

## OPUS solution : 033845\_14\_239\_A0.14O OP1409695304122

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

Tue 9/2/2014 4:04 PM

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

FILE: 033845\_14\_239\_A0.14O OP1409695304122

## 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: 0338239r.14oDATE: September 02, 2014  
TIME: 22:04:11 UTCSOFTWARE: page5 1209.04 master90.pl 022814 START: 2014/08/27 17:05:00  
EPHEMERIS: igr18073.eph [rapid] STOP: 2014/08/27 20:03:00  
NAV FILE: brdc2390.14n OBS USED: 7123 / 7922 : 90%  
ANT NAME: CHCX90D-OPUS NONE # FIXED AMB: 48 / 53 : 91%  
ARP HEIGHT: 1.8000 OVERALL RMS: 0.015(m)

REF FRAME: NAD\_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2014.6542)

X: -1313038.896(m) 0.004(m) -1313039.756(m) 0.004(m)  
Y: -4273154.552(m) 0.009(m) -4273153.300(m) 0.009(m)  
Z: 4535660.023(m) 0.011(m) 4535659.984(m) 0.011(m)LAT: 45 36 28.54601 0.013(m) 45 36 28.56697 0.013(m)  
E LON: 252 55 8.58129 0.005(m) 252 55 8.52639 0.005(m)  
W LON: 107 4 51.41871 0.005(m) 107 4 51.47361 0.005(m)  
EL HGT: 1107.075(m) 0.008(m) 1106.386(m) 0.008(m)  
ORTHO HGT: 1121.737(m) 0.016(m) [NAVD88 (Computed using GEOID12A)]

## UTM COORDINATES STATE PLANE COORDINATES

UTM (Zone 13) SPC (2500 MT )

Northing (Y) [meters] 5052593.355 153830.080  
Easting (X) [meters] 337733.675 788618.149  
Convergence [degrees] -1.48730634 1.76954551  
Point Scale 0.99992373 0.99968952  
Combined Factor 0.99975021 0.99951604

US NATIONAL GRID DESIGNATOR: 13TCL3773352593(NAD 83)

## BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DM7161	WYSH SHERIDAN CORS ARP	N444801.769	W1070035.715	89924.3
DL7728	P051 BILLINGSAPMT2005 CORS ARP	N454823.741	W1083246.070	116228.3
DG9745	MTEI ENGINC CORS ARP	N454447.035	W1083600.736	119381.2

## NEAREST NGS PUBLISHED CONTROL POINT

QV0410	ARROW	N453519.761	W1070304.034	3149.9
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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 9.6532 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 @ 2014.6542
XYZ	0.0000	0.0000	0.0000	+ XYZ ADJUSTMENTS
XYZ	-1326396.4411	-4335757.9288	4472504.2557	NEW L1 PHS CEN @ 2014.6542
XYZ	-1326396.4274	-4335757.8845	4472504.2078	NEW ARP @ 2014.6542
XYZ	-1326396.4274	-4335757.8845	4472504.2078	NEW MON @ 2014.6542
LLH	44 48 1.79015	252 59 24.23032	1220.7140	NEW L1 PHS CEN @ 2014.6542
LLH	44 48 1.79011	252 59 24.23033	1220.6472	NEW ARP @ 2014.6542
LLH	44 48 1.79011	252 59 24.23033	1220.6472	NEW MON @ 2014.6542

STATION NAME: p051 a 1 (BillingsAPMT2005; Billings, MT United States)

MONUMENT: NO DOMES NUMBER

XYZ	-1416838.9478	-4223178.9397	4551064.1207	MON @ 2005.0000 (M)
XYZ	-0.0158	-0.0003	-0.0052	VEL (M/YR)
NEU	-0.0000	0.0000	0.0083	MON TO ARP (M)
NEU	0.0012	0.0008	0.0860	ARP TO L1 PHASE CENTER (M)
NEU	0.0006	-0.0006	0.1183	ARP TO L2 PHASE CENTER (M)
XYZ	-0.1525	-0.0029	-0.0502	VEL TIMES 9.6532 YRS
XYZ	-0.0018	-0.0055	0.0060	MON TO ARP
XYZ	-0.0181	-0.0563	0.0625	ARP TO L1 PHASE CENTER
XYZ	-1416839.1203	-4223179.0044	4551064.1389	L1 PHS CEN @ 2014.6542
XYZ	-0.0000	0.0000	-0.0000	+ XYZ ADJUSTMENTS
XYZ	-1416839.1203	-4223179.0044	4551064.1389	NEW L1 PHS CEN @ 2014.6542
XYZ	-1416839.1022	-4223178.9481	4551064.0765	NEW ARP @ 2014.6542
XYZ	-1416839.1003	-4223178.9426	4551064.0705	NEW MON @ 2014.6542
LLH	45 48 23.76230	251 27 13.87307	1081.1886	NEW L1 PHS CEN @ 2014.6542

