MobileMark
antenna solutions

Selecting the Optimal Antenna for a
Mobile Mesh Network

INTRODUCTION

The antenna selection process can make or break the success of a wireless network deployment. This is never truer than in a mobile mesh network where environmental conditions, terrain, and location of "nodes" on the network are all largely unpredictable and in a constant state of change. In mobile deployments, selection and proper use of the right antenna can dramatically improve the coverage range and robustness of the network.

The High-Performance Tactical Mesh Antenna (HP-TMA) from Mobile Mark is specifically designed for use in rugged military mobile networking environments. It improves wireless signal quality and reach using Mobile Mark's 3D Signal™ technology that combines a unique high-performance circular wave pattern with patented signal boosting technology in a low profile, easy-to-implement device. The result is a highly efficient and farther-reaching wireless network, as well as a more forgiving signal pattern that delivers greater link stability between mobile clients. As vehicles and nodes in a mobile network traverse uneven terrain or varying elevations, the HP-TMA ensures superior signal coverage and data throughput while providing improved signal penetration through trees, buildings, and other obstacles.

MOBILE MESH NETWORK CHALLENGES AND CONSIDERATIONS

The deployment of a wireless mobile network introduces several unique challenges—not the least of which is maintaining consistent and usable signal coverage across a reasonable area without sacrificing mobile connectivity. When designing such a network, there are many usage factors to be considered. The type of terrain vehicles will operate in; distance between vehicles; location, number, and type of mobile client devices that need access to the network; and data throughput tolerances are all important usage considerations. Additionally, material and physical factors often come into play. For example, a particular vehicle may have certain limitations in terms of placement options, profile, and footprint of the antenna and other equipment. The fact is that the right antenna can help simplify the mobile mesh design and implementation process. Whereas the antenna is often an afterthought in many fixed network implementations, in a mobile network deployment the choice of antenna can have a tremendous and lasting impact on user experience and network usability.

Maintaining consistent usable signal coverage at a distance can be a real challenge in any mobile networking environment. In many network deployments, high gain (8 to 10dBi) "stick" style omni antennas have traditionally been used to increase signal distances and coverage areas. While increasing signal reach, this approach introduces other potential problems:

- High gain antennas produce a flat "pancake" signal pattern. This signal pattern provides greater distance on level terrain but on uneven terrain the signal can lead to signal misalignment with other nodes on the network as the narrow beam is directed into space and into the ground.
- Because of the high profile, placement options of stick style antennas on vehicles can be limited, often requiring longer cable runs that can degrade performance.
- Stick style antennas often become hand grips on vehicles and are subject to breakage.

Figure 1: Representation of typical signal pattern of vehicles using 9dBi omni*

Conversely, a low gain (2 to 5dBi) omni antenna delivers a much broader vertical signal pattern that partially solves the mobility issue—so long as all nodes are in proximity. While the low gain antenna delivers a more attractive signal pattern, the distance limitations make it impractical for use in any serious mobile mesh environments (see figure 2).

