

## OPUS solution : 018772\_14\_239\_A0.14O OP1409694942939

opus &lt;opus@ngs.noaa.gov&gt;

Tue 9/2/2014 3:58 PM

To: John Freetly &lt;John.Freetly@neciusa.com&gt;;

FILE: 018772\_14\_239\_A0.14O OP1409694942939

## NGS OPUS SOLUTION REPORT

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All computed coordinate accuracies are listed as peak-to-peak values.

For additional information: <http://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>USER: john.freetly@neciusa.com  
RINEX FILE: 0187239q.14oDATE: September 02, 2014  
TIME: 21:58:10 UTCSOFTWARE: page5 1209.04 master53.pl 022814 START: 2014/08/27 16:08:00  
EPHEMERIS: igr18073.eph [rapid] STOP: 2014/08/27 18:30:30  
NAV FILE: brdc2390.14n OBS USED: 5991 / 6789 : 88%  
ANT NAME: CHCX90D-OPUS NONE # FIXED AMB: 42 / 47 : 89%  
ARP HEIGHT: 1.8000 OVERALL RMS: 0.012(m)

REF FRAME: NAD\_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2014.6540)

X: -1340159.672(m) 0.012(m) -1340160.532(m) 0.012(m)  
Y: -4279104.921(m) 0.013(m) -4279103.668(m) 0.013(m)  
Z: 4522047.883(m) 0.014(m) 4522047.843(m) 0.014(m)LAT: 45 26 2.66211 0.005(m) 45 26 2.68286 0.005(m)  
E LON: 252 36 36.45560 0.007(m) 252 36 36.40062 0.007(m)  
W LON: 107 23 23.54440 0.007(m) 107 23 23.59938 0.007(m)  
EL HGT: 1006.944(m) 0.021(m) 1006.257(m) 0.021(m)  
ORTHO HGT: 1021.427(m) 0.036(m) [NAVD88 (Computed using GEOID12A)]

## UTM COORDINATES STATE PLANE COORDINATES

UTM (Zone 13) SPC (2500 MT )

Northing (Y) [meters] 5033950.519 133823.150  
Easting (X) [meters] 313069.804 765057.359  
Convergence [degrees] -1.70314092 1.54356645  
Point Scale 1.00002964 0.99976718  
Combined Factor 0.99987179 0.99960937

US NATIONAL GRID DESIGNATOR: 13TCL1306933950(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DM7161	WYSH SHERIDAN CORS ARP	N444801.769	W1070035.715	76509.6
DG9745	MTEI ENGINC CORS ARP	N454447.035	W1083600.736	100636.4
DI3062	BIL5 BILLINGS 5 CORS ARP	N455816.237	W1075947.298	76137.5

NEAREST NGS PUBLISHED CONTROL POINT

QV0173	N 486	N452621.	W1072356.	904.1
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BASE STATION INFORMATION

STATION NAME: wysh a 1 (Sheridan; Sheridan, Wyoming USA)

MONUMENT: NO DOMES NUMBER

XYZ	-1326396.2772	-4335757.8813	4472504.2552	MON @ 2005.0000 (M)
XYZ	-0.0156	-0.0003	-0.0049	VEL (M/YR)
NEU	0.0000	0.0000	0.0000	MON TO ARP (M)
NEU	0.0013	-0.0002	0.0667	ARP TO L1 PHASE CENTER (M)
NEU	0.0004	0.0006	0.0577	ARP TO L2 PHASE CENTER (M)
XYZ	-0.1502	-0.0032	-0.0474	VEL TIMES 9.6531 YRS
XYZ	0.0000	0.0000	0.0000	MON TO ARP
XYZ	-0.0138	-0.0444	0.0479	ARP TO L1 PHASE CENTER
XYZ	-1326396.4412	-4335757.9288	4472504.2557	L1 PHS CEN @ 2014.6540
XYZ	0.0000	0.0000	0.0000	+ XYZ ADJUSTMENTS
XYZ	-1326396.4411	-4335757.9288	4472504.2557	NEW L1 PHS CEN @ 2014.6540
XYZ	-1326396.4274	-4335757.8845	4472504.2078	NEW ARP @ 2014.6540
XYZ	-1326396.4274	-4335757.8845	4472504.2078	NEW MON @ 2014.6540
LLH	44 48 1.79015	252 59 24.23032	1220.7140	NEW L1 PHS CEN @ 2014.6540
LLH	44 48 1.79011	252 59 24.23033	1220.6472	NEW ARP @ 2014.6540
LLH	44 48 1.79011	252 59 24.23033	1220.6472	NEW MON @ 2014.6540

STATION NAME: mtei a 1 (ENGINC; Billings, Montana, U.S.A.)

