

## OPUS solution : 033845\_14\_238\_A1.14O OP1409690581912

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

Tue 9/2/2014 2:45 PM

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

FILE: 033845\_14\_238\_A1.14O OP1409690581912

## 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

DATE: September 02, 2014

RINEX FILE: 0338238p.14o

TIME: 20:45:28 UTC

SOFTWARE: page5 1209.04 master53.pl 022814 START: 2014/08/26 15:58:00

EPHEMERIS: igr18072.eph [rapid] STOP: 2014/08/26 18:26:00

NAV FILE: brdc2380.14n OBS USED: 6601 / 7170 : 92%

ANT NAME: CHCX90D-OPUS NONE # FIXED AMB: 45 / 48 : 94%

ARP HEIGHT: 1.80000 OVERALL RMS: 0.012(m)

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

IGS08 (EPOCH:2014.6513)

X: -1324285.753(m) 0.011(m) -1324286.613(m) 0.011(m)

Y: -4276860.107(m) 0.016(m) -4276858.855(m) 0.016(m)

Z: 4528942.302(m) 0.012(m) 4528942.263(m) 0.012(m)

LAT: 45 31 17.69551 0.007(m) 45 31 17.71638 0.007(m)

E LON: 252 47 43.43491 0.006(m) 252 47 43.38001 0.006(m)

W LON: 107 12 16.56509 0.006(m) 107 12 16.61999 0.006(m)

EL HGT: 1110.234(m) 0.021(m) 1109.546(m) 0.021(m)

ORTHO HGT: 1124.815(m) 0.038(m) [NAVD88 (Computed using GEOID12A)]

## UTM COORDINATES STATE PLANE COORDINATES

UTM (Zone 13) SPC (2500 MT )

Northing (Y) [meters] 5043258.226 143949.953

Easting (X) [meters] 327828.075 779260.731

Convergence [degrees] -1.57339981 1.67909372

Point Scale 0.99996447 0.99972698

Combined Factor 0.99979045 0.99955300

US NATIONAL GRID DESIGNATOR: 13TCL2782843258(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DG9745	MTEI ENGINC CORS ARP	N454447.035	W1083600.736	111665.8
DL7728	P051 BILLINGSAPMT2005 CORS ARP	N454823.741	W1083246.070	109256.0
DI3062	BIL5 BILLINGS 5 CORS ARP	N455816.237	W1075947.298	79347.3

NEAREST NGS PUBLISHED CONTROL POINT

QV0425	CREEK	N453025.589	W1071226.635	1625.9
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BASE STATION INFORMATION

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	-0.1491	0.0025	-0.0750	VEL TIMES 9.6503 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 @ 2014.6513
XYZ	0.0000	0.0000	0.0000	+ XYZ ADJUSTMENTS
XYZ	-1422329.0722	-4226311.6014	4546317.4574	NEW L1 PHS CEN @ 2014.6513
XYZ	-1422329.0573	-4226311.5581	4546317.4088	NEW ARP @ 2014.6513
XYZ	-1422329.0573	-4226311.5581	4546317.4088	NEW MON @ 2014.6513
LLH	45 44 47.05575	251 23 59.20746	970.2674	NEW L1 PHS CEN @ 2014.6513
LLH	45 44 47.05571	251 23 59.20747	970.2006	NEW ARP @ 2014.6513
LLH	45 44 47.05571	251 23 59.20747	970.2006	NEW MON @ 2014.6513

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 9.6503 YRS
XYZ	-0.0018	-0.0055	0.0060	MON TO ARP
XYZ	-0.0181	-0.0563	0.0625	ARP TO L1 PHASE CENTER
XYZ	-1416839.1202	-4223179.0044	4551064.1389	L1 PHS CEN @ 2014.6513
XYZ	0.0000	-0.0000	-0.0000	+ XYZ ADJUSTMENTS
XYZ	-1416839.1202	-4223179.0044	4551064.1389	NEW L1 PHS CEN @ 2014.6513
XYZ	-1416839.1021	-4223178.9481	4551064.0765	NEW ARP @ 2014.6513
XYZ	-1416839.1003	-4223178.9426	4551064.0705	NEW MON @ 2014.6513
LLH	45 48 23.76230	251 27 13.87307	1081.1886	NEW L1 PHS CEN @ 2014.6513