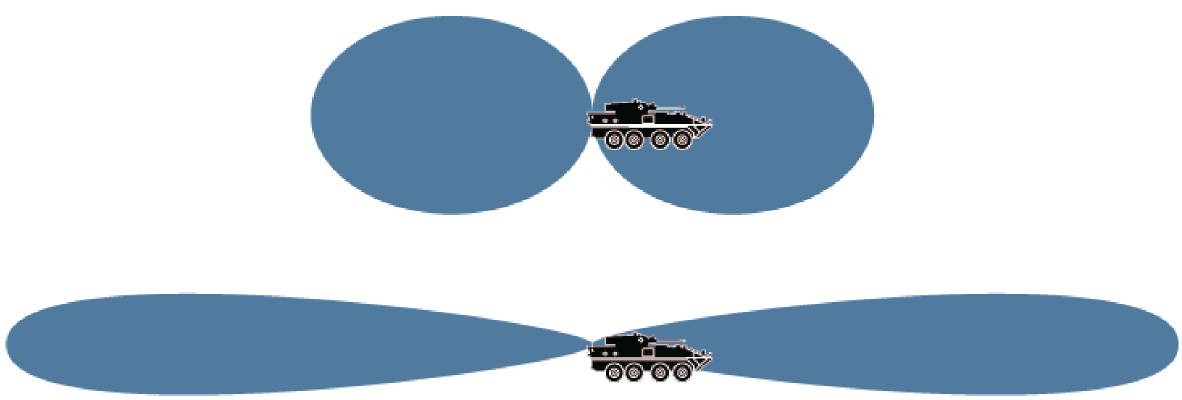


Figure 2: Representation of typical signal pattern of vehicles using 5dBi omni*

Additionally, consideration should be given to the type of signal propagation being implemented by the nodes within a mesh use Linear Polarized antennas for broadcasting signals. This means that signal waves are propagated in a single plane, either vertically or horizontally (see figure 3). These technologies are sufficient when used in applications with fixed network nodes, direct line of site and minimal interference. However, such ideal conditions don't always exist in real world wireless applications–especially as network clients become more mobile and usage requirements more data intensive. The use of linear antennas in mobile applications introduces antenna misalignment (see Figure 4) which negatively impacts network performance and data rates. In a mobile environment, maintaining reliable connections between nodes requires more sophisticated signal propagation technology.

Figure 3:
Traditional Linear Polarized antenna signal

Figure 4: Example of Linear Polarized antenna misalignment

THE SOLUTION

The reality is that a reliable mobile mesh network deployment requires the best of both worlds–the broad signal pattern of a low gain omni along with the longer distances and wider coverage area associated with the use of a high gain antenna. This is exactly the solution delivered by the HP-TMA from Mobile Mark.

Circular Polarized (CP) omni antenna to deliver a farther reaching and more usable signal. Further enhancements to the coverage area are derived from the circular pattern which CP antennas offer numerous advantages over linear technologies. Regardless of antenna orientation, a CP

High Performance
Tactical Mesh Antenna

antenna will deliver a more reliable connection between nodes as well as to mobile clients–even when those clients have linear antennas. CP antennas also have superior propagation characteristics, allowing signals to penetrate obstructions and adverse weather conditions more easily.

The HP-TMA incorporates patented 3D Signal™ technology that cleanly amplifies the signal which allows for superior penetration of obstacles such as trees, walls, and buildings. There are several elements that make the HP-TMA an ideal solution for use in mobile mesh network applications:

Circular Polarization: Traditional linear technologies. With a circular signal pattern that transmits in all planes, CP eliminates the antenna misalignment issues associated with the use of traditional linear technologies. Regardless of antenna orientation, CP will deliver a more reliable connection between nodes as well as to mobile clients–even when those clients have linear antennas. CP also has superior propagation characteristics, allowing signals to penetrate obstructions and adverse weather conditions more easily.

Broad Signal Pattern: The HP-TMA implements a low gain antenna to maintain a broad signal pattern. This signal pattern is then augmented with the use of efficient signal boosting technologies delivering both a far reaching and forgiving signal that is ideal for mobile environments with uneven terrain.

Bi-Directional Signal Boosting: The HP-TMA incorporates patented bi-directional Signal Boosting technology that cleanly amplifies the signal and further enhances the ability to maintain a clean connection with mobile clients on the network. In addition to delivering 20dB of transmit gain, up to 18dB of receive gain pulls the signal from low powered client devices delivering a more reliable and stable connection.

High Data Throughput: Maintaining good data rates throughout the entire network is a hallmark of the HP-TMA. The clean signal boosting capability ensures highest possible data rates, even at the edge of the network. Data rates are further sustained and enhanced by the 18dB of receive gain incorporated into the 3D Signal technology. And finally, the circular 3D Signal pattern helps to ensure a solid connection to client devices, regardless of antenna orientation–eliminating misalignment issues that can disrupt data rate integrity in mobile applications.

Form Factor, Profile, and Footprint: The HP-TMA is specifically designed for use in rugged and mobile environments. It has a footprint of 4.4" and stands just 5.5" tall–making it an ideal option for on vehicle use. Compared to traditional antenna options, the HP-TMA offers a significant footprint and durability advantage.

