



DIFFERENTIAL GPS (DGPS) SITE OPERATIONAL ASSESSMENT

NDGPS Site: Lincoln DGPS Site (764)
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Date: 23JAN13

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 Lincoln 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

LINCOLN DGPS SITE PARAMETERS:

Frequency	314 KHz
Forward Output Power	700 W
Transmission Rate	200 baud
Field Strength/Range	100 μ V/m (40 dB μ V/m) at 225 km

RESULTS:

Signal Strength:

A verification of the Lincoln DGPS coverage area was conducted from Sacramento, CA, through the Coastal Mountains, and then along the Pacific coast of California to Paso Robles, CA. The advertised signal strength range is 225 km. Per reference (3), the minimum signal strength for a site with a transmission rate of 200 baud is 40 dB μ V/m. Figure 1 displays the signal strength

verification results; green and red points represent areas of satisfactory and unsatisfactory signal strength levels, respectively. Satisfactory signal strength was verified throughout the predicted coverage area with exception of the northwest region. The northwest region was slightly lower than the required 40 dB μ V/m, but signal-to-noise-ratio (SNR) levels remained high. The Redwood Forest lives in the mountainous terrain within this region. It is assumed that the lower signal strength levels were a result of this topography.

Far-field (FF) signal strength readings were taken at western and southern points along the advertised range (Table 1 and Table 2). The southern FF reading exceeded the required signal strength levels on both operational sides. The western FF reading was taken along the coastline and was slightly below the required signal strength level; however, as mentioned above, SNR levels were high which could result in a useable signal depending on the specific user equipment. In this case, the Trimble SPS 461 receiver and GA 530 antenna which the verification team used were able to track a usable signal.

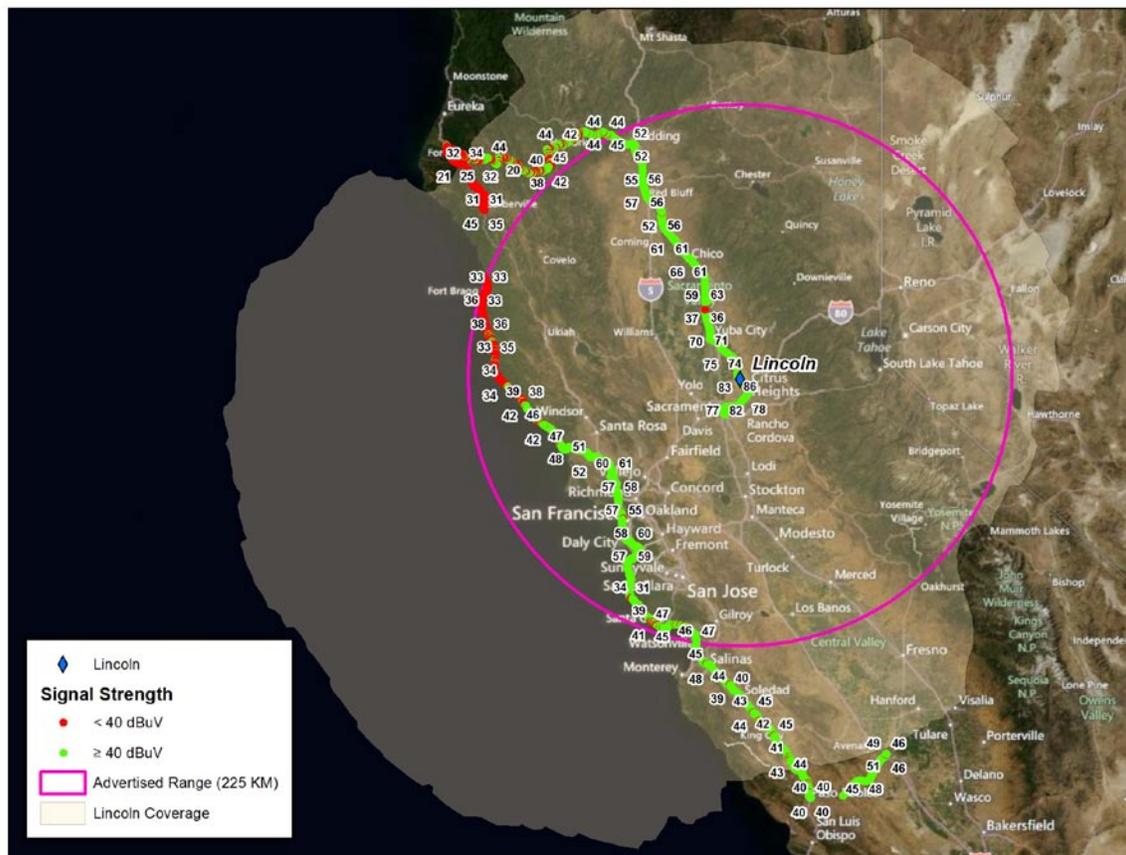


Figure 1: DNAV Signal Strength Results

	POSITION	Trimble SPS461	4100 FIM Meter
Side A SS	39° 35' 11.04"N 123° 46' 22.94"W	30 dB μ V/m, 15 SNR	31.3 dB μ V/m
Side B SS	39° 35' 11.04"N 123° 46' 22.94"W	31 dB μ V/m, 17 SNR	31.7 dB μ V/m

Table 1: West Far-Field Signal Strength Reading

	POSITION	Trimble SPS461	4100 FIM Meter
Side A SS	36° 50' 35.383"N 121° 46' 16.18"W	48 dBμV/m, 26 SNR	49.9 dBμV/m
Side B SS	36° 50' 35.383"N 121° 46' 16.18"W	48 dBμV/m, 26 SNR	49.8 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
<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 operational 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 and 6). Side A was 0.43373 meters, bearing 247.3304°, away from the monument while Side B was .65715 meters, bearing 302.809°, 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 from the Lincoln DGPS site and 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 0.1847 meters; Side B's average deviation was 0.12295 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 Lincoln DGPS site significantly improves the positional accuracy in this area.

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

Averaged LAT:	38° 54' 50.83654787" N
Averaged LON:	123° 42' 31.38506" W
Distance from DGPS Site:	204 km
Antenna Distance from Monument:	.43373 m (1.4230704 ft)
Antenna Bearing from Monument:	247.3304°

Table 5: Side A Accuracy Check Results

Averaged LAT:	38° 54' 50.85348822" N
Averaged LON:	123° 42' 31.39139142" W
Distance from DGPS Site:	204 km
Distance from Monument:	.65715 m (2.156106524 ft)
Bearing from Monument:	302.81°

Table 6: Side B Accuracy Check Results

<i>Antenna Location</i>	<i>GPS Satellites Tracked (PRN)</i>										
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	
Reference Station B	32	31	30	25	23	22	20	14	11	1	
Integrity Monitor B	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
NGS Monument Location, Side B	32	31	30	25	23	22	20	17	14	11	1

Table 7: GPS Satellite Comparison

SUMMARY:

The Operational Assessment of the Lincoln DGPS site revealed that the overall provided coverage is consistent with the predicted coverage plot and advertised range; however, the northwest region is lower due to the terrain. The southern Far-Field measurement exceeded the required minimum signal strength while the western measurement did not. It is assumed that the low signal strength reading at the western position was due to the topography surrounding the Far-Field reading area. At this location, the signal propagation had to contend with Redwood

forest areas as well as the Coastal Mountain range. The SNR levels at the west Far-Field location, however, were 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, 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 204 km from the broadcast site, the horizontal accuracy is sub-meter and within the accuracy requirements set forth by Reference (1) and (2).