Hemisphere®

GNSS HEADING: GET BIG PERFORMANCE FROM A SMALL SPACE

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Antenna separation and heading accuracy.

It is no secret GNSS compass heading performance improves when antennas are placed further apart. Some manufacturers take advantage of this and while making truthful claims about their product's heading performance, they base it on somewhat impractical antenna separations. The key is to look for the accuracy you want to achieve, with the shortest possible antenna separation. This becomes very important when esthetics and maintaining clean lines are a high priority. It is also a concern for scientific instruments, the autonomous-everything industry, and Internet of Things (IoT) applications.

With some competitors, be prepared for antenna separations of 1, 2, or even 5 meters (3, 6, or 16 feet) to meet the accuracy they headline for their product. The truth is integrators often don't have space for this, they would rather have something more compact instead.

One complication of placing the two antennas close together is they can start to interfere with each other. This is not something competitors highlight in their design documentation, opting instead to simply not specify the accuracy performance to expect at shorter antenna separations. While most precision GNSS manufacturers list their shortest antenna separation as 1 or 2 meters apart (3.3 or 6.6 feet), Hemisphere's Vega series of OEM GNSS heading products can be safely used with as little as 0.5 meters (19.7 inches) separation.

Careful comparison of heading accuracy specifications shows there is a wide variety of heading performance on the market from top GNSS manufacturers.

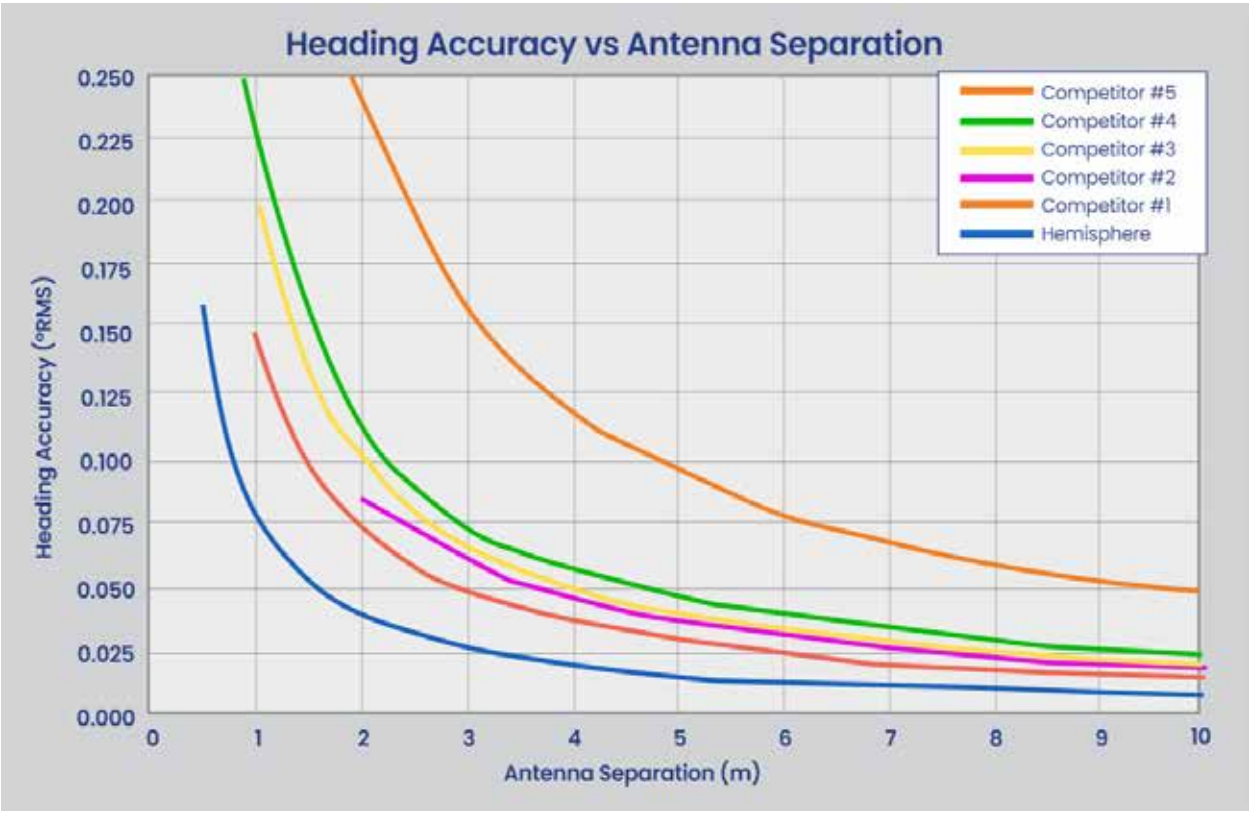


Figure 1: Plot showing heading accuracy vs antenna separation for various receivers.