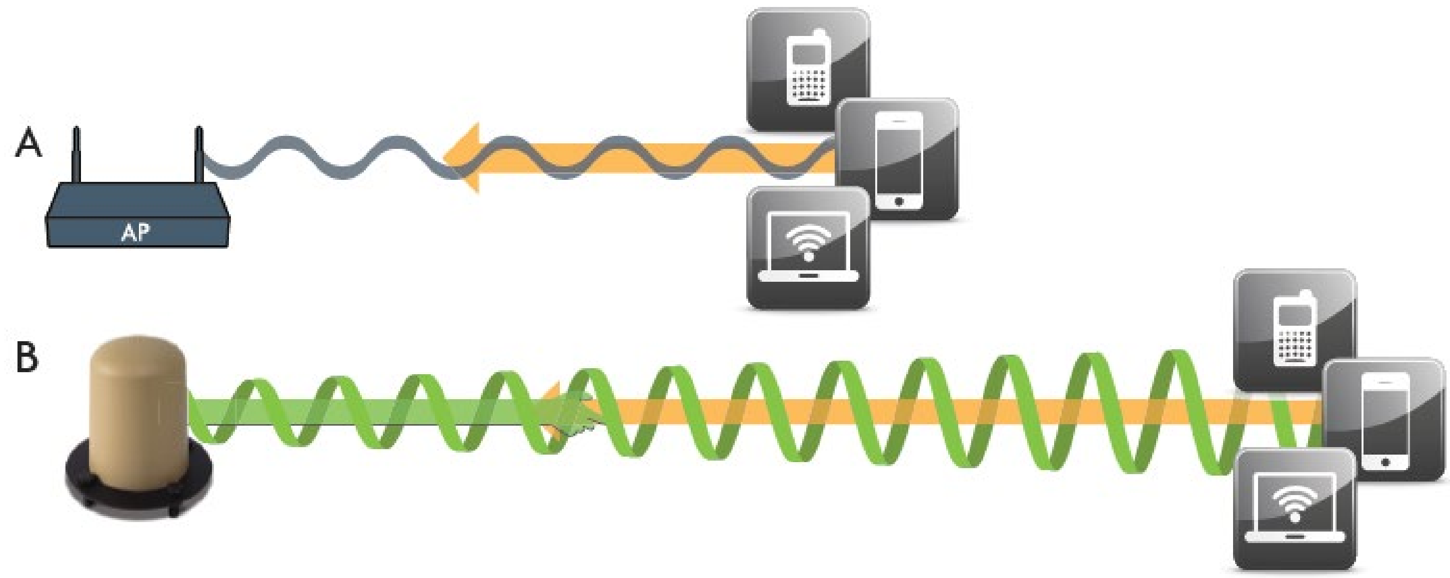


Figure 5:

A. Access Point (AP) using Vertically Polarized Omni Antenna.

B. HP-TMA using Circular Polarization and Bi-Directional Amplification improves connectivity with mobile clients

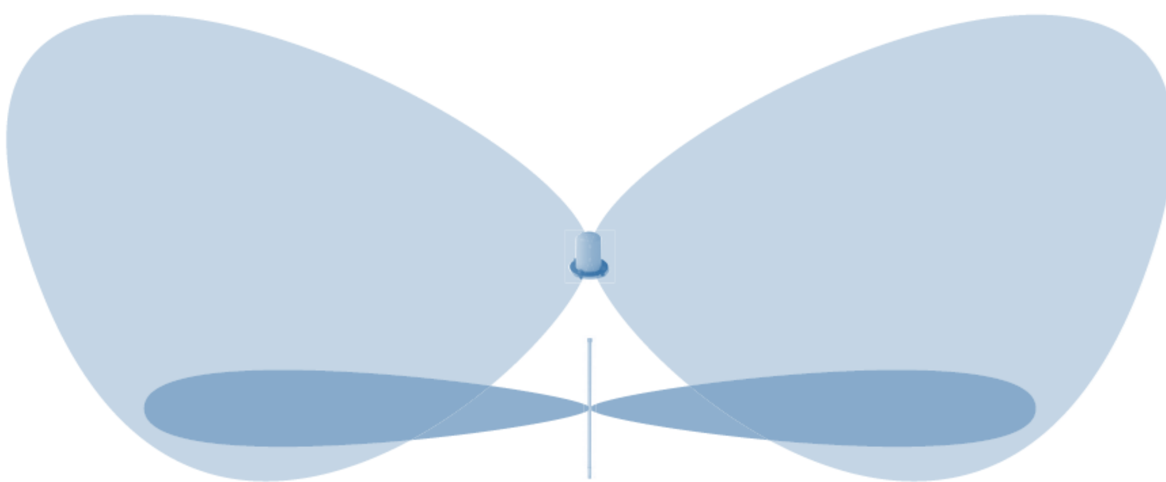


Figure 6: HP-TMA signal pattern compared to 9dBi Linear Omni signal pattern*

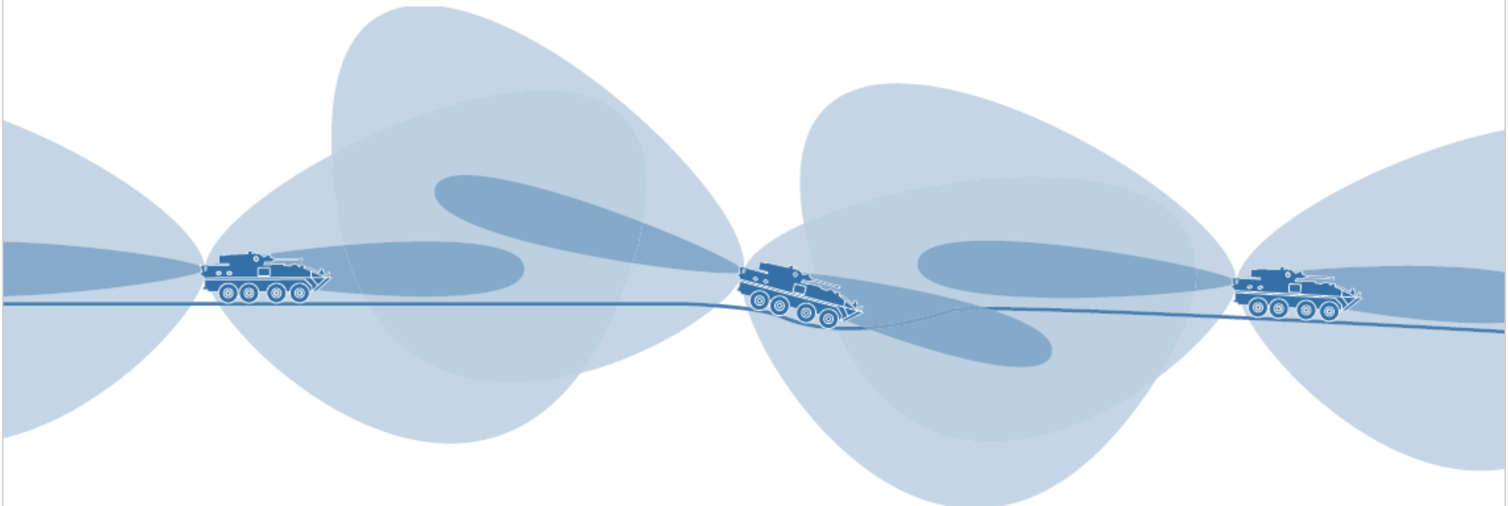


Figure 7: When vehicles pass over uneven surfaces, the broad signal pattern of the HP-TMA keeps vehicles connected, while the narrow signal pattern of a 9dBi Omni Linear Antenna allows connection to be lost*

The bottom line is that the HP-TMA will greatly enhance the performance of a mobile mesh network and improve the ability of any vehicle or node to remain connected to a mobile mesh network on even or uneven ground. When properly deployed as a central component of a mobile network application, the HP-TMA delivers:

- More Stable Mobile Client Connectivity
- A Larger Usable Coverage Area
- Consistently Higher Data Rates

REAL WORLD TEST RESULTS

Extensive testing has been conducted to support the claims made above. The following is a real-world case study that exhibits the power and performance of the HP-TMA.

