



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

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<b>NDGPS Site:</b>	Flagstaff DGPS Site (876)
<b>Inspector(s):</b>	CWO3 Louie Baytan, LT Michael Brashier
<b>Date:</b>	03-07 June 2013

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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 Flagstaff DGPS site.
- Validate required RTCM message scheduling and delivery.
- Test differential correction accuracy versus a predetermined survey monument.

### **EQUIPMENT:**

Raven INVICTA Receiver  
MBA-2 Receive Antenna  
Trimble SPS461 Receiver  
Trimble GA 530 Antenna  
Potomac Instruments 4100 FIM meter

### **FLAGSTAFF DGPS SITE PARAMETERS:**

Frequency	319 KHz
Forward Output Power	1000 W
Transmission Rate	100 baud
Field Strength/Range	75 $\mu$ V/m at 450 km

### **RESULTS:**

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

A verification of the Flagstaff DGPS coverage area was conducted from Huntington, UT, south to Cortez, CO through the Navaho Indian Reservation and Flagstaff, then west to Las Vegas, NV. The advertised signal range is 450 km. Figure 1 below displays adequate signal strength, beyond the advertised range and throughout the predicted coverage area. 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 northern point of the advertised

range from both sides of the site (Table 1 and Table 2). The FF readings were well below the required 37.5 dB $\mu$ V/m signal strength on both sides

