DIFFERENTIAL GPS (DGPS) SITE OPERATIONAL ASSESSMENT

NDGPS Site: Pigeon Point DGPS Site (883)
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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 Pigeon Point DGPS site.
- Validate required RTCM message scheduling and delivery.
- Test differential correction accuracy versus a predetermined survey monument.

EQUIPMENT:
Trimble SPS461 Receiver
Trimble GA 530 Antenna
Potomac Instruments 4100 FIM meter
Hemisphere R110 Receiver
Raven MBA-2 Antenna
Dell Latitude 6300 Laptop
Garmin GPSmap 60CS Handheld Receiver
iPhone 5

PIGEON POINT DGPS SITE PARAMETERS:

Frequency	287 KHz
Forward Output Power	500 W
Transmission Rate	100 baud
Field Strength/Range	75µV/m (37.5 dBµV/m) at 250 km

RESULTS:
Signal Strength:
A verification of the Pigeon Point DGPS coverage area was conducted from Fortuna, CA, along the Pacific coast of California, to Paso Robles, CA. The verification included areas east of the Pigeon Point DGPS site around Sacramento, CA. The advertised signal strength range is 250 km. Per reference (3), the minimum signal strength for a site with a transmission rate of 100

baud is 37.5 dBµV/m. Figure 1 displays the results of the signal strength verification; green and red points represent areas of satisfactory and unsatisfactory signal strength levels, respectively. Satisfactory signal strength was verified along the coastline for the majority of the predicted coverage area; the signal strength dropped below 37.5 dBµV/m just before the northern and southern edges of the advertised range. As the verification turned east toward the inland portion of the coverage area, it crossed into the Coastal Mountain range. At this point signal strength began to decrease and become slightly erratic. When driving directly adjacent to a mountain face, the signal strength would drop below the required level but would return to satisfactory levels once an open area was reached. The majority of the inland verification was below the required signal strength level due to the mountainous terrain.

Far-field (FF) signal strength readings were taken at northern and southern points of the advertised range (Table 1 and Table 2). FF signal strength readings could only be taken from Side A due to an ongoing maintenance issue on Side B. As mentioned above, both FF readings were slightly below the required 37.5 dBµV/m level, however, signal-to-noise-ratio (SNR) levels were high which may result in a useable signal. The southern FF reading was taken along the Coastal Mountain range, which, as mentioned above, created lower signal strength results overall. The northern FF reading was taken along the pacific coastline where the signal had several cliffs, hills, and forest areas to contend with. It is assumed that the reduction in signal strength at both FF locations was due to the inland and coastal topography.