The following discussion is based on the publicly available product information provided in the data sheets and integration manuals from the following manufacturers:

- Javad, TRE-DUO / Sigma
- NovAtel, OEM7720
- Septentrio, AsteRx 4 / Mosaic-H
- Trimble, MB-Two
- uBlox, ZED F9 series

Hemisphere has verified the performance of Trimble, NovAtel, and Septentrio heading products and finds their real-world performance meets and closely follows their published accuracies.

Understandably, every competitor lists their product's accuracy in a slightly different way. Here are some notable items on each product:

- Competitor #5 has the lowest accuracy, listing 0.4° accuracy at 1.0 m separation, at 50% confidence. Most manufacturers use 67% (RMS) values for heading accuracy which are 1.2 times larger than 50% values, meaning this product has 0.48° RMS. The manufacturer does not provide any other information on what the accuracy would be on shorter or longer separations.
- Competitor #4 obscures the heading accuracy by listing it in radians instead of degrees (0.004 radians at 1.0 m sounds much more accurate than 0.23°). They do not provide any guidance on what the minimum antenna separation is recommended.
- Competitor #3's highest performance heading receiver outperforms their other heading receiver series at separations of over 4.0 m. They list 0.1° heading performance with as little as 1.0 m antenna separation.
- Competitor #2 only specifies heading performance starting at 2.0 m separation, being 0.08° accuracy. They only specify one other performance number, at 4.0 m, being 0.05°, which does not follow the generally accepted behavior where accuracy values are ½ when antenna separation doubles.
- Competitor #1's receiver achieves 0.15° heading accuracy at 1.0 m antenna separation.
- Hemisphere's Vega series of receivers achieve 0.08° heading accuracy at 1.0 m, and as good as 0.15° at 0.5 m separation, the closest published antenna separation of any of these manufacturers.

Let's look at an Autonomous Surface Vehicle application. An integrator is looking to achieve 0.075° accuracy. Figure 2 shows what separation is needed for each receiver to achieve this accuracy.

There is a remarkable difference from 1.07 meters (42 inches), with several choices in the 2-to-3-meter range (79 to 120 inches), out to a massive 6.4 meters (252 inches, or 21 feet).

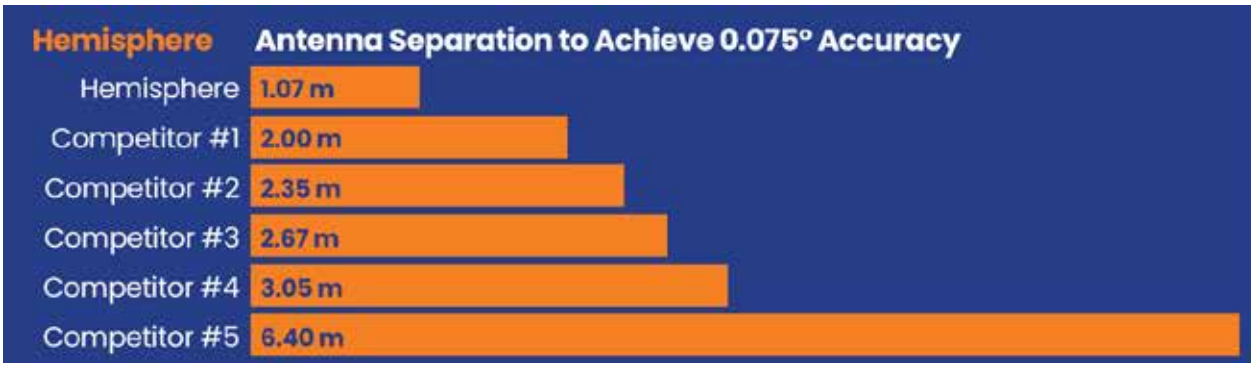


Figure 2: Antenna separations for various receivers at 0.075° heading accuracy.