LLH 45 48 23.76226 251 27 13.87303 1081.1026 NEW ARP @ 2014.6542  
 LLH 45 48 23.76226 251 27 13.87303 1081.0943 NEW MON @ 2014.6542

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 9.6532 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 @ 2014.6542  
 XYZ -0.0000 0.0000 0.0000 + XYZ ADJUSTMENTS  
 XYZ -1422329.0722 -4226311.6014 4546317.4574 NEW L1 PHS CEN @ 2014.6542  
 XYZ -1422329.0573 -4226311.5581 4546317.4088 NEW ARP @ 2014.6542  
 XYZ -1422329.0573 -4226311.5581 4546317.4088 NEW MON @ 2014.6542  
 LLH 45 44 47.05575 251 23 59.20745 970.2674 NEW L1 PHS CEN @ 2014.6542  
 LLH 45 44 47.05571 251 23 59.20747 970.2006 NEW ARP @ 2014.6542  
 LLH 45 44 47.05571 251 23 59.20747 970.2006 NEW MON @ 2014.6542

#### REMOTE STATION INFORMATION

STATION NAME: 0338 1

MONUMENT: NO DOMES NUMBER

XYZ -1313039.3835 -4273153.3722 4535659.5961 MON @ 2014.6540 (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 -0.3695 -1.2046 1.2855 MON TO ARP  
 XYZ -0.0188 -0.0587 0.0645 ARP TO L1 PHASE CENTER  
 XYZ -1313039.7717 -4273154.6356 4535660.9461 L1 PHS CEN @ 2014.6542

BASELINE NAME: wysh 0338

XYZ -0.3741 0.0752 0.3950 + XYZ ADJUSTMENTS  
 XYZ -1313040.1458 -4273154.5604 4535661.3412 NEW L1 PHS CEN @ 2014.6542  
 XYZ -1313040.1271 -4273154.5016 4535661.2766 NEW ARP @ 2014.6542  
 XYZ -1313039.7576 -4273153.2970 4535659.9911 NEW MON @ 2014.6542  
 LLH 45 36 28.56719 252 55 8.52628 1108.2790 NEW L1 PHS CEN @ 2014.6542  
 LLH 45 36 28.56715 252 55 8.52631 1108.1898 NEW ARP @ 2014.6542  
 LLH 45 36 28.56719 252 55 8.52628 1106.3897 NEW MON @ 2014.6542

BASELINE NAME: p051 0338

XYZ -0.3705 0.0741 0.3843 + XYZ ADJUSTMENTS  
 XYZ -1313040.1422 -4273154.5615 4535661.3305 NEW L1 PHS CEN @ 2014.6542  
 XYZ -1313040.1235 -4273154.5027 4535661.2659 NEW ARP @ 2014.6542  
 XYZ -1313039.7540 -4273153.2981 4535659.9804 NEW MON @ 2014.6542  
 LLH 45 36 28.56695 252 55 8.52646 1108.2714 NEW L1 PHS CEN @ 2014.6542  
 LLH 45 36 28.56691 252 55 8.52649 1108.1822 NEW ARP @ 2014.6542  
 LLH 45 36 28.56695 252 55 8.52646 1106.3821 NEW MON @ 2014.6542

BASELINE NAME: mtei 0338

XYZ -0.3717 0.0663 0.3840 + XYZ ADJUSTMENTS  
 XYZ -1313040.1435 -4273154.5693 4535661.3301 NEW L1 PHS CEN @ 2014.6542  
 XYZ -1313040.1247 -4273154.5105 4535661.2656 NEW ARP @ 2014.6542  
 XYZ -1313039.7552 -4273153.3059 4535659.9801 NEW MON @ 2014.6542  
 LLH 45 36 28.56676 252 55 8.52651 1108.2766 NEW L1 PHS CEN @ 2014.6542  
 LLH 45 36 28.56672 252 55 8.52654 1108.1874 NEW ARP @ 2014.6542  
 LLH 45 36 28.56676 252 55 8.52651 1106.3873 NEW MON @ 2014.6542

