

# OPUS solution : 018773\_14\_248\_A1.14O OP1410469275795

opus <opus@ngs.noaa.gov>

Thu 9/11/2014 3:04 PM

Inbox

To:Chad Mozol <Chad.Mozol@neciusa.com>;

FILE: 018773\_14\_248\_A1.14O OP1410469275795

## 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: cmozol@neciusa.com                      DATE: September 11, 2014  
RINEX FILE: 0187248s.14o                      TIME: 21:04:08 UTC

SOFTWARE: page5 1209.04 master93.pl 022814    START: 2014/09/05 18:35:00  
EPHEMERIS: igr18085.eph [rapid]              STOP: 2014/09/05 22:11:00  
NAV FILE: brdc2480.14n                      OBS USED: 7827 / 8359 : 94%  
ANT NAME: CHCX90D-OPUS    NONE              # FIXED AMB: 37 / 38 : 97%  
ARP HEIGHT: 1.8000                      OVERALL RMS: 0.011(m)

REF FRAME: NAD\_83(2011)(EPOCH:2010.0000)              IGS08 (EPOCH:2014.6790)

X: -1361743.194(m) 0.007(m)              -1361744.053(m) 0.007(m)  
Y: -4297712.985(m) 0.017(m)              -4297711.731(m) 0.017(m)  
Z: 4498457.083(m) 0.002(m)              4498457.040(m) 0.002(m)

LAT: 45 7 47.39436 0.013(m)              45 7 47.41486 0.013(m)  
E LON: 252 25 8.54163 0.002(m)              252 25 8.48684 0.002(m)  
W LON: 107 34 51.45837 0.002(m)              107 34 51.51316 0.002(m)  
EL HGT: 1294.867(m) 0.014(m)              1294.177(m) 0.014(m)  
ORTHO HGT: 1307.650(m) 0.025(m) [NAVD88 (Computed using GEOID12A)]

### UTM COORDINATES    STATE PLANE COORDINATES

UTM (Zone 13)              SPC (2500 MT )

Northing (Y) [meters]    5000614.023              99641.608  
Easting (X) [meters]    297040.962              750941.579  
Convergence [degrees]    -1.82976770              1.40378535  
Point Scale              1.00010652              0.99992455  
Combined Factor              0.99990352              0.99972159

US NATIONAL GRID DESIGNATOR: 13TBL9704000614(NAD 83)

## BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL7728	P051 BILLINGSAPMT2005	CORS ARP	N454823.741 W1083246.070	106574.4
DM7161	WYSH SHERIDAN	CORS ARP	N444801.769 W1070035.715	58056.1
DG9745	MTEI ENGINC	CORS ARP	N454447.035 W1083600.736	105162.5

## NEAREST NGS PUBLISHED CONTROL POINT

QV0340	WAVE	N450858.687 W1073149.176	4546.2
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## BASE STATION INFORMATION

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 -0.1529 -0.0029 -0.0503 VEL TIMES 9.6781 YRS

XYZ -0.0018 -0.0055 0.0060 MON TO ARP

XYZ -0.0181 -0.0563 0.0625 ARP TO L1 PHASE CENTER

XYZ -1416839.1206 -4223179.0044 4551064.1388 L1 PHS CEN @ 2014.6790

XYZ -0.0000 -0.0000 -0.0000 + XYZ ADJUSTMENTS

XYZ -1416839.1206 -4223179.0044 4551064.1388 NEW L1 PHS CEN @ 2014.6790

XYZ -1416839.1026 -4223178.9481 4551064.0763 NEW ARP @ 2014.6790

XYZ -1416839.1007 -4223178.9426 4551064.0704 NEW MON @ 2014.6790

LLH 45 48 23.76229 251 27 13.87305 1081.1886 NEW L1 PHS CEN @ 2014.6790

LLH 45 48 23.76225 251 27 13.87302 1081.1026 NEW ARP @ 2014.6790

LLH 45 48 23.76225 251 27 13.87302 1081.0943 NEW MON @ 2014.6790

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 -0.1506 -0.0032 -0.0475 VEL TIMES 9.6781 YRS