Testing Objectives: To contrast a typical 9dBi omni antenna against a Mobile Mark Military HP-TMA in a real-world outdoor environment. Testing includes measurement of signal range and data throughput at various test points. Tests conducted on a level surface and at a 20-degree angle to simulate the impact of uneven terrain.

Testing was performed using the following parameters:

Test Area:

- 6 Million Sq Ft (1800m x 1000m), uneven terrain with moderate foliage
- Access point at 5300 ft ASL
- Test points ranged from 5200 to 5500 ft ASL
- Data Collection Tools:
- AirMagnet Survey (signal strength)
- IPERF (data throughput)

Access Point:

- COTS grade, outdoor 802.11 b/g
- Power: Full Power (400mW, 26 dBm)

Antennas Tested:

(Both antennas connected to access point via 12 ft of LMR-195 coax cable)

- Baseline Antenna Configuration: Standard 2.4 GHz 9dBi omni antenna
- Comparison Configuration: Mobile Mark 2.4 GHz High Performance Tactical Mesh Antenna (HP-TMA)

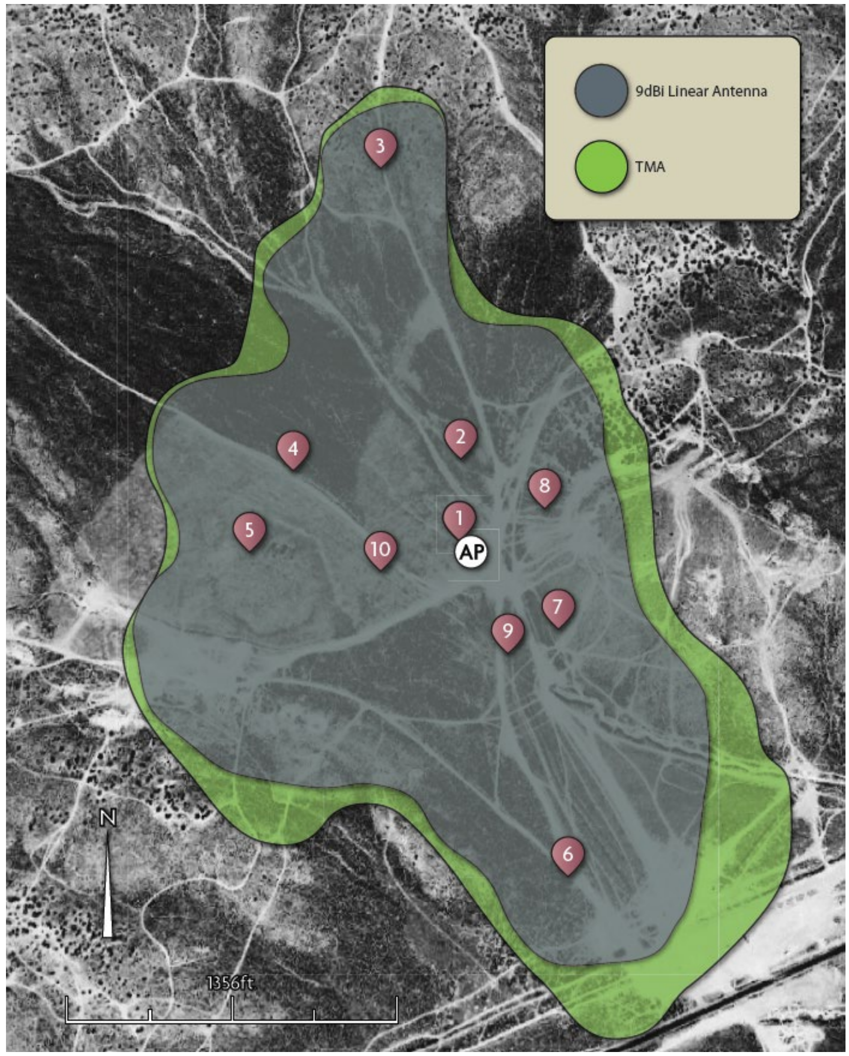
Tests Performed:

- Test 1: Vehicle set on Level Surface
- Test 2: Vehicle set at 20 Degree Angle

TEST 1: SIGNAL STRENGTH SURVEY AND DATA THROUGHPUT–LEVEL SURFACE

	9dBi Linear Antenna	HP-TMA
Point 1	26.3	26.3
Point 2	22.2	22.6
Point 3	0.7	3.1
Point 4	4.1	11.2
Point 5	4.3	12.7
Point 6	2.3	7.8
Point 7	4.7	21.2
Point 8	4.3	23.6
Point 9	22.6	24.2
Point 10	24.2	23.8

Table 1: Level surface test (Rates in Mbps)



Refer to Table 3 for Distances and elevations of measurement points

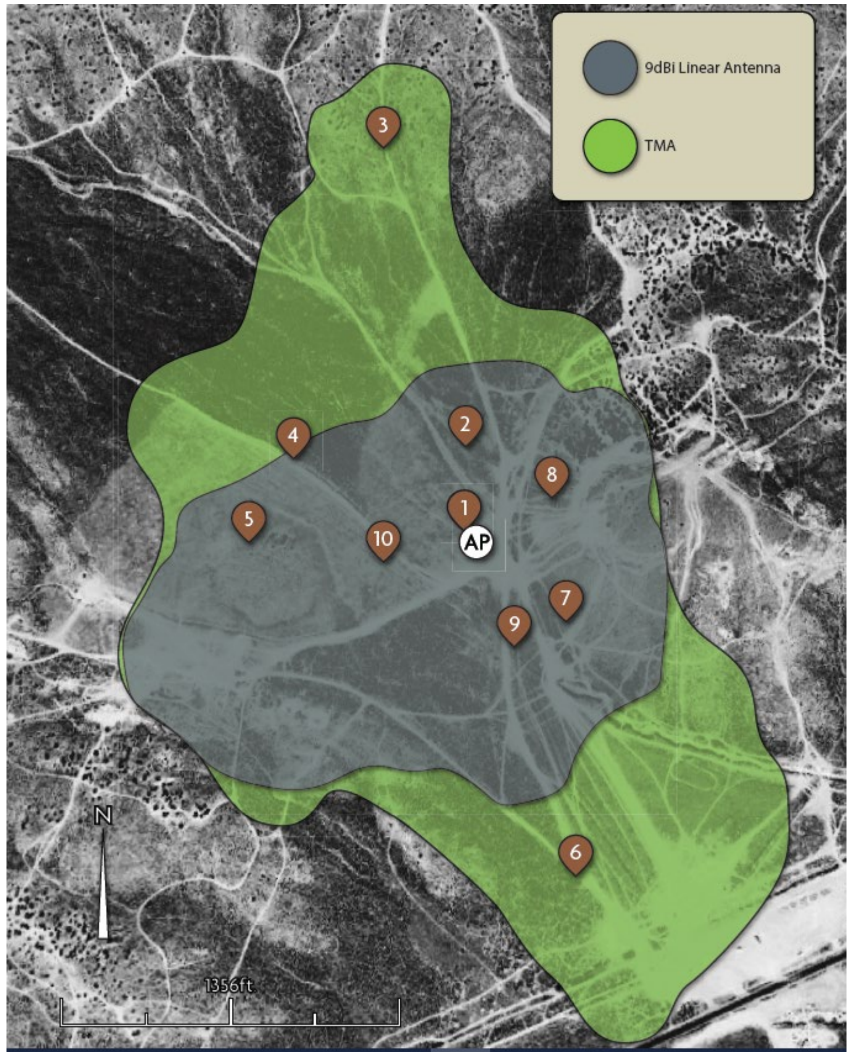
LEVEL SURFACE RESULTS SUMMARY

Initial comparisons of the signal strength surveys indicate that the 9dBi omni and the HP-TMA demonstrate similar results. However, in reviewing this data, it is important to consider signal usability–signal reach tells only half of the story. With that in mind, in reviewing data throughput results, the HP-TMA clearly demonstrates a significant advantage over the 9dBiantenna. As expected, the results for both solutions are similar at points close to the access point. However, at points further from the access point and wherever there are changes in elevation, HP-TMA data rates outperform those of the 9dBi antenna by as much as 500%.