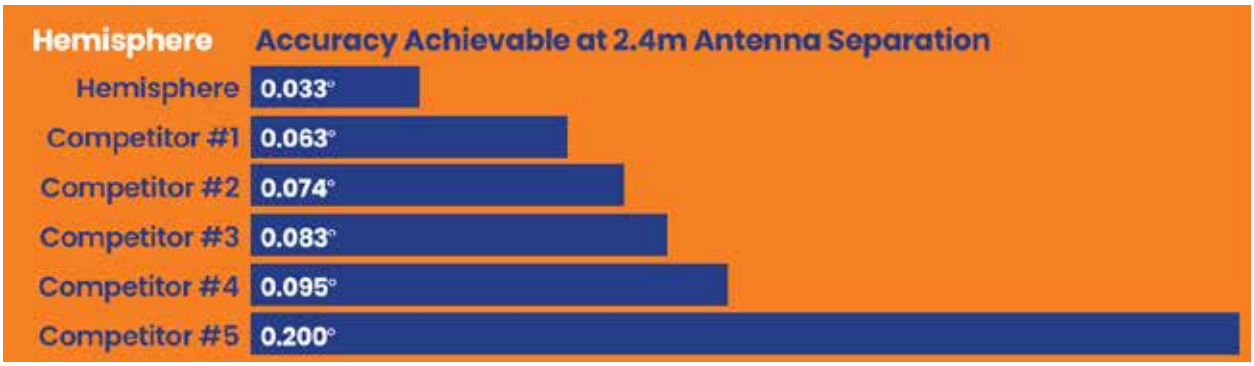


Figure 3: Heading accuracy for various receivers at 2.4 meters antenna separation.

Perhaps the integration team realizes they need to maximize the distance between the antennas, and they determine 2.4 meters (about 96 inches) is the largest possible separation. Figure 3 shows the vast difference in heading performance these receivers would have with this limited-length antenna separation.

Clearly, there is a significant advantage to selecting Hemisphere's Vega heading technology.

Figure 4: High multipath 2.0 m heading test.

As mentioned earlier, Hemisphere has run comparative tests with Trimble, NovAtel, and Septentrio products and found all manufacturers' performance closely follows their published values – in open sky environments. But what about real-world performance? What about a 2.0 meter (79 inch) separation on top of a vehicle, next to a building? Hemisphere conducted those tests as well and found a similar spectrum of performance when run over a 6-hour time span. Each system was about 5 times worse than their open sky specification, a testament to the challenges faced in real-world environments.

In a surprising twist, the test was repeated using a 0.5 m (19.7 inch) separation, and results were notably closer to published values, seeing an average of about 3 times worse than their respective specifications. Having both antennas closer to the center of the vehicle's roof provides a similar multipath environment for the antennas which improves their heading results. This shows having the antennas at their furthest point does not always translate to optimal performance. Having the best

Figure 5: Open sky environment test location.

Figure 6: High multipath 0.5 m heading test.

available performance for a given antenna separation is again an advantage, allowing integrators to find the optimal installation point for their application.

Over the decades of providing quality GNSS heading solutions, Hemisphere has recognized the importance of accurate solutions in small form factors. This helps integrators hide a heading solution in the space normally used for position-only antennas. Be it small assemblies of scientific measurement equipment, or the exotic world of virtual anchor and assisted-docking pleasure-crafts, compact solutions are in high demand.

Shallow water hydrographic equipment does not have room for large antenna separations. The platform limits how far apart the antennas can be. With autonomous vehicles of all descriptions for land, air, and on water, keeping things compact is essential to achieving efficiency. The IoT and scientific instruments market also

Figure 7: Shallow water hydrographic equipment.

Figure 8: Many applications require compact antenna installations.

Figure 9: Obvious advantage for short antenna separations.

cannot afford poor heading performance, nor large platform designs.

Leisure vessel designers are looking for sleek lines, not antenna-mast structures reminiscent of WWII battleships – they want clients to look past the antennas and see their trademark designs. Minimizing antenna spacing helps achieve all of this.

Through precise and careful engineering, Hemisphere's all-in-one V200 series heading antennas can even provide a reliable solution with just 0.2 meters (7.9 inches) separation. The entire receiver and combined antenna housing measures only 35 by 16 cm (13.7 by 6.2 inches). This compact solution provides 0.75° heading accuracy and is available in either serial or NMEA2000 formats.