XYZ 0.0000 0.0000 0.0000 MON TO ARP

XYZ -0.0138 -0.0444 0.0479 ARP TO L1 PHASE CENTER

XYZ -1326396.4415 -4335757.9288 4472504.2556 L1 PHS CEN @ 2014.6790

XYZ 0.0000 0.0000 0.0000 + XYZ ADJUSTMENTS

XYZ -1326396.4415 -4335757.9288 4472504.2556 NEW L1 PHS CEN @ 2014.6790

XYZ -1326396.4278 -4335757.8845 4472504.2077 NEW ARP @ 2014.6790

XYZ -1326396.4278 -4335757.8845 4472504.2077 NEW MON @ 2014.6790

LLH 44 48 1.79015 252 59 24.23030 1220.7140 NEW L1 PHS CEN @ 2014.6790

LLH 44 48 1.79011 252 59 24.23031 1220.6472 NEW ARP @ 2014.6790

LLH 44 48 1.79011 252 59 24.23031 1220.6472 NEW MON @ 2014.6790

STATION NAME: mtei a 1 (ENGINE; 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 -0.1495 0.0025 -0.0753 VEL TIMES 9.6781 YRS  
 XYZ 0.0000 0.0000 0.0000 MON TO ARP  
 XYZ -0.0149 -0.0433 0.0486 ARP TO L1 PHASE CENTER  
 XYZ -1422329.0726 -4226311.6014 4546317.4572 L1 PHS CEN @ 2014.6790  
 XYZ -0.0000 0.0000 -0.0000 + XYZ ADJUSTMENTS  
 XYZ -1422329.0726 -4226311.6014 4546317.4572 NEW L1 PHS CEN @ 2014.6790  
 XYZ -1422329.0577 -4226311.5581 4546317.4086 NEW ARP @ 2014.6790  
 XYZ -1422329.0577 -4226311.5581 4546317.4086 NEW MON @ 2014.6790  
 LLH 45 44 47.05574 251 23 59.20744 970.2673 NEW L1 PHS CEN @ 2014.6790  
 LLH 45 44 47.05571 251 23 59.20745 970.2006 NEW ARP @ 2014.6790  
 LLH 45 44 47.05571 251 23 59.20745 970.2006 NEW MON @ 2014.6790

#### REMOTE STATION INFORMATION

STATION NAME: 0187 1

MONUMENT: NO DOMES NUMBER

XYZ -1361744.1973 -4297711.3665 4498456.9438 MON @ 2014.6788 (M)  
 NEU -0.0011 0.0007 1.8001 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 -0.3832 -1.2116 1.2749 MON TO ARP  
 XYZ -0.0194 -0.0591 0.0640 ARP TO L1 PHASE CENTER  
 XYZ -1361744.5999 -4297712.6371 4498458.2828 L1 PHS CEN @ 2014.6790

BASELINE NAME: p051 0187

XYZ 0.1449 -0.3643 0.0946 + XYZ ADJUSTMENTS  
 XYZ -1361744.4550 -4297713.0015 4498458.3773 NEW L1 PHS CEN @ 2014.6790  
 XYZ -1361744.4356 -4297712.9424 4498458.3133 NEW ARP @ 2014.6790  
 XYZ -1361744.0524 -4297711.7308 4498457.0384 NEW MON @ 2014.6790  
 LLH 45 7 47.41483 252 25 8.48686 1296.0644 NEW L1 PHS CEN @ 2014.6790  
 LLH 45 7 47.41479 252 25 8.48689 1295.9752 NEW ARP @ 2014.6790  
 LLH 45 7 47.41483 252 25 8.48686 1294.1751 NEW MON @ 2014.6790

BASELINE NAME: wysh 0187

XYZ 0.1469 -0.3559 0.0960 + XYZ ADJUSTMENTS  
 XYZ -1361744.4530 -4297712.9931 4498458.3788 NEW L1 PHS CEN @ 2014.6790  
 XYZ -1361744.4335 -4297712.9340 4498458.3147 NEW ARP @ 2014.6790  
 XYZ -1361744.0504 -4297711.7224 4498457.0398 NEW MON @ 2014.6790  
 LLH 45 7 47.41506 252 25 8.48683 1296.0593 NEW L1 PHS CEN @ 2014.6790  
 LLH 45 7 47.41502 252 25 8.48686 1295.9701 NEW ARP @ 2014.6790  
 LLH 45 7 47.41506 252 25 8.48683 1294.1700 NEW MON @ 2014.6790

BASELINE NAME: mtei 0187

XYZ 0.1403 -0.3733 0.0966 + XYZ ADJUSTMENTS  
 XYZ -1361744.4596 -4297713.0104 4498458.3794 NEW L1 PHS CEN @ 2014.6790  
 XYZ -1361744.4402 -4297712.9513 4498458.3153 NEW ARP @ 2014.6790

