



DGPS SITE OPERATIONAL ASSESSMENT

NDGPS Site: *Pickford DGPS Site (835)*

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PURPOSE:

- Validate advertised DGPS coverage of the Pickford DGPS site.
- Validate required RTCM message scheduling and delivery.
- Test differential correction accuracy versus a predetermined survey monument.
- Verify site documentation accuracy and consistency.

REFERENCE: (1) DGPS Concept of Operations, COMDTINST 16577.2 (AUG 1995).
(2) Broadcast Standard for the USCG DGPS Navigation Service, COMDTINST M1677.1 (APR 1993).
(3) RTCM Recommend Standards for Differential GNSS Service, Version 2.3.

EQUIPMENT: STARLINK DNAV-212 DGPS Receiver
Trimble MBA-2 Receive Antenna
Trimble SPS461 Receiver
Trimble GA 530Antenna
Potomac Instruments 4100 FIM meter

PARAMETERS:

Frequency	309 KHz
Forward Output Power	600W
Transmission Rate	200 baud
Field Strength/Range	100 μ V/m (40.0 dB μ V/m) at 96 km

RESULTS

Signal Strength:

A verification of the Pickford Differential GPS (DGPS) coverage area was conducted from Saginaw, MI, along the west coast of Lake Huron, through Cheboygan, along the east coast of Lake Michigan, to Manistee, MI. The advertised signal strength range is 96 km. Figure 1 below displays the recorded signal strength throughout the trip; the measurements were conducted with a STARLINK DNAV 212 DGPS receiver paired with a Trimble MBA-2 Antenna. Green points represent areas of satisfactory signal strength. Areas of unsatisfactory signal strength are represented with red points. Far-field (FF) signal strength readings were taken at southeast and

southwest points of the advertised range from both sides of the site with both the STARLINK DNAV 212 DGPS receiver and the Potomac Instruments 4100 FIM meter (Table 1 and Table 2). Both FF signal strength readings were well within the minimum 40 dB μ V/m for a site transmission baud rate of 200. The verification did show, however, that the theoretical coverage area (coverage cloud) predicts available coverage beyond what was truly available. This theoretical prediction is based on Millington’s ground conductivity prediction method and is only an estimate; therefore, no action is necessary.

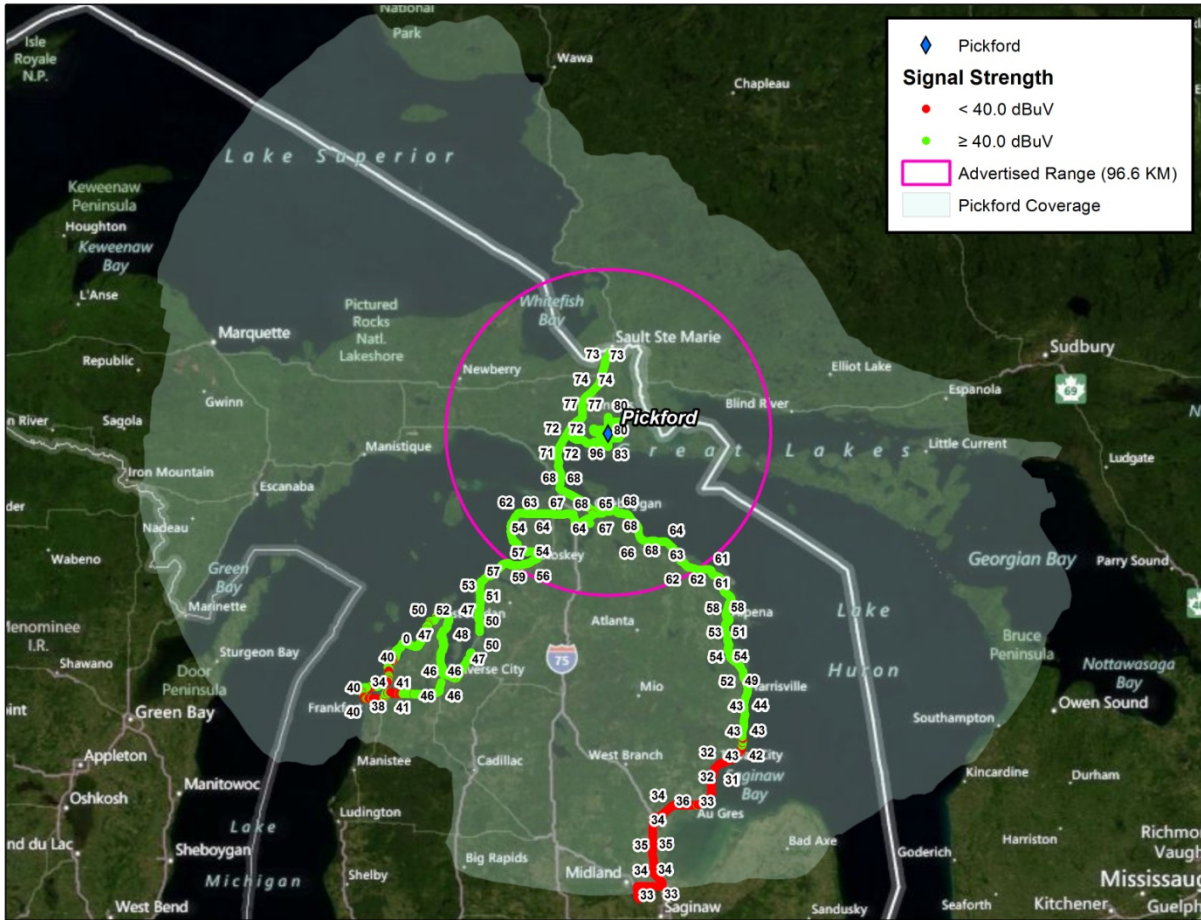


Figure 1: DNAV Signal Strength Results

	POSITION	Starlink DNAV 212, MBA 2 Antenna	4100 FIM Meter
Side A SS	45° 20' 24.5"N 083° 41' 59.9"W	59 dB μ V/m, 16 SNR	59.1 dB μ V/m
Side B SS	45° 20' 24.5"N 083° 41' 59.9"W	58 dB μ V/m, 16 SNR	59.0 dB μ V/m