MONUMENT: NO DOMES NUMBER

XYZ	-1422328.9082	-4226311.5606	4546317.4839	MON @ 2005.0000 (M)
XYZ	-0.0155	0.0003	-0.0078	VEL (M/YR)
NEU	0.0000	0.0000	0.0000	MON TO ARP (M)
NEU	0.0011	-0.0003	0.0668	ARP TO L1 PHASE CENTER (M)
NEU	0.0001	0.0007	0.0578	ARP TO L2 PHASE CENTER (M)
XYZ	-0.1492	0.0025	-0.0751	VEL TIMES 9.6531 YRS
XYZ	0.0000	0.0000	0.0000	MON TO ARP
XYZ	-0.0149	-0.0433	0.0486	ARP TO L1 PHASE CENTER
XYZ	-1422329.0722	-4226311.6014	4546317.4574	L1 PHS CEN @ 2014.6540
XYZ	-0.0000	0.0000	0.0000	+ XYZ ADJUSTMENTS
XYZ	-1422329.0722	-4226311.6014	4546317.4574	NEW L1 PHS CEN @ 2014.6540
XYZ	-1422329.0573	-4226311.5581	4546317.4088	NEW ARP @ 2014.6540
XYZ	-1422329.0573	-4226311.5581	4546317.4088	NEW MON @ 2014.6540
LLH	45 44 47.05575	251 23 59.20745	970.2674	NEW L1 PHS CEN @ 2014.6540

LLH 45 44 47.05571 251 23 59.20747 970.2006 NEW ARP @ 2014.6540  
 LLH 45 44 47.05571 251 23 59.20747 970.2006 NEW MON @ 2014.6540

STATION NAME: bil5 a 1 (Billings 5; Billings, Montana USA)

MONUMENT: NO DOMES NUMBER

XYZ -1372156.7413 -4223945.7929 4563650.2922 MON @ 2005.0000 (M)  
 XYZ -0.0154 0.0005 -0.0072 VEL (M/YR)  
 NEU 0.0000 0.0000 0.0000 MON TO ARP (M)  
 NEU -0.0028 -0.0023 0.0631 ARP TO L1 PHASE CENTER (M)  
 NEU -0.0038 -0.0021 0.0612 ARP TO L2 PHASE CENTER (M)  
 XYZ -0.1484 0.0046 -0.0694 VEL TIMES 9.6531 YRS  
 XYZ 0.0000 0.0000 0.0000 MON TO ARP  
 XYZ -0.0163 -0.0430 0.0434 ARP TO L1 PHASE CENTER  
 XYZ -1372156.9060 -4223945.8313 4563650.2663 L1 PHS CEN @ 2014.6540  
 XYZ -0.0000 -0.0000 -0.0000 + XYZ ADJUSTMENTS  
 XYZ -1372156.9060 -4223945.8313 4563650.2663 NEW L1 PHS CEN @ 2014.6540  
 XYZ -1372156.8897 -4223945.7883 4563650.2228 NEW ARP @ 2014.6540  
 XYZ -1372156.8897 -4223945.7883 4563650.2228 NEW MON @ 2014.6540  
 LLH 45 58 16.25826 252 0 12.64546 873.9125 NEW L1 PHS CEN @ 2014.6540  
 LLH 45 58 16.25835 252 0 12.64557 873.8493 NEW ARP @ 2014.6540  
 LLH 45 58 16.25835 252 0 12.64557 873.8493 NEW MON @ 2014.6540

#### REMOTE STATION INFORMATION

STATION NAME: 0187 1

MONUMENT: NO DOMES NUMBER

XYZ -1340160.4507 -4279103.6992 4522047.4085 MON @ 2014.6539 (M)  
 NEU -0.0011 0.0007 1.8000 MON TO ARP (M)  
 NEU 0.0011 -0.0007 0.0892 ARP TO L1 PHASE CENTER (M)  
 NEU 0.0007 -0.0031 0.1017 ARP TO L2 PHASE CENTER (M)  
 XYZ -0.3771 -1.2063 1.2817 MON TO ARP  
 XYZ -0.0191 -0.0588 0.0643 ARP TO L1 PHASE CENTER  
 XYZ -1340160.8469 -4279104.9644 4522048.7545 L1 PHS CEN @ 2014.6540

