congested urban areas.

Summary of findings

Data presented demonstrates that:

- TMAs can fully compensate for UL degradation when the RRU is moved to the ground
- TMAs and ground-mounted RRUs can improve UL performance compared to tower-mounted RRUs only
- TMAs can improve UL throughput in a major part of the area served by a cell
- TMAs help improve in-building UL performance

Further, the analysis dispels some common myths and perceptions about TMAs:

- TMAs only provide benefits in rural areas but don't help urban areas
- TMAs only help to increase coverage but don't help with capacity/throughput
- TMAs do not provide additional benefits in systems using four-way receive uplink

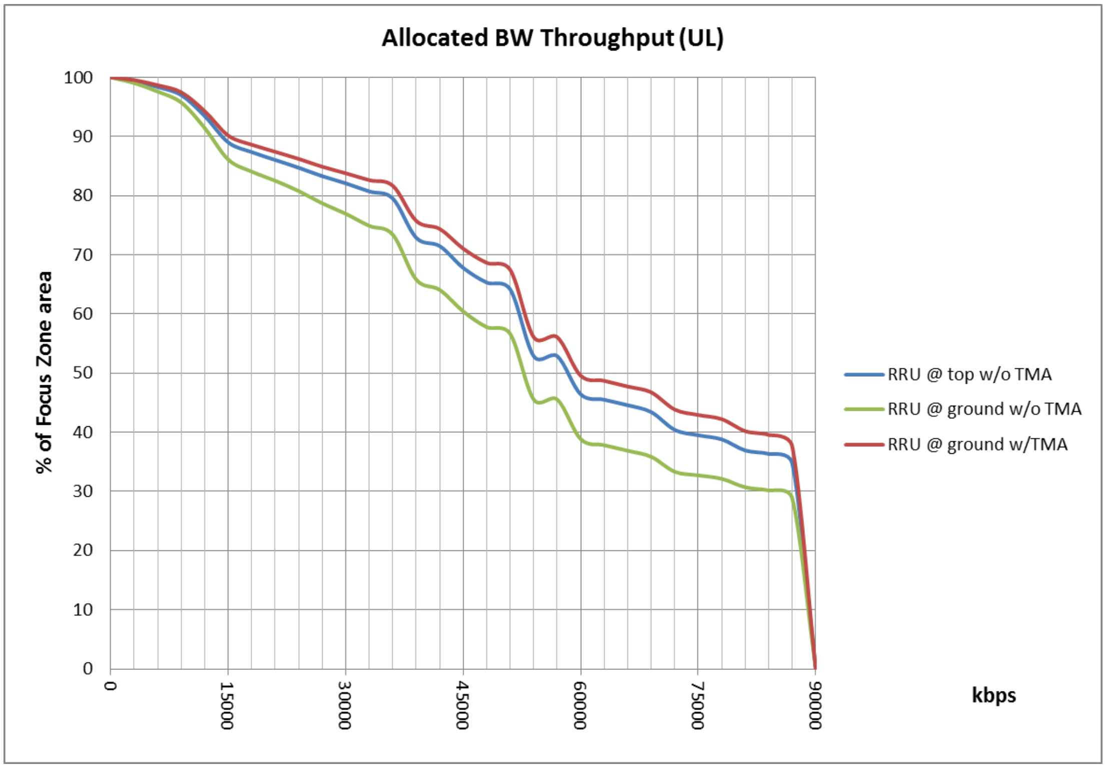

Figure 4: Comparison of cumulative UL throughput distribution in focus zone; baseline, second and third scenario.

This study considered a typical network in an urban environment. Results will vary depending on a number of variables, such as:

- Noise figure of eNodeB and TMA, type and length of feeder
- Carrier frequency, use of ICIC and CoMP features
- Inter-site distance and terrain characteristics, including indoor locations
- Traffic load, network capacity and UE capabilities

The study used additional background data and assumptions not included in this paper. For more information about the study or about TMAs, please contact your local CommScope account manager or product line manager.

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