Table 1: North Far-Field Signal Strength Reading

	POSITION	Starlink DNAV 212, MBA 2 Antenna	4100 FIM Meter
Side A SS	45° 21' 35.7N 085° 5' 46.6W	52 dB μ V/m, 14 SNR	51.7 dB μ V/m

Side B SS	45° 21' 35.7N 085° 5' 46.6W	52 dB μ V/m, 13 SNR	51.1 dB μ V/m
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Table 2: South Far-Field Signal Strength Reading

RTCM Message Verification:

RTCM message scheduling, receipt, and content were checked during the assessment (Table 3 and 4). RTCM message scheduling on both Side A and Side B was validated with the DGPS watch and is in accordance with the Reference (2). Receipt of all RTCM messages was validated utilizing a Remote Desktop Session whereby the assessment team witnessed the on-time receipt of all messages on the active and standby Integrity Monitor computers. All message content was verified and is in accordance with Reference (3).

Message Type	Received	Scheduled	Content Verified/Accurate
<i>Type 3</i>	Y	Y	Y
<i>Type 5 (ensure message is not being transmitted)</i>	N	N	N/A
<i>Type 7</i>	Y	Y	Y
<i>Type 9</i>	Y	Y	Y
<i>Type 16</i>	Y	Y	Y

Table 3: Side A RTCM Message Validation

Message Type	Received	Scheduled	Content Verified/Accurate
<i>Type 3</i>	Y	Y	Y
<i>Type 5 (ensure message is not being transmitted)</i>	N	N	N/A
<i>Type 7</i>	Y	Y	Y
<i>Type 9</i>	Y	Y	Y
<i>Type 16</i>	Y	Y	Y

Table 4: Side B RTCM Message Validation

Accuracy Validation:

Positional data was collected for 10 minutes per side using a Trimble SPS461 receiver with a Trimble GA 530 receive antenna. The data was then post-processed and compared to a National Geodetic Survey (NGS) marker to verify the horizontal accuracy of the broadcast correction (Table 5 and 6). Side A was 0.21 meters (0.6 feet) bearing 56.95° away from the monument while Side B was 0.34 meters (1.1 feet) bearing 32.0° away from the monument. Both respective distances were well within the advertised accuracy requirement of 10 meters. The GPS satellites in view at the Pickford DGPS site were compared to those in view at the NGS monument location to identify any differences in the GPS satellite geometry used at the respective locations; any differences in geometry could lead to accuracy ambiguity (Table 7). In this case, the GPS satellites tracked by the RS and IM GPS receivers at the site were the same as those tracked at the NGS monument location. A two dimension radial review for the same time period was

completed for the integrity monitors. Side A's average deviation was 0.06626 meters and Side B's average deviation was 0.06747 meters. Both findings were consistent with the finding observed in the field and are well within the 4 meter control-station alarm threshold. Furthermore, a comparison between the uncorrected GPS position and the NGS Monument was conducted to see how effective the DGPS corrections were. GPS accuracy was 2.76 meters away from the surveyed monument location proving the DGPS corrections are significantly improving the GPS positional solution.

NGS Monument ID:	RJ0617
Monument LAT:	46° 29' 8.28237" N
Monument LON:	084° 18' 5.15009" W

Averaged LAT:	46° 29' 8.286" N
Averaged LON:	084° 18' 5.142" W
Distance from DGPS Site:	47.03 km
Antenna Distance from Monument:	0.21 m (0.6 ft)
Antenna Bearing from Monument:	56.95°

Table 5: Side A Accuracy Check Results

Averaged LAT:	46° 29' 8.291606558" N
Averaged LON:	084° 18' 5.141704918" W
Distance from DGPS Site:	47.03 km
Distance from Monument:	0.34 m (1.1 ft)
Bearing from Monument:	32.0°

Table 6: Side B Accuracy Check Results

<i>Antenna Location</i>	<i>GPS Satellites Tracked (PRN)</i>											
Reference Station A	3	6	7	10	13	16	19	20	23	30	31	32
Integrity Monitor A	3	6	7	10	13	16	19	20	23	30	31	32
Reference Station B	3	6	7	10	13	16	19	20	23	30	31	32
Integrity Monitor B	3	6	7	10	13	16	20	23	30	31	32	
NGS Monument, Side A	3	6	7	10	13	16	19	23	30	31	32	
NGS Monument, Side B	3	6	7	10	13	16	19	23	30	31	32	

Table 7: GPS Satellite Comparison

SUMMARY:

The Operational Assessment of the Pickford DGPS site revealed that the provided coverage is consistent with advertised range but is slightly less than the theoretical coverage area. Both southeast and southwest Far-Field signal strength readings were well within the required signal strength. Additionally, the signal strength measurements throughout the majority of the predicted coverage area were satisfactory. Redundant DGPS coverage is provided by the Sturgeon Bay, Detroit, and Cheboygan DGPS sites. All RTCM messages were verified, evaluated, and are consistent with the requirements set forth by Reference (2) and (3). Finally, accuracy measurements and analysis proved that at a distance of approximately 47 km from the broadcast site, the horizontal accuracy is sub-meter and within the accuracy requirements set forth by Reference (1) and (2).