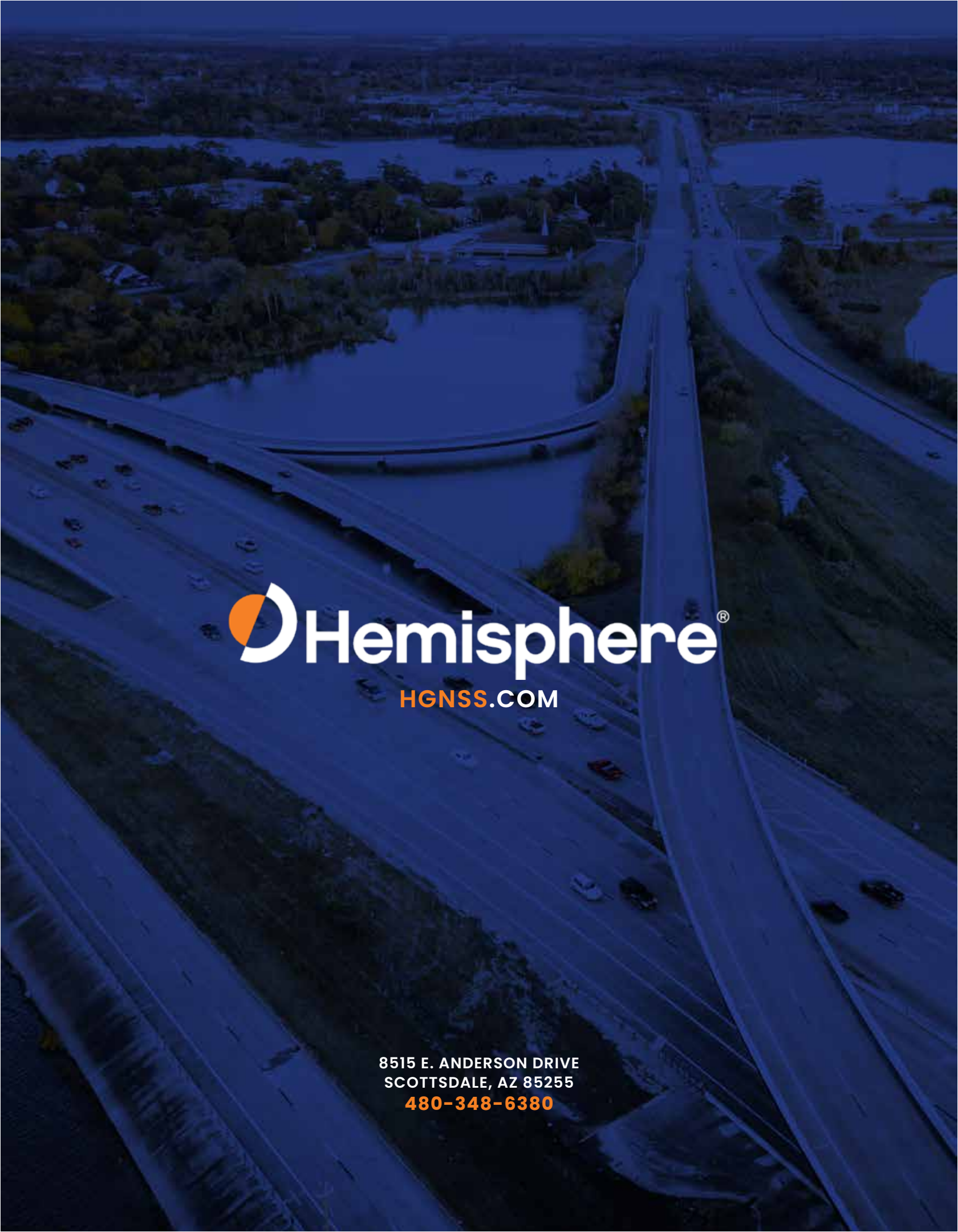
Figure 10: Applications with scientific equipment often have constrained antenna placement opportunities.

Figure 11: Clean lines highlight characteristics of the vessel's design.

Figure 12: Large antenna masts have their place in history.

When you are faced with selecting a heading solution for your next integration, consider all the factors, and understand the importance of antenna placement. Don't get caught with a product which only meets your performance targets in open sky conditions. Similarly, pay attention to how far apart you can comfortably put the antennas, and how similar their multipath environments will be. There are a lot of tough questions to answer, but the clear solution is to select the GNSS heading devices which provide the best performance in the most compact package, select Hemisphere.

Visit our website **hgnss.com** for all-in-one heading smart antennas like the V200 series, dual antenna receivers like R632, or our Vega series OEM boards.



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HGNSS.COM

8515 E. ANDERSON DRIVE
SCOTTSDALE, AZ 85255
480-348-6380