BASELINE NAME: wysh 0187

XYZ -0.0828 0.0267 0.4414 + XYZ ADJUSTMENTS  
 XYZ -1340160.9298 -4279104.9377 4522049.1959 NEW L1 PHS CEN @ 2014.6540  
 XYZ -1340160.9107 -4279104.8789 4522049.1316 NEW ARP @ 2014.6540  
 XYZ -1340160.5335 -4279103.6725 4522047.8499 NEW MON @ 2014.6540  
 LLH 45 26 2.68291 252 36 36.40062 1008.1542 NEW L1 PHS CEN @ 2014.6540  
 LLH 45 26 2.68288 252 36 36.40065 1008.0649 NEW ARP @ 2014.6540  
 LLH 45 26 2.68291 252 36 36.40062 1006.2649 NEW MON @ 2014.6540

BASELINE NAME: mtei 0187

XYZ -0.0869 0.0270 0.4359 + XYZ ADJUSTMENTS  
 XYZ -1340160.9339 -4279104.9374 4522049.1904 NEW L1 PHS CEN @ 2014.6540  
 XYZ -1340160.9147 -4279104.8786 4522049.1260 NEW ARP @ 2014.6540  
 XYZ -1340160.5376 -4279103.6722 4522047.8444 NEW MON @ 2014.6540  
 LLH 45 26 2.68276 252 36 36.40044 1008.1509 NEW L1 PHS CEN @ 2014.6540  
 LLH 45 26 2.68273 252 36 36.40047 1008.0617 NEW ARP @ 2014.6540  
 LLH 45 26 2.68276 252 36 36.40044 1006.2616 NEW MON @ 2014.6540

BASELINE NAME: bil5 0187  
 XYZ -0.0752 0.0398 0.4270 + XYZ ADJUSTMENTS  
 XYZ -1340160.9221 -4279104.9246 4522049.1815 NEW L1 PHS CEN @ 2014.6540  
 XYZ -1340160.9030 -4279104.8657 4522049.1172 NEW ARP @ 2014.6540  
 XYZ -1340160.5259 -4279103.6594 4522047.8355 NEW MON @ 2014.6540  
 LLH 45 26 2.68293 252 36 36.40077 1008.1335 NEW L1 PHS CEN @ 2014.6540  
 LLH 45 26 2.68289 252 36 36.40080 1008.0443 NEW ARP @ 2014.6540  
 LLH 45 26 2.68293 252 36 36.40077 1006.2442 NEW MON @ 2014.6540

G-FILES

Axx2014 827 14 827  
 B2014 82716 8 14 8271830 1 page5 v1209.04IGS 126 1 2 27NGS 2014 9 2IFDDPX  
 IIGS08\_1805 IGS 20140810  
 C00090004 137641062 8 -566542120 26 -495436421 25 X2394A0187X2394AWYSH  
 D 1 2 7270154 1 3 -8166564 2 3 -8132577

Axx2014 827 14 827  
 B2014 82716 8 14 8271830 1 page5 v1209.04IGS 126 1 2 27NGS 2014 9 2IFDDPX  
 IIGS08\_1805 IGS 20140810  
 C00090001 -821685197 8 527921141 18 242695644 20 X2394A0187X2394AMTEI  
 D 1 2 6473418 1 3 -7495156 2 3 -9018587

Axx2014 827 14 827  
 B2014 82716 8 14 8271830 1 page5 v1209.04IGS 126 1 2 27NGS 2014 9 2IFDDPX  
 IIGS08\_1805 IGS 20140810  
 C00090003 -319963638 6 551578711 21 416023873 20 X2394A0187X2394ABIL5  
 D 1 2 6128501 1 3 -7594636 2 3 -8456309

POST-FIT RMS BY SATELLITE VS. BASELINE

OVERALL 01 02 04 06 07 08 11 12  
 wysh-0187| 0.012 0.014 ... 0.007 0.011 0.015 0.012 0.013 ...  
 15 17 20 24 26 28 30  
 wysh-0187| 0.024 ... 0.028 0.013 0.011 0.006 0.012