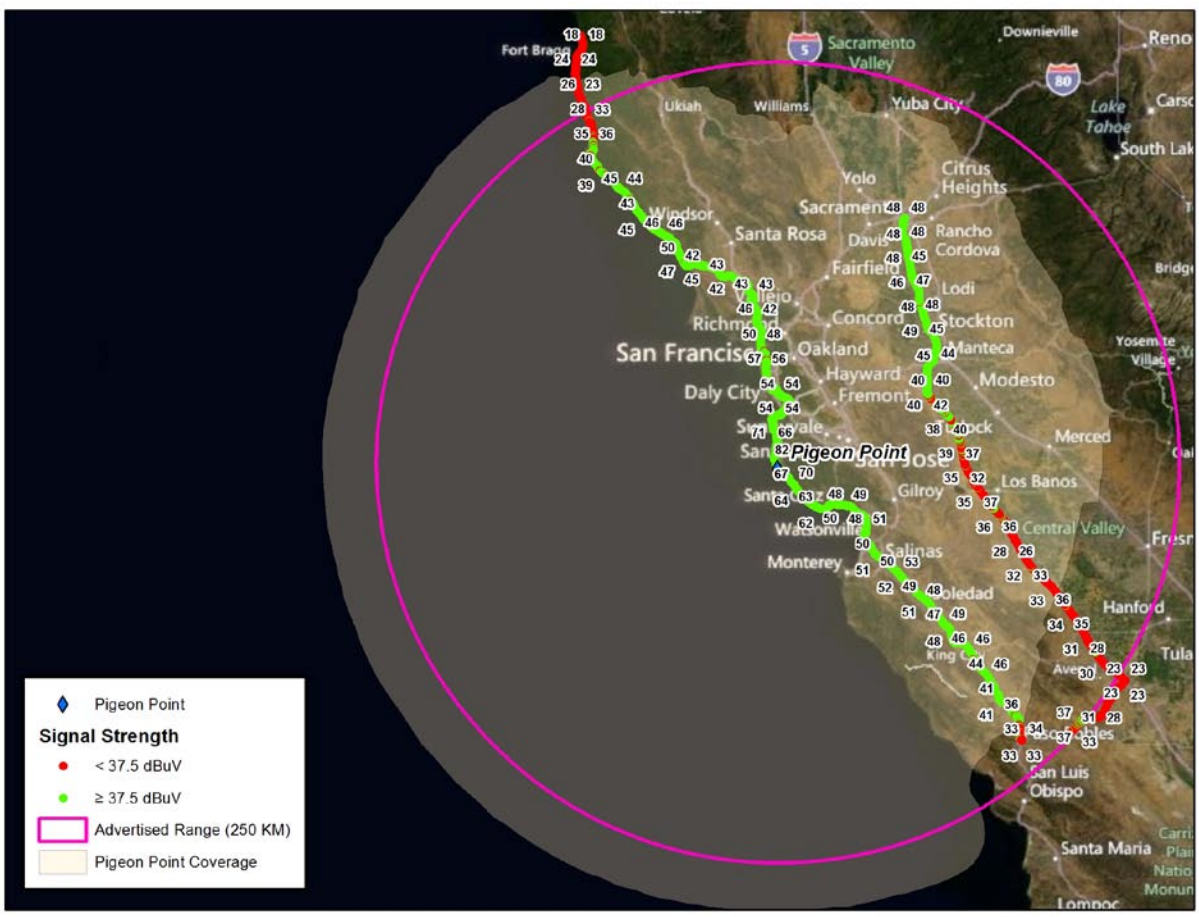

Figure 1: DNAV Signal Strength Results

	POSITION	Trimble SPS461	4100 FIM Meter
Side A SS	39° 10’ 11.503’N 123° 44’ 37.982”W	31.0 dBµV/m, 11 SNR	33.5 dBµV/m

Table 1: North Far-Field Signal Strength Reading

	POSITION	Trimble SPS461	4100 FIM Meter
Side A SS	35° 46’ 46.668”N 120° 12’ 40.784”W	33 dBµV/m, 20 SNR	35.6 dBµV/m

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 (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).

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 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 4: Side B RTCM Message Validation

Accuracy Validation:

Positional data was collected for 10 minutes per side using the Hemisphere R110 receiver with Raven MBA-2 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). Side B was inoperative due to an equipment failure; therefore, data could only be recorded from Side A. Side A was 0.486142552 meters, bearing 302.255868º, away from the monument. As

per Reference (1) and (2), the difference was well within advertised accuracy requirements of 10 meters. A comparison between the GPS satellites in view at the Pigeon Point 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 Side A Reference Station and Integrity Monitor 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 0.37875 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. Using a Garmin GPSmap 60CS handheld receiver the positional accuracy was 5.35 meters away from the monument. Using an iPhone 5, the positional accuracy was 38.86 meters from the monument. Therefore, the DGPS service provided from the Pigeon Point site significantly improves the positional accuracy in this area.

NGS Monument ID:	**BBCP23**
Monument LAT:	38º 54' 50.84196" N
Monument LON:	123º 42' 31.36841" W

Averaged LAT:	38º 54' 50.85036" N
Averaged LON:	123º 42' 31.38551625" W
Distance from DGPS Site:	224 km
Antenna Distance from Monument:	0.486142552 m (1.595033712 ft)
Antenna Bearing from Monument:	302.255868º

Table 5: Side A Accuracy Check Results

Antenna Location	***GPS Satellites Tracked (PRN)***										
Reference Station A	32	31	30	25	23	22	20	14	11	1	
Integrity Monitor A	32	31	30	25	23	22	20	14	11	1	
NGS Monument Location, Side A	32	31	30	25	23	22	20	17	14	11	1

Table 6: GPS Satellite Comparison

SUMMARY:

The Operational Assessment of the Pigeon Point DGPS site revealed that the provided coverage is slightly different than the predicted coverage plot and advertised range. Both northern and southern Far-Field signal strength readings were less than the required 37.5 dBµV/m for a 100 baud site. The lower signal strength is assumed to be caused by the terrain over which the signal must propagate. The route driven through the Coastal Mountain range included several areas directly alongside cliff faces which essentially masked the DGPS signal. The northern portion of the verification included areas through the redwoods and windy roads along the coast that cut in and out of the hilly terrain. The SNR at the two Far-Field locations, however, was relatively high which enabled the receiver to maintain lock on the DGPS signal despite the low signal strength. In addition, all RTCM messages were verified and 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 224 km from the broadcast site, the horizontal accuracy is sub-meter and within the accuracy requirements set forth by Reference (1) and (2).