XYZ -1361744.0570 -4297711.7398 4498457.0404 NEW MON @ 2014.6790  
 LLH 45 7 47.41465 252 25 8.48678 1296.0728 NEW L1 PHS CEN @ 2014.6790  
 LLH 45 7 47.41461 252 25 8.48681 1295.9836 NEW ARP @ 2014.6790  
 LLH 45 7 47.41465 252 25 8.48678 1294.1835 NEW MON @ 2014.6790

G-FILES

Axx2014 9 5 14 9 5  
 B2014 9 51835 14 9 52211 1 page5 v1209.04IGS 126 1 2 27NGS 2014 911IFDDPX  
 IIGS08\_1808 IGS 20140831  
 C00090002 -550950483 6 745327882 15 526070320 17 X2484A0187X2484AP051  
 D 1 2 7133106 1 3 -7936624 2 3 -8896470

Axx2014 9 5 14 9 5  
 B2014 9 51835 14 9 52211 1 page5 v1209.04IGS 126 1 2 27NGS 2014 911IFDDPX  
 IIGS08\_1808 IGS 20140831  
 C00090005 353476226 7 -380461621 16 -259528321 17 X2484A0187X2484AWYSH  
 D 1 2 7033968 1 3 -7814925 2 3 -8923974

Axx2014 9 5 14 9 5  
 B2014 9 51835 14 9 52211 1 page5 v1209.04IGS 126 1 2 27NGS 2014 911IFDDPX  
 IIGS08\_1808 IGS 20140831  
 C00090001 -605850007 6 714001816 15 478603682 16 X2484A0187X2484AMTEI  
 D 1 2 6221887 1 3 -7296643 2 3 -8705691

POST-FIT RMS BY SATELLITE VS. BASELINE

OVERALL 02 04 05 06 10 12 17 20  
 p051-0187| 0.010 ... 0.027 0.010 0.007 0.010 0.007 0.014 0.026  
 24 25 28 29 31  
 p051-0187| 0.011 0.010 0.020 0.013 0.020

OVERALL 02 04 05 06 10 12 17 20  
 wysh-0187| 0.011 ... 0.019 0.011 0.008 0.010 0.009 0.017 0.024  
 24 25 28 29 31  
 wysh-0187| 0.014 0.010 0.019 0.012 0.021

OVERALL 02 04 05 06 10 12 17 20  
 mtei-0187| 0.011 ... 0.029 0.011 0.010 0.008 0.008 0.014 0.029  
 24 25 28 29 31  
 mtei-0187| 0.012 0.010 ... 0.014 0.018

OBS BY SATELLITE VS. BASELINE

OVERALL 02 04 05 06 10 12 17 20  
 p051-0187| 2651 ... 36 252 357 399 425 188 82  
 24 25 28 29 31  
 p051-0187| 235 366 26 202 83

OVERALL 02 04 05 06 10 12 17 20  
 wysh-0187| 2576 ... 39 258 357 371 425 177 82  
 24 25 28 29 31  
 wysh-0187| 236 329 37 210 55

OVERALL 02 04 05 06 10 12 17 20

```
mtei-0187| 2600 ... 25 264 395 378 425 178 82
          24 25 28 29 31
mtei-0187| 236 361 ... 193 63
```

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

```
0.0000002400  0.0000000454  -0.0000000547
0.0000000454  0.0000017200  -0.0000001677
-0.0000000547 -0.0000001677  0.0000021000
```

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

```
0.0000003489  -0.0000002758  0.0000002744
-0.0000002758  0.0000016797  0.0000002448
0.0000002744  0.0000002448  0.0000020314
```

Horizontal network accuracy = 0.00264 meters.

Vertical network accuracy = 0.00279 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)
P051 -1416838.24007 -4223180.19340 4551064.10960 2010.00
WYSH -1326395.57266 -4335759.14462 4472504.25410 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)
P051 -1416838.23827 -4223180.18790 4551064.10360 2010.00
WYSH -1326395.57266 -4335759.14462 4472504.25410 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)
P051  -0.01580   -0.00030   -0.00520
WYSH   -0.01560   -0.00030   -0.00490
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)
P051 -55095.04427  74532.79710  52607.02060 2010.00
WYSH  35347.62134 -38046.15962 -25952.82890 2010.00
MTEI -60585.00317  71400.17885  47860.37138 2010.00
```

STATE PLANE COORDINATES - International Foot

SPC (2500 MT )

```
Northing (Y) [feet]  326908.163
Easting (X) [feet]   2463719.091
Convergence [degrees] 1.40378535
Point Scale          0.99992455
```

Combined Factor      0.99972159

\*\* 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: 1306.798 (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.