LLH 45 48 23.76226 251 27 13.87303 1081.1026 NEW ARP @ 2014.6513  
 LLH 45 48 23.76226 251 27 13.87303 1081.0943 NEW MON @ 2014.6513

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 -0.1483 0.0046 -0.0694 VEL TIMES 9.6503 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 @ 2014.6513  
 XYZ 0.0000 -0.0000 -0.0000 + XYZ ADJUSTMENTS  
 XYZ -1372156.9060 -4223945.8313 4563650.2663 NEW L1 PHS CEN @ 2014.6513  
 XYZ -1372156.8897 -4223945.7883 4563650.2229 NEW ARP @ 2014.6513  
 XYZ -1372156.8897 -4223945.7883 4563650.2229 NEW MON @ 2014.6513  
 LLH 45 58 16.25826 252 0 12.64547 873.9125 NEW L1 PHS CEN @ 2014.6513  
 LLH 45 58 16.25835 252 0 12.64557 873.8494 NEW ARP @ 2014.6513  
 LLH 45 58 16.25835 252 0 12.64557 873.8494 NEW MON @ 2014.6513

#### REMOTE STATION INFORMATION

STATION NAME: 0338 1

MONUMENT: NO DOMES NUMBER

XYZ -1324286.2840 -4276858.9069 4528941.5666 MON @ 2014.6511 (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 -0.3726 -1.2057 1.2836 MON TO ARP  
 XYZ -0.0189 -0.0588 0.0644 ARP TO L1 PHASE CENTER  
 XYZ -1324286.6755 -4276860.1714 4528942.9146 L1 PHS CEN @ 2014.6513

BASELINE NAME: mtei 0338

XYZ -0.3351 0.0417 0.7033 + XYZ ADJUSTMENTS  
 XYZ -1324287.0107 -4276860.1297 4528943.6180 NEW L1 PHS CEN @ 2014.6513  
 XYZ -1324286.9918 -4276860.0709 4528943.5535 NEW ARP @ 2014.6513  
 XYZ -1324286.6191 -4276858.8652 4528942.2699 NEW MON @ 2014.6513  
 LLH 45 31 17.71627 252 47 43.37987 1111.4486 NEW L1 PHS CEN @ 2014.6513  
 LLH 45 31 17.71624 252 47 43.37991 1111.3593 NEW ARP @ 2014.6513  
 LLH 45 31 17.71627 252 47 43.37987 1109.5593 NEW MON @ 2014.6513

BASELINE NAME: p051 0338

XYZ -0.3271 0.0575 0.6952 + XYZ ADJUSTMENTS  
 XYZ -1324287.0027 -4276860.1139 4528943.6098 NEW L1 PHS CEN @ 2014.6513  
 XYZ -1324286.9838 -4276860.0551 4528943.5454 NEW ARP @ 2014.6513  
 XYZ -1324286.6111 -4276858.8494 4528942.2618 NEW MON @ 2014.6513  
 LLH 45 31 17.71649 252 47 43.38001 1111.4305 NEW L1 PHS CEN @ 2014.6513  
 LLH 45 31 17.71646 252 47 43.38004 1111.3413 NEW ARP @ 2014.6513  
 LLH 45 31 17.71649 252 47 43.38001 1109.5412 NEW MON @ 2014.6513

BASELINE NAME: bil5 0338  
 XYZ -0.3240 0.0576 0.6914 + XYZ ADJUSTMENTS  
 XYZ -1324286.9996 -4276860.1138 4528943.6061 NEW L1 PHS CEN @ 2014.6513  
 XYZ -1324286.9807 -4276860.0550 4528943.5416 NEW ARP @ 2014.6513  
 XYZ -1324286.6080 -4276858.8493 4528942.2580 NEW MON @ 2014.6513  
 LLH 45 31 17.71643 252 47 43.38015 1111.4271 NEW L1 PHS CEN @ 2014.6513  
 LLH 45 31 17.71639 252 47 43.38018 1111.3379 NEW ARP @ 2014.6513  
 LLH 45 31 17.71643 252 47 43.38015 1109.5378 NEW MON @ 2014.6513