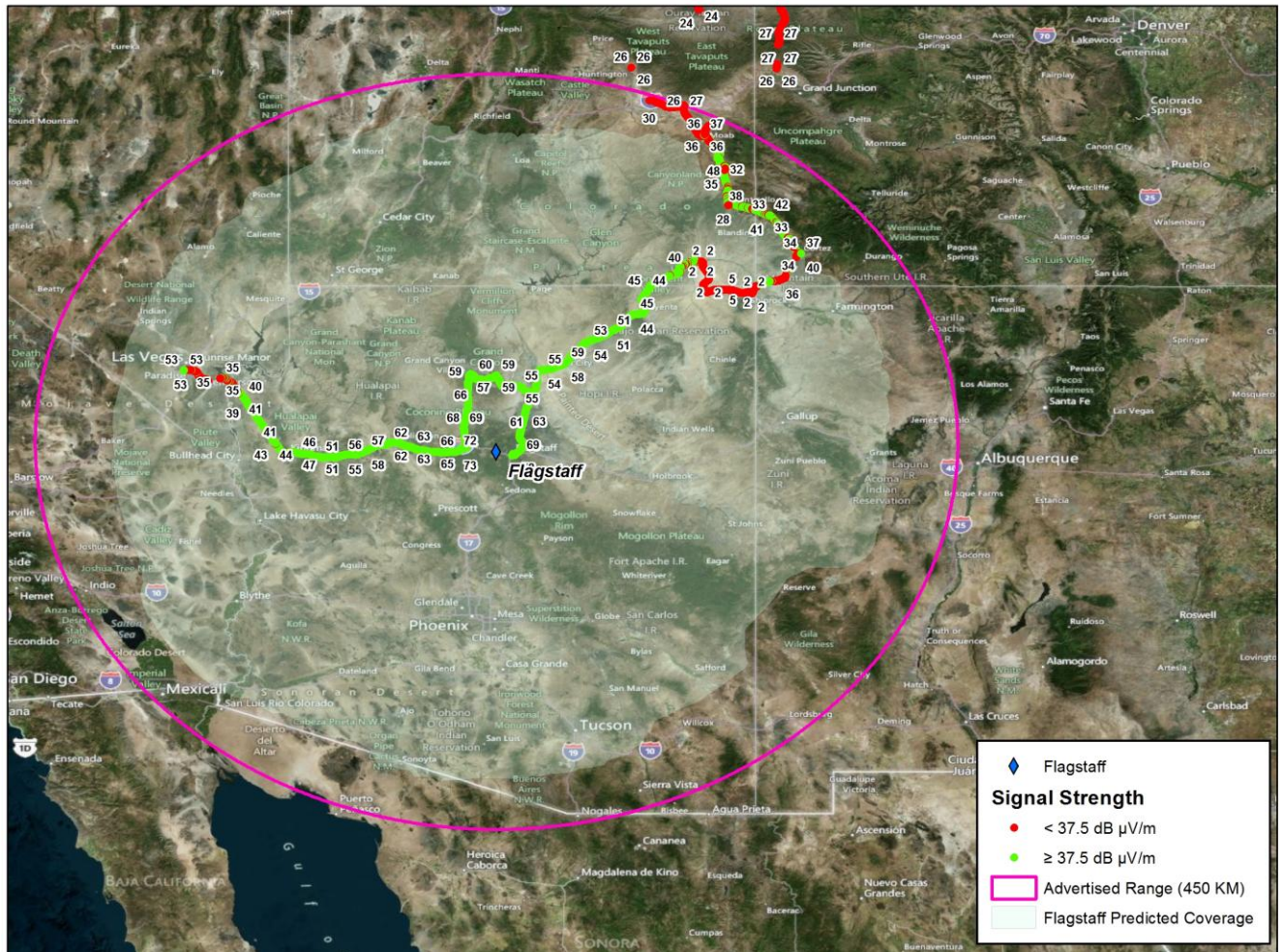


Figure 1: DNAV Signal Strength Results

	POSITION	Trimble SPS461	4100 FIM Meter
Side A SS	38° 59' 39.0"N 110° 11' 04.4"W	27.0 dB $\mu$ V/m, 10 SNR	24.0 dB $\mu$ V/m
Side B SS	44° 50' 44.0"N 083° 24' 25.8"W	27.0 dB $\mu$ V/m, 10 SNR	23.9 dB $\mu$ V/m

Table 1: North Far-Field Signal Strength Reading

**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 Raven Invicta Receiver whereby the assessment team witnessed the on-time receipt of all messages with the exception of the Type 16 message on the active and standby Integrity Monitor computers. Type 16 messages were witnessed receiving at initial broadcast but were

not present at required interval and sync times. All other message content was verified and is in accordance with Reference (4).

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>	N	Y	N

Table 2: 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>	N	Y	N

Table 3: Side B RTCM Message Validation

**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 4 and 5). Side A was .5883 meters, bearing 105.71°, away from the monument while Side B was 1.008 meters, bearing 300.94°, 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 Flagstaff DGPS site and at the NGS monument location was conducted (Table 6) 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 similar 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 0.19964 meters; Side B’s average deviation was 0.22928 meters. Both findings were consistent with the findings observed in the field and are well within system parameters. 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 4.852 meters away from the monument. Therefore, the DGPS site is effectively improving the positional solution by over 508%.

<b>NGS Monument ID:</b>	<b>FS0348</b>
Monument LAT:	35° 32' 02.75970" N
Monument LON:	114° 21' 21.71319" W

<b>Averaged LAT:</b>	35° 32' 02.776488" N
<b>Averaged LON:</b>	114° 21' 21.747600" W
<b>Distance from DGPS Site:</b>	232.7 km
<b>Antenna Distance from Monument:</b>	.5883 m (1.912 ft)
<b>Antenna Bearing from Monument:</b>	105.71889°

Table 4: Side A Accuracy Check Results

<b>Averaged LAT:</b>	35° 32' 02.776488" N
<b>Averaged LON:</b>	114° 21' 21.747600" W
<b>Distance from DGPS Site:</b>	232.7 km
<b>Distance from Monument:</b>	1.008 m (3.276 ft)
<b>Bearing from Monument:</b>	300.94417°

Table 5: Side B Accuracy Check Results

<i>Antenna Location</i>	<i>GPS Satellites Tracked (PRN)</i>										
Reference Station A	3	5	6	7	8	10	13	19	23	25	28
Integrity Monitor A	3	5	6	7	8	10	13	19	23	25	28
Reference Station B	6	9	14	15	18	21	22				
Integrity Monitor B	1	7	8	9	11	15	17	26	28		
NGS Monument Location, Side A	1	7	8	9	11	15	11	26	28		
NGS Monument Location, Side B	1	6	7	8	9	11	17	26	28		

Table 6: GPS Satellite Comparison

**SUMMARY:**

The Operational Assessment of the Flagstaff DGPS site revealed that the provided coverage is consistent with the predicted coverage plot and less than the advertised range. The Far-Field signal strength readings were below the required signal strength. The signal strength measurements, throughout the predicted coverage area within the advertised range, were satisfactory with the exception of mountain regions near the northeast corner of Arizona and Hoover Dam region in Nevada. Additionally, 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 not consistent with the requirements set forth by reference (3) and (4) as RTCM Type 16 messages were not received after initial broadcast. Finally, accuracy measurements and analysis proved that at a distance of approximately 232 km from the broadcast site, the horizontal accuracy is 1 meter or less and within the accuracy requirements set forth by Reference (1) and (2).