



## DGPS SITE OPERATIONAL ASSESSMENT

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**NDGPS Site:** *Cheboygan DGPS Site (836)*  
**Inspector(s):** LT Christian Hernaez, LT Michael Brashier  
**Date:** 27JUL12

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### **PURPOSE:**

- Validate advertised DGPS coverage of the Cheboygan 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 530 Antenna  
Potomac Instruments 4100 FIM meter

### **PARAMETERS:**

Frequency	292 KHz
Forward Output Power	460W
Transmission Rate	200 baud
Field Strength/Range	100 $\mu$ V/m (40.0 dB $\mu$ V/m) at 177 km

## **RESULTS**

### **Signal Strength:**

A verification of the Cheboygan 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 177 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 southwest and southeast 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). The signal strength readings taken at the FF points failed to meet the minimum 40 dB $\mu$ V/m for a site with a transmission baud rate of 200. Transmission output power and reflected power were confirmed with the NAVCEN DGPS watchstander to be at satisfactory levels. The local weather was mid-70's, partly cloudy, and was not a factor. The lack of signal strength may be due to the land over which the ground-wave must propagate. A decrease in the advertised range ring or increase in the operating power may be required. The vast majority of the signal strength readings along the coastline were well within the required signal strength minimum.

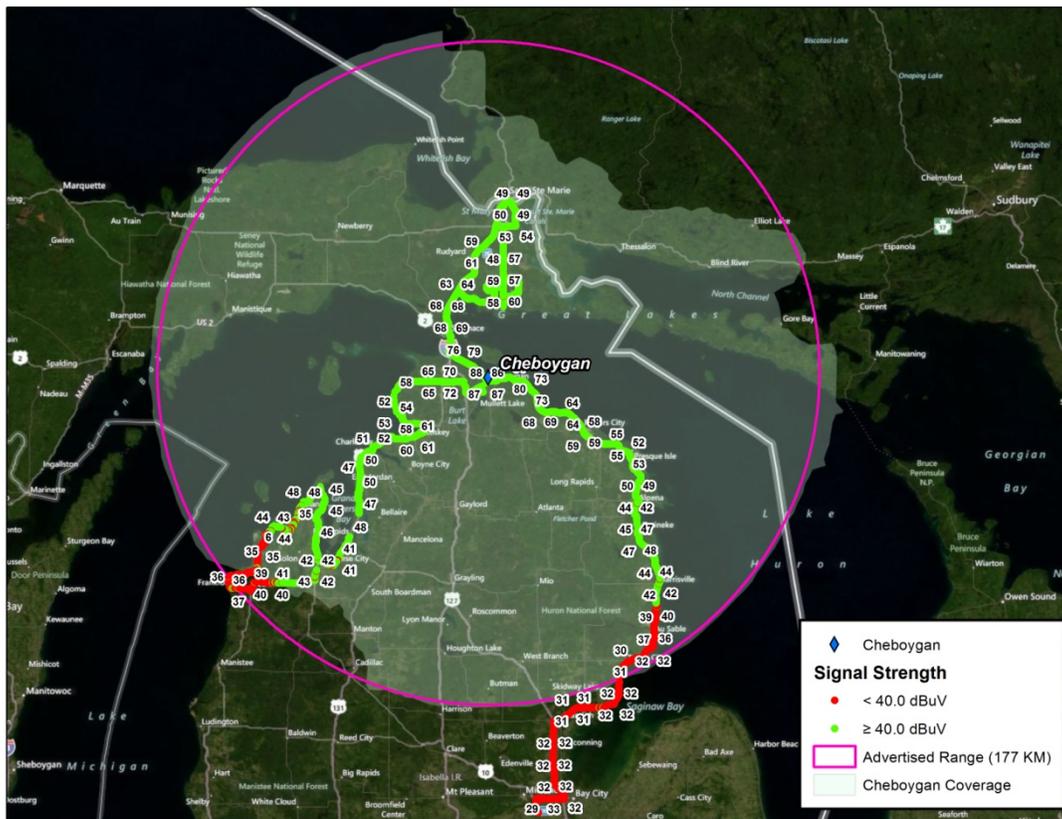


Figure 1: DNAV Signal Strength Results

	POSITION	Starlink DNAV 212, MBA 2 Antenna	4100 FIM Meter
Side A SS	44° 12' 14.3"N 083° 33' 41.8"W	33 dB $\mu$ V/m, 0 SNR	32.5 dB $\mu$ V/m
Side B SS	44° 12' 14.3"N 083° 33' 41.8"W	32 dB $\mu$ V/m, 0 SNR	33.3 dB $\mu$ V/m

Table 1: North Far-Field Signal Strength Reading

	POSITION	Starlink DNAV 212, MBA 2 Antenna	4100 FIM Meter
Side A SS	44° 37' 59.9N 086° 11' 24.4W	35 dB $\mu$ V/m, 0 SNR	37.1 dB $\mu$ V/m

Side B SS	44° 37' 59.9N 086° 11' 24.4W	35 dB $\mu$ V/m, 0 SNR	37.6 dB $\mu$ 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 0.5 meters (1.63 feet) bearing 18.34° away from the monument while Side B was 0.37 meters (1.22 feet) bearing 36.62° away from the monument. Both respective distances were well within the advertised accuracy requirement of 10 meters. The GPS satellites in view at the Cheboygan 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 0.11323 meters and Side B’s average deviation was 0.11643 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.

<b>NGS Monument ID:</b>	<b>RJ0617</b>
Monument LAT:	46° 29’ 8.28237’’ N
Monument LON:	084° 18’ 5.15009’’ W

<b>Averaged LAT:</b>	46° 29’ 8.297630769’’ N
<b>Averaged LON:</b>	084° 18’ 5.142738461’’ W
<b>Distance from DGPS Site:</b>	75.07 km
<b>Antenna Distance from Monument:</b>	0.5 m (1.63 ft)
<b>Antenna Bearing from Monument:</b>	18.34°

Table 5: Side A Accuracy Check Results

<b>Averaged LAT:</b>	46° 29’ 8.292’’ N
<b>Averaged LON:</b>	084° 18’ 5.139677419’’ W
<b>Distance from DGPS Site:</b>	75.07 km
<b>Distance from Monument:</b>	0.37 m (1.22 ft)
<b>Bearing from Monument:</b>	36.62°

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	23	30	31	32	
Reference Station B	3	6	7	10	13	16	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 Cheboygan DGPS site revealed a slight inconsistency between the advertised range ring and the actual signal strength range. However, the majority of the coastal area is receiving satisfactory signal strength. Areas of the Cheboygan coverage area that did not meet the minimum signal strength levels have redundant coverage provided by the Sturgeon Bay DGPS site and the Detroit DGPS site. 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 75 km from the broadcast site, the horizontal accuracy is sub-meter and within the accuracy requirements set forth by Reference (1) and (2).