



## **DIFFERENTIAL GPS (DGPS) SITE OPERATIONAL ASSESSMENT**

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**NDGPS Site:** Billings DGPS Site (874)  
**Inspector(s):** LT Hermie Mendoza  
**Date:** 04AUG14

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### **REFERENCES:**

- (1) DGPS Concept of Operations, COMDTINST 16577.2 (AUG 1995)
- (2) 2010 Federal Radio Navigation Plan
- (3) Broadcast Standard for the USCG DGPS Navigation Service, CIM 16577.1 (APR 1993).
- (4) RTCM Recommend Standards for Differential GNSS Service, Version 2.3.

### **PURPOSE:**

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

### **EQUIPMENT:**

Hemisphere GNSS Eclipse VS330 Receiver  
Hemisphere GNSS A43 Antenna  
Trimble SPS461 Receiver  
Trimble GA 530 Antenna

### **BILLINGS DGPS SITE PARAMETERS:**

Frequency	313 KHz
Forward Output Power	1000 W
Transmission Rate	100 baud
Field Strength/Range	75 $\mu$ V/m (37.5 dB $\mu$ V/m) at 400 km

### **RESULTS:**

#### ***Signal Strength:***

A verification of the Billings DGPS coverage area was conducted from Whitney, NE to Helena, MT and portions of Flathead Lake Valley in MT. The advertised signal strength range is 400 km. Figure 1 below displays adequate signal strength in limited areas beyond the advertised range of 400 km from the site and throughout the predicted coverage area. Green points represent areas of satisfactory signal strength. Areas of unsatisfactory signal strength are represented with red points, which occurred most frequently along portions of the Rocky Mountains. Additionally, far-field (FF) signal strength readings were taken at the southeastern point of the advertised

range from both sides of the site (Table 1). FF readings were well above the required 37.5 dB $\mu$ V/m signal strength on both sides.