OVERALL 01 02 04 06 07 08 11 12  
 mtei-0187| 0.011 0.013 0.018 0.008 0.015 0.018 0.014 0.014 0.022  
 15 17 20 24 26 28 30  
 mtei-0187| 0.015 ... ... 0.012 0.011 0.006 0.010

OVERALL 01 02 04 06 07 08 11 12  
 bil5-0187| 0.011 0.012 0.021 0.008 0.011 0.016 0.016 0.012 ...  
 15 17 20 24 26 28 30  
 bil5-0187| 0.017 ... 0.023 0.013 0.012 0.007 0.007

OBS BY SATELLITE VS. BASELINE

OVERALL 01 02 04 06 07 08 11 12  
 wysh-0187| 1968 250 ... 277 155 37 47 121 ...

```

15 17 20 24 26 28 30
wysh-0187| 205 ... 19 175 196 281 205
OVERALL 01 02 04 06 07 08 11 12
mtei-0187| 2040 257 41 277 163 56 47 118 25
15 17 20 24 26 28 30
mtei-0187| 215 ... 188 186 281 186
OVERALL 01 02 04 06 07 08 11 12
bil5-0187| 1983 253 29 277 156 56 47 119 ...
15 17 20 24 26 28 30
bil5-0187| 195 ... 22 177 195 281 176
    
```

Covariance Matrix for the xyz OPUS Position (meters^2).

```

0.0000003311 0.0000000505 -0.0000000645
0.0000000505 0.0000022689 -0.0000002047
-0.0000000645 -0.0000002047 0.0000024200
    
```

Covariance Matrix for the enu OPUS Position (meters^2).

```

0.0000004754 -0.0000003632 0.0000003597
-0.0000003632 0.0000020564 0.0000001459
0.0000003597 0.0000001459 0.0000024882
    
```

Horizontal network accuracy = 0.00294 meters.

Vertical network accuracy = 0.00309 meters.

### Derivation of NAD 83 vector components

Position of reference station ARP in NAD\_83(2011)(EPOCH:2010.0000).

```

Xa(m) Ya(m) Za(m)
WYSH -1326395.57266 -4335759.14462 4472504.25410 2010.00
MTEI -1422328.19717 -4226312.80615 4546317.45438 2010.00
BIL5 -1372156.02966 -4223947.03790 4563650.26522 2010.00
    
```

Position of reference station monument in NAD\_83(2011)(EPOCH:2010.0000).

```

Xr(m) Yr(m) Zr(m)
WYSH -1326395.57266 -4335759.14462 4472504.25410 2010.00
MTEI -1422328.19717 -4226312.80615 4546317.45438 2010.00
BIL5 -1372156.02966 -4223947.03790 4563650.26522 2010.00
    
```

Velocity of reference station monument in NAD\_83(2011)(EPOCH:2010.0000).

```

Vx (m/yr) Vy (m/yr) Vz (m/yr)
WYSH -0.01560 -0.00030 -0.00490
MTEI -0.01550 0.00030 -0.00780
BIL5 -0.01540 0.00050 -0.00720
    
```

Vectors from unknown station monument to reference station monument in NAD\_83(2011)(EPOCH:2010.0000).

```

Xr-X= DX(m) Yr-Y= DY(m) Zr-Z= DZ(m)
WYSH 13764.09934 -56654.22362 -49543.62890 2010.00
    
```

MTEI	-82168.52517	52792.11485	24269.57138	2010.00
BIL5	-31996.35766	55157.88310	41602.38222	2010.00

## STATE PLANE COORDINATES - International Foot

SPC (2500 MT )

Northing (Y) [feet]	439052.329
Easting (X) [feet]	2510030.705
Convergence [degrees]	1.54356645
Point Scale	0.99976718
Combined Factor	0.99960937

\*\* Orthometric Heights Above Future Geopotential Datum.

Prototype orthometric heights are now being made available as a precursor to the completion of GRAV-D and the replacement of NAVD 88 with a new geopotential reference system. The following height reflects the current best estimate of the true orthometric height, based on the existing gravimetric geoid model. This height is subject to change as data and modeling for the gravimetric geoid change throughout the lifetime of the GRAV-D project, or as new realizations of the ITRF are adopted. However, at the completion of GRAV-D, these heights will supersede the NAVD 88 heights

APPROX ORTHO HGT: 1020.567 (m) [PROTOTYPE (Computed using USGG2012,GRS80,IGS08)]

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.