TEST 2: SIGNAL STRENGTH SURVEY AND DATA THROUGHPUT–20 DEGREE ANGLE

	9dBi Linear Antenna	HP-TMA
Point 1	5.3	24.3
Point 2	4.1	7.5
Point 3	0.0	3.8
Point 4	0.5	9.4
Point 5	4.3	8.5
Point 6	0.3	6.5
Point 7	2.0	24.0
Point 8	4.4	15.4
Point 9	4.3	24.4
Point 10	24.3	24.2

Table 2: 20 degree angled surface test (Rates in Mbps)



Refer to Table 3 for distances and elevations of measurement points

20 DEGREE ANGLE RESULTS SUMMARY

While in the level surface testing the HP-TMA demonstrated a clear performance advantage over the 9dBi omni, at a 20degree angle the results were even more dramatic. At a 20-degree angle, the 9dBiantenna struggled to maintain either signal or sustainable data rates much beyond the immediate perimeter of the access point. On the other hand, the HP-TMA delivered similar results to those attained during the level surface testing. At all test points, the HP-TMA demonstrated usable signal with solid data throughput rates.

Measurement Point Number	Elevation Feet (Meters)	Elevation Feet (Meters)+ above or - below AP	Distance from AP Feet (miles) - Meters
AP	5308 (1618)	0	0
Point 1	5287 (1611)	-21 (-6.4)	87 (.016) - 26
Point 2	5286 (1611)	-22 (-6.7)	580 (.11) - 177
Point 3	5470 (1667)	+162 (49.3)	2798 (.53) - 853
Point 4	5302 (1606)	-6 (-1.8)	1056 (.2) - 322
Point 5	5335 (1626)	+27 (+8.2)	1162 (.22) - 354
Point 6	5230 (1594)	-78 (-23.8)	1637 (.31) - 499
Point 7	5271 (1607)	-37 (-11.2)	580 (.11) - 177
Point 8	5405 (1647)	+97 (+29.6)	471 (.09) - 144
Point 9	5255 (1602)	-53 (-16.1)	465 (.09) - 142
Point 10	5280 (1609)	-28 (-8.5)	307 (.06) - 94

Table 3: Distances and elevations of measurement points in tests 1 and 2.

SUMMARY

In any mobile networking environment, the Mobile Mark HP-TMA will extend the usable signal range and data throughput rates of a standard COTS wireless access point. The high performance and highly forgiving HP-TMA signal pattern allows for optimal connectivity between network nodes–and even enhances performance of low powered mobile devices. This is accomplished using unique and patented signal propagation and bi-directional signal boosting technologies incorporated into the HP-TMA. The combination of these technologies into a single ruggedized solution offers the most robust antenna option for deploying a reliable mobile mesh network.

* Vehicles and Signal Patterns represented in the illustrations may not be to scale

NOTE: The HP-TMA is available for use by United States Military, or export only.

Results may vary depending on building layout, type of construction and other environmental factors including Wi-Fi traffic, Microwaves Ovens, Cordless Phones, etc.

FCC NOTICE: The use of all radio equipment is subject to regulations in each country. To comply with FCC part 15 rules in the United States, radio equipment must only be used in systems that have been FCC certified. It is the responsibility of the user/professional installer/operator to ensure that only approved equipment/systems are deployed. To ensure FCC part 15 compliance, Mobile Mark amplified products should only be installed in certified systems by licensed professionals.

Mobile Mark, Inc. designs and manufactures site, mobile and device antennas for 30 MHz – 6 GHz. Applications include GPS Tracking & Fleet Management, Cellular 4G LTE & 5G Ready, Wi-Fi, RFID, Public Safety FirstNet, M2M & IoT, Smart City Networks and Autonomous & Connected Cars. Engineering and custom design services are available. Mobile Mark's global headquarters, research facilities and manufacturing plant, are located near Chicago, IL. An additional manufacturing and sales facility is located near Birmingham, UK.

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