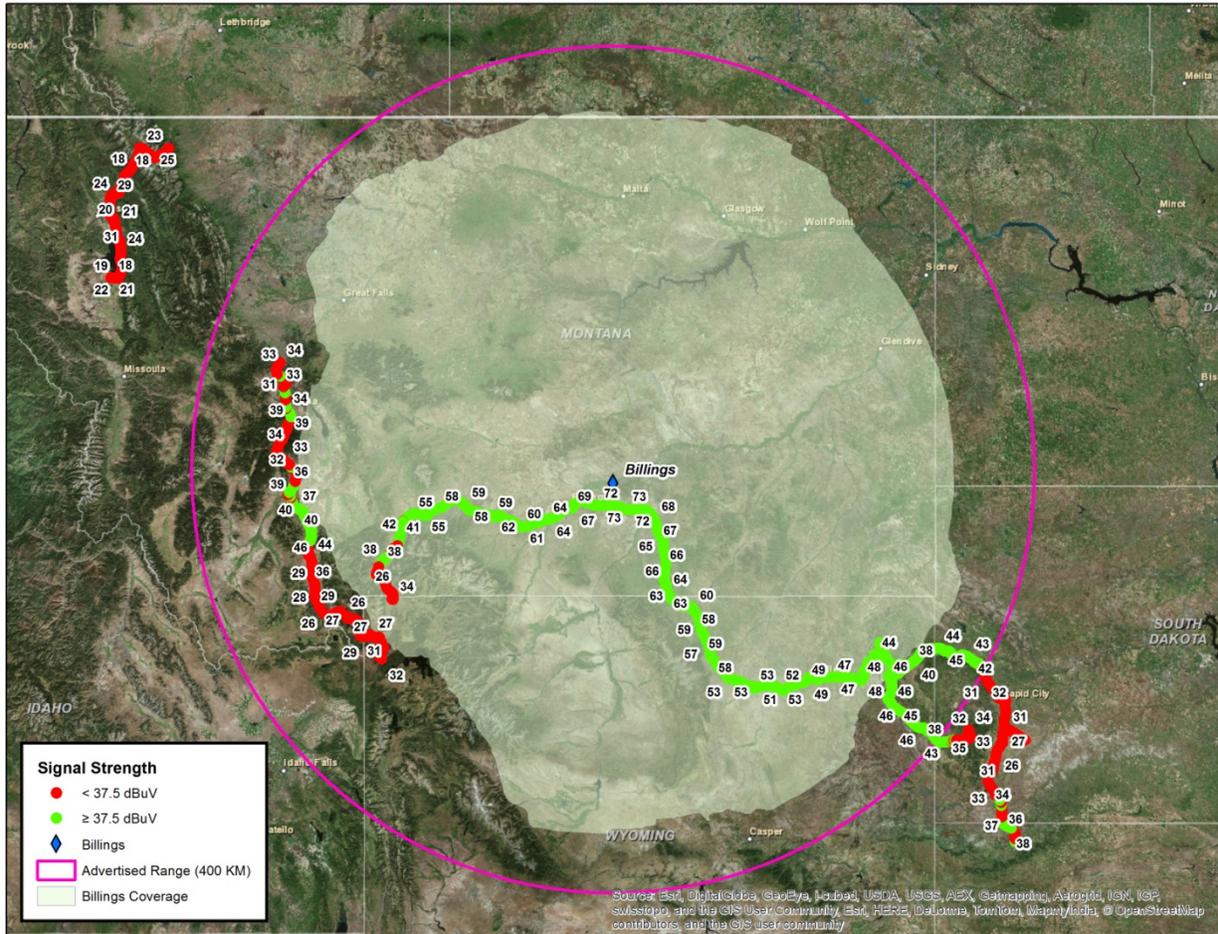


Figure 1: DNAV Signal Strength Results

Table 1: Southeast Far-Field Signal Strength Reading

Side	Signal Strength	Signal to Noise ratio	Position
A	39 dB $\mu$ V/m	24 dB $\mu$ V/m	44° 21.121160' N, 103° 27.256003' W
B	39 dB $\mu$ V/m	24 dB $\mu$ V/m	

**RTCM Message Verification:**

RTCM message scheduling, receipt, and content were checked during the assessment (Table 2 and 3). RTCM message scheduling on both Side A and Side B was validated with the DGPS watch and is in accordance with the Reference (3). 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 (4).

Table 2: Side A RTCM Message Validation

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

Table 3: Side B RTCM Message Validation

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

**Accuracy Validation:**

Positional data was collected for 10 minutes per side using the Trimble SPS461. 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 0.480 meters, bearing 313.78°, away from the monument while Side B was 0.61 meters, bearing 201.93°, away from the monument. As per Reference (1) and (2), both respective distances were well within advertised accuracy requirements. A comparison between the GPS satellites in view at the Billings DGPS site and at the NGS monument location was conducted (Table 7) to identify any differences in the GPS satellite geometry used at the respective locations; any differences in geometry could lead to accuracy discrepancies. In this case, the satellites being tracked by the RS and IM GPS receivers at the site were almost identical to those tracked at the NGS monument location. A two dimension radial review of the same time period was completed for the integrity monitors. Side A’s average deviation was 0.39607 meters; Side B’s average deviation was 0.36730 meters. Both findings were consistent with the findings observed in the field and are well within system parameters.

Table 4: Monument ID

<b>NGS Monument ID:</b>	<b>BBCS85</b>
Monument LAT:	44° 13' 31.90217" N
Monument LON:	104° 34' 39.98171" W
Distance from DGPS Site	280.55 km

Table 5: Side A Accuracy Check Results

<b>Averaged LAT:</b>	44° 13' 31.8881397" N
<b>Averaged LON:</b>	104° 34' 39.9913941" W
<b>Antenna Distance from Monument:</b>	0.48 m (1.574803 ft)
<b>Antenna Bearing from Monument:</b>	313.78 °

Table 6: Side B Accuracy Check Results

<b>Averaged LAT:</b>	44° 13' 31.883998" N
<b>Averaged LON:</b>	104° 34' 39.9715" W
<b>Distance from Monument:</b>	0.61 m (2.001312 ft)
<b>Bearing from Monument:</b>	201.93°

Table 7: GPS Satellite Comparison

<i>Antenna Location</i>	<i>GPS Satellites Tracked (PRN)</i>										
Reference Station A	1	4	6	8	11	15	17	24	26	28	30
Integrity Monitor A	1	4	6	8	11	15	17	24	26	28	30
Reference Station B	1	4	6	8	11	15	17	24	26	28	30
Integrity Monitor B	1	4	6	8	11	15	17	24	26	28	30
NGS Monument Location, Side A	1	4	6	15	17	24	28	30			
NGS Monument Location, Side B	1	4	6	11	15	17	24	26	28	30	

**SUMMARY:**

The Operational Assessment of the Billings DGPS site revealed that the provided coverage is consistent with the predicted coverage plot but not the advertised range. Additionally, the far-field signal strength readings were well within the required signal strength. The signal strength measurements, throughout the predicted coverage area within the advertised range, were satisfactory. Moreover, a review of the output/reflected power and near-field signal strength levels was conducted and found to be satisfactory. All RTCM messages were verified and evaluated and are consistent with the requirements set forth by reference (3) and (4). Finally, accuracy measurements and analysis proved that at a distance of approximately 280.55 km from the broadcast site, the horizontal accuracy is sub-meter and within the accuracy requirements set forth by Reference (1) and (2).