G-FILES

Axx2014 826 14 826  
 B2014 8261557 14 8261826 1 page5 v1209.04IGS 126 1 2 27NGS 2014 9 2IFDDPX  
 IIGS08\_1805 IGS 20140810  
 C00090001 -980424381 8 505473071 19 173751389 20 X2384A0338X2384AMTEI  
 D 1 2 4166949 1 3 -6120524 2 3 -9036377

Axx2014 826 14 826  
 B2014 8261557 14 8261826 1 page5 v1209.04IGS 126 1 2 27NGS 2014 9 2IFDDPX  
 IIGS08\_1805 IGS 20140810  
 C00090002 -925524891 8 536799068 19 221218087 20 X2384A0338X2384AP051  
 D 1 2 4527228 1 3 -6601133 2 3 -9015670

Axx2014 826 14 826  
 B2014 8261557 14 8261826 1 page5 v1209.04IGS 126 1 2 27NGS 2014 9 2IFDDPX  
 IIGS08\_1805 IGS 20140810  
 C00090003 -478702816 7 529130610 20 347079648 21 X2384A0338X2384ABIL5  
 D 1 2 5245726 1 3 -7535778 2 3 -8589324

POST-FIT RMS BY SATELLITE VS. BASELINE

OVERALL 01 02 04 06 07 08 11 12  
 mtei-0338| 0.013 0.012 ... 0.011 0.018 0.014 0.015 0.015 ...  
 15 17 19 20 24 26 28 30  
 mtei-0338| 0.017 ... ... 0.029 0.012 0.014 0.011 0.012

OVERALL 01 02 04 06 07 08 11 12  
 p051-0338| 0.012 0.011 ... 0.010 0.011 0.015 0.014 0.010 ...  
 15 17 19 20 24 26 28 30  
 p051-0338| 0.019 ... ... 0.018 0.012 0.012 0.011 0.011

OVERALL 01 02 04 06 07 08 11 12  
 bil5-0338| 0.012 0.010 ... 0.009 0.012 0.015 0.013 0.012 ...  
 15 17 19 20 24 26 28 30  
 bil5-0338| 0.021 ... ... 0.034 0.012 0.012 0.012 0.011

OBS BY SATELLITE VS. BASELINE

OVERALL 01 02 04 06 07 08 11 12  
 mtei-0338| 2236 293 ... 293 139 96 97 175 ...

```

    15  17  19  20  24  26  28  30
mtei-0338| 229  ...  ...  20  171  196  294  233
    OVERALL  01  02  04  06  07  08  11  12
p051-0338| 2207  293  ...  293  125  96  107  156  ...
    15  17  19  20  24  26  28  30
p051-0338| 226  ...  ...  25  171  196  294  225
    OVERALL  01  02  04  06  07  08  11  12
bil5-0338| 2158  294  ...  293  133  94  89  157  ...
    15  17  19  20  24  26  28  30
bil5-0338| 209  ...  ...  7  163  202  294  223
    
```

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

```

0.0000003933  0.0000000457  -0.0000000698
0.0000000457  0.0000024933  -0.0000002326
-0.0000000698  -0.0000002326  0.0000027578
    
```

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

```

0.0000005512  -0.0000003937  0.0000003921
-0.0000003937  0.0000023013  0.0000002084
0.0000003921  0.0000002084  0.0000027919
    
```

Horizontal network accuracy = 0.00312 meters.

Vertical network accuracy = 0.00328 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)	
MTEI	-1422328.19717	-4226312.80615	4546317.45438	2010.00
P051	-1416838.24007	-4223180.19340	4551064.10960	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)	
MTEI	-1422328.19717	-4226312.80615	4546317.45438	2010.00
P051	-1416838.23827	-4223180.18790	4551064.10360	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)
MTEI	-0.01550	0.00030	-0.00780
P051	-0.01580	-0.00030	-0.00520
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)	
MTEI	-98042.44417	50547.30085	17375.15238	2010.00

P051	-92552.48527	53679.91910	22121.80160	2010.00
BIL5	-47870.27666	52913.06910	34707.96322	2010.00

STATE PLANE COORDINATES - International Foot  
SPC (2500 MT )

Northing (Y) [feet]	472276.749
Easting (X) [feet]	2556629.695
Convergence [degrees]	1.67909372
Point Scale	0.99972698
Combined Factor	0.99955300

\*\* 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: 1123.960 (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.