G-FILES

Axx2014 827 14 827

B2014 82717 5 14 82720 3 1 page5 v1209.04IGS 126 1 2 27NGS 2014 9 2IFDDPX  
 IIGS08\_1805 IGS 20140810  
 C00090004 -133566698 8 -626045875 22 -631557833 24 X2394A0338X2394AWYSH  
 D 1 2 8477402 1 3 -7167051 2 3 -8332410

Axx2014 827 14 827

B2014 82717 5 14 82720 3 1 page5 v1209.04IGS 126 1 2 27NGS 2014 9 2IFDDPX  
 IIGS08\_1805 IGS 20140810  
 C00090002-1037993463 8 499743555 18 154040901 19 X2394A0338X2394AP051  
 D 1 2 6354072 1 3 -6814170 2 3 -9367900

Axx2014 827 14 827

B2014 82717 5 14 82720 3 1 page5 v1209.04IGS 126 1 2 27NGS 2014 9 2IFDDPX  
 IIGS08\_1805 IGS 20140810  
 C00090001-1092893021 10 468417478 21 106574287 24 X2394A0338X2394AMTEI  
 D 1 2 6537422 1 3 -7077374 2 3 -9369836

POST-FIT RMS BY SATELLITE VS. BASELINE

OVERALL 01 02 04 06 10 11 12 15  
 wysh-0338| 0.015 0.014 0.012 0.009 0.011 0.025 ... 0.017 0.016  
 17 20 24 25 26 28 30  
 wysh-0338| ... 0.036 0.011 0.029 0.011 0.011 0.015

OVERALL 01 02 04 06 10 11 12 15  
 p051-0338| 0.014 0.012 0.012 0.012 0.011 0.020 0.018 0.015 0.013  
 17 20 24 25 26 28 30  
 p051-0338| ... 0.029 0.012 0.026 0.012 0.013 0.015

OVERALL 01 02 04 06 10 11 12 15  
 mtei-0338| 0.015 0.014 0.011 0.011 0.011 0.022 ... 0.017 0.018  
 17 20 24 25 26 28 30  
 mtei-0338| ... 0.035 0.012 0.021 0.017 0.012 0.019

OBS BY SATELLITE VS. BASELINE

OVERALL 01 02 04 06 10 11 12 15  
 wysh-0338| 2305 119 217 287 347 48 ... 209 99

```

    17  20  24  25  26  28  30
wysh-0338| ... 237 315 36 71 240 80
    OVERALL 01 02 04 06 10 11 12 15
p051-0338| 2449 119 218 312 342 35 50 224 104
    17  20  24  25  26  28  30
p051-0338| ... 228 339 40 72 275 91
    OVERALL 01 02 04 06 10 11 12 15
mtei-0338| 2369 147 216 293 341 42 ... 224 103
    17  20  24  25  26  28  30
mtei-0338| ... 217 335 29 79 252 91
    
```

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

```

0.0000005067  0.0000000746  -0.0000000906
0.0000000746  0.0000025889  -0.0000002660
-0.0000000906 -0.0000002660  0.0000031578
    
```

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

```

0.0000006444  -0.0000003783  0.0000003610
-0.0000003783  0.0000025185  0.0000003492
0.0000003610  0.0000003492  0.0000030904
    
```

Horizontal network accuracy = 0.00326 meters.

Vertical network accuracy = 0.00345 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
P051 -1416838.24007 -4223180.19340 4551064.10960 2010.00
MTEI -1422328.19717 -4226312.80615 4546317.45438 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
P051 -1416838.23827 -4223180.18790 4551064.10360 2010.00
MTEI -1422328.19717 -4226312.80615 4546317.45438 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
P051   -0.01580  -0.00030  -0.00520
MTEI   -0.01550   0.00030  -0.00780
    
```

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 -13356.67666 -62604.59262 -63155.76890 2010.00
    
```

P051	-103799.34227	49974.36410	15404.08060	2010.00
MTEI	-109289.30117	46841.74585	10657.43138	2010.00

## STATE PLANE COORDINATES - International Foot

SPC (2500 MT )

Northing (Y) [feet]	504691.864
Easting (X) [feet]	2587329.885
Convergence [degrees]	1.76954551
Point Scale	0.99968952
Combined Factor	0.99951604

\*\* 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: